Foundations and Applications for a

CERTIFIED PERSONAL TRAINER

Tenth Edition

ISSA INTERNATIONAL SPORTS SCIENCES ASSOCIATION

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SPORTS SCIENCES
ASSOCIATION

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SUBJECTS COVERED

Foundations and Applications for a

CERTIFIED PERSONAL TRAINER

- Psychology of behavior change
- Human anatomy and physiology
- Energy systems
- Human metabolism
- Biomechanics and human movement
- Principles of program design
- Flexibility training
- Cardiovascular training
- Resistance training
- Exercise selection and technique
- Cueing clients
- Nutrition and supplementation
- Common chronic health conditions
- Lifespan considerations
- Growing and marketing a personal training business
- Emergency management in fitness

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CHAPTER 01

HEALTH, FITNESS, AND PERSONAL TRAINING

LEARNING OBJECTIVES

1 | Describe what a personal trainer does and who they can help.

2 | List the subject matter a successful personal trainer must be educated in.

3 | Describe the general benefits of personal training as it relates to exercise and physical activity.

The fitness industry is a multibillion-dollar business bringing in more than $94 billion in 2019 according to the International Health, Racquet & Sportsclub Association (IHRSA). The industry includes fitness technology and wearables, wellness programs, large and small membership-based gyms, fitness studios, nutrition services, and physical recovery services. Within these aspects of fitness, personal training is one of the most prevalent.

THE HISTORY OF PERSONAL TRAINING

The roots of personal training are difficult to pinpoint. Some say personal training started in the 1950s, when personal trainers were first becoming actively certified, while others contend that personal training dates back to the beginning of recorded history. Dedicated health and fitness destination resorts dating back to the 1800s have been identified.

While the profession and terminology associated with personal training did not yet exist, the concept of optimal health (which is the motivation behind the profession) was already being touted by ancient philosophers. Around 400 BCE (Before Common Era), Hippocrates wrote:

Eating alone will not keep a man well; he must also take exercise. For food and exercise, while possessing opposite qualities, yet work together to produce health…and it is necessary, as it appears, to discern the power of various exercises, both natural exercises and artificial, to know which of them tends to increase flesh and which to lessen it; and not only this, but also to proportion exercise to bulk of food, to the constitution of the patient, to the age of the individual.

PERSONAL TRAINING DEFINED

The profession of personal training is a relatively new field that continues to expand its boundaries and redefine itself. Prior to the early 1980s, no minimal requirements existed to qualify or identify a person as a personal trainer. People engaging in training was fairly uncommon. Many learned about training solely through personal experiences in the gym. Recognizing the need for standardization and credibility, Dr. Sal Arria and Dr. Frederick Hatfield pioneered a program of personal fitness training that merged gym experience with practical and applied sciences.

Today, a personal fitness trainer can be defined as a person who educates and trains clients in the performance of safe and appropriate exercises to effectively lead them to optimal health. Personal trainers can be self-employed (in-home and private) or work in health clubs, physicians' offices, physical therapy clinics, wellness centers, schools, hospitals, rehabilitation facilities, and private studios.

What a Personal Trainer Knows

As the industry continues to expand its boundaries and the realm of scientific knowledge concerning the human response and adaptation to exercise continues to grow, it is essential for personal trainers to be competent in the following topics and subjects:

- Exercise programming
- Exercise physiology
- Functional anatomy and **biomechanics**
- Fitness assessments
- Nutrition and supplementation
- Common **chronic diseases**
- Basic emergency and safety procedures
- Psychological and physiological challenges throughout the stages of life
- Human behavior and motivation

BIOMECHANICS: The study of the mechanical laws governing movement of living organisms.

CHRONIC DISEASES: Conditions lasting a year or more that limits daily activities and/or require ongoing medical attention.

Arguably, the science of motivation and changing behaviors are the most important aspects of a successful health and wellness program. However, many fitness professionals do not know enough about either to effectively help clients make lasting change.

A fitness professional's ability to educate and effectively draw clients into the fitness lifestyle and optimal health comes from a plan that is based in the aforementioned areas as well as the knowledge of muscular, cardiovascular, and metabolic adaptations. These adaptations

TRAINING EFFECT:
The body's adaptation to the learned and expected stress imposed by physical activity.

RESTING HEART RATE (RHR):
The measure of heart rate when completely at rest.

BLOOD PRESSURE:
The force of blood pushing against the walls of the arteries during the two phases of the cardiac cycle.

are known as the **training effect**. The training effect is the body's adaptation to the learned and expected stress imposed by physical activity. When the body experiences the training effect, it begins to change at the cellular level, allowing more energy to be released with less oxygen. The heart and capillaries become stronger and more dispersed to allow a more efficient flow of oxygen and nutrients. The muscles, tendons, and bones involved with this activity also strengthen to become more proficient. In time, the body releases unnecessary fat from its frame, and movements become more efficient. Additionally, **resting heart rate (RHR)** and **blood pressure** drop.

These adaptations can be achieved with the help of an educated trainer who can develop an appropriate fitness and health plan for most individuals. To be effective, this plan must account for the basic principles of fitness training: overload, specificity, individual differences, reversibility, periodization, rest, overtraining, and stimulus variability. The plan requires a thorough understanding of the major muscles of the body and how they work, as well as an understanding of metabolism—how the body converts food into other forms of energy. In addition, trainers must learn about the function and regulation of the lungs, heart, blood vessels, hormones, brain, and nerves at rest and during exercise. Once a fitness professional has the knowledge and support to develop comprehensive, individualized, and periodized plans that effectively produce the training effect, they can make a drastic impact on the lives and health of their clients.

THE CURRENT STATE OF HUMAN HEALTH

The US surgeon general's Physical Activity and Health report supports the role of physical activity for good health and disease prevention. The National Institutes of Health released a consensus statement on the importance of physical activity for cardiovascular health. In addition, the Centers for Disease Control and Prevention (CDC) launched the Healthy People initiative, which lists physical activity, fitness, and nutrition at the top of 22 priority areas. Finally, the American Heart Association included physical inactivity and low fitness levels, along with smoking, **hypertension**, and high cholesterol, as primary **risk factors** for disease.

HYPERTENSION:
High blood pressure measuring more than 140/90 mm Hg.

RISK FACTORS:
Variables associated with increased risk of disease or infection.

OBESITY:
An abnormal or excessive accumulation of bodyfat that may cause additional health risks.

Unfortunately, although the resounding benefits of physical activity and fitness are touted and reported, the United States is currently undergoing an **obesity** epidemic. In the United States, 25 to 35 percent of people remain sedentary (inactive). To make matters worse, federal resources and funding for physical activity programs have lagged far behind other aspects of health. Health and physical education in schools are low priorities, and when school districts are looking to trim their budgets, health and physical education programs are among the first expenditures to be reduced or cut altogether.

Each year in the United States, people spend more than $2.5 trillion on health care. This enormous figure translates into an expenditure of almost $7,000 for each member of the US population. Regrettably, this financial commitment has neither shown signs of abating nor produced satisfactory results with regard to treating a wide variety of chronic health problems.

Attempts to identify the factors that have been major contributors to this virtual epidemic of medical problems have produced a litany of probable reasons why such a large number of individuals are so apparently unhealthy, including poor eating habits, sedentary lifestyle, stress, and poor health habits (e.g., smoking). At the same time, a number of studies have been undertaken to identify what, if anything, can be done to diminish either the number or the severity of medical problems affecting the public. These studies have provided considerable evidence that exercise and increasing physical activity has substantial medicinal benefits for people of all ages.

PERSONAL TRAINING CLIENTELE

According to IHRSA, as of 2019, health club memberships are projected to reach 230 million worldwide by the year 2030, and health club memberships among children under 18 years of age have increased by 187 percent since 1987. The number of people considering personal training services continues to grow. According to IHRSA's annual Health Club Consumer Report (2019), 52.9 million Americans aged 6 years and older are members of health clubs. Over 12 percent of these members pay for the services of a personal trainer, and over 6 million health club members alone paid for a personal trainer this past year. In-home sessions, park boot camp sessions, and other nontraditional training sessions were not included in the gym data.

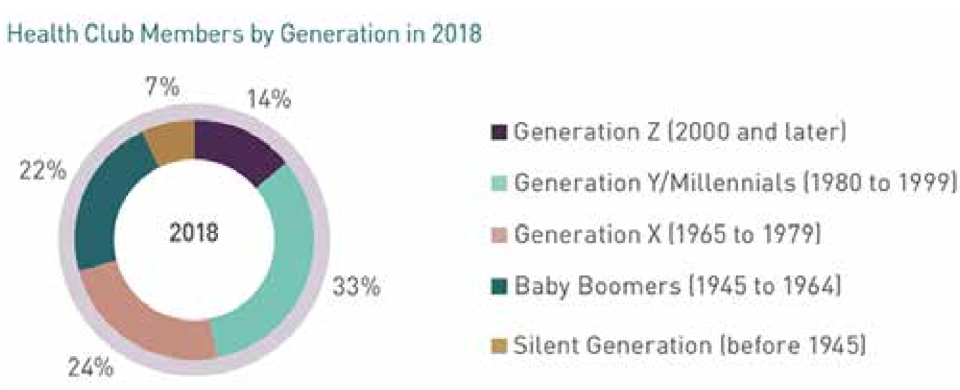


Figure 1.1 Health Club Members by Generation (IHRSA, 2019)

Here are some statistics from the report:

- Three out of five personal training clients are women.
- Clients report an average of 18 sessions with a trainer.
- The average personal trainer charges between $15 and $100 per hour—with the average being $50 per hour.
- The average number of training sessions used in 12 months breaks down as follows:

SESSIONS	PERCENTAGE
1-6 sessions	47 percent
7-11 sessions	12 percent
12-24 sessions	11 percent
25-49 sessions	8 percent
50+ sessions	11 percent
Not reported	11 percent

- The number of training sessions clients of different ages used break down as follows:

AGE RANGE	SESSIONS
6-11 years old	22 sessions
12-17 years old	26 sessions
18-34 years old	15 sessions
35-54 years old	14 sessions
55+ years old	24 sessions

These statistics support the growing trend and need for personal training services. While those 6 million people who purchased personal training services are sold on the need for personal training, there are many millions more who do not know or understand the benefits of hiring a personal trainer regardless of their health and fitness goals. This population represents the greatest opportunity for growth and income for fitness professionals.

BENEFITS OF PERSONAL TRAINING

Two of the most widely publicized efforts to investigate the possible relationship between exercise and disease were longitudinal studies, each of which involved more than 10,000 subjects. In a renowned study of 17,000 Harvard graduates, Dr. Ralph Paffenbarger found that men who expended approximately 300 calories a day (the equivalent of walking briskly for 45 minutes) reduced their death rates from all causes by an extraordinary 28 percent and lived an average of more than two years longer than their sedentary classmates. Another study conducted by Dr. Steven Blair of the Cooper Institute for Aerobics Research in Dallas documented the fact that a relatively modest amount of exercise has a significant effect on the mortality rates of both men and women. The higher the fitness level, the lower the death rate (after the data was adjusted for age differences between the 13,344 subjects in this eight-year investigation). An analysis of the extensive data yielded by both studies suggests one inescapable conclusion: exercise is medicine!

Accepting the premise that regular exercise can play a key role in reducing the risk of medical problems and decreasing health care costs is critical. Despite the vast number of individuals who lead a sedentary lifestyle, the need for and the value of exercising on a regular basis is an irrefutable fact of life (and death). For example, after a detailed review of the results of his long-term investigation, Dr. Paffenbarger concluded that not exercising had the equivalent impact on a person's health as smoking one and a half packs of cigarettes a day. Fortunately, with few exceptions, most people are too sensible to ever consider ravaging their health by smoking excessively. Unfortunately, many of these same people fail to recognize the extraordinary benefits of exercise in the prevention of medical problems.

Any list of the medical problems and health-related conditions that can be at least partially treated and controlled by exercise would be extensive. Exploring the most significant of these health concerns, here are details on how exercise is thought to help alleviate each condition:

- **Allergies:** Exercise is one of the body's most efficient ways to control nasal congestion (and the accompanying discomfort of restricted nasal blood flow).
- **Angina:** Regular aerobic exercise dilates blood vessels, increasing blood flow and thereby improving the body's ability to extract oxygen from the bloodstream.
- **Anxiety:** Exercise triggers the release of mood-altering chemicals in the brain.
- **Arthritis:** By forcing a skeletal **joint** to move, exercise induces the manufacture of synovial fluid (fluid found in the cavities of synovial joints), helps to distribute it over the **cartilage**, and forces it to circulate throughout the joint space.
- **Back pain:** Exercise helps to strengthen the abdominal muscles, the lower back extensor muscles, and the hamstring muscles (muscles in the upper back of the leg).
- **Bursitis and tendinitis:** Exercise can strengthen the **tendons**, enabling them to handle greater loads without being injured.
- **Cancer:** Exercise may be an effective intervention for improving the quality of life for those with or recovering from cancer.
- **Carpal tunnel syndrome:** Exercise helps build up the muscles in the wrists and forearms, thereby reducing the stress on arms, elbows, and hands.
- **Cholesterol:** Exercise helps to raise HDL (high-density lipoprotein, the "good" cholesterol) levels in the blood and lower LDL (low-density lipoprotein, the "bad" cholesterol) levels.
- **Depression:** Exercise helps speed **metabolism** and deliver more oxygen to the brain; the improved level of circulation in the brain tends to enhance mood.
- **Diabetes:** Exercise helps lower blood sugar levels, strengthen the skeletal muscles and heart, improve circulation, and reduce stress.
- **Fatigue:** Exercise can help alleviate the fatigue-causing effects of stress, poor circulation and blood oxygenation, bad posture, and poor breathing habits.
- **Glaucoma:** Exercise helps relieve intraocular hypertension (the pressure buildup on the eyeball that heralds the onset of glaucoma).
- **Headaches:** Exercise helps force the brain to secrete more of the body's opiate-like, pain-dampening chemicals (e.g., endorphins and enkephalins).

JOINT:
An articulation between two bones in the body.

CARTILAGE:
Firm, flexible connective tissue that pads and protects joints and structural components of the body.

TENDONS:
Strong, fibrous cords made of collagen that attach muscle to bone.

METABOLISM:
All of the chemical processes that occur in the body to support life including converting food into energy.

DIABETES:
A condition characterized by an elevated level of glucose in the blood.

- **Heart disease:** Exercise helps promote many changes—a decrease in body fat, a decrease in LDL cholesterol, an increase in the efficiency of the heart and lungs, a decrease in blood pressure, and a lowered heart rate—that collectively lower the risk of **heart disease**.
- **High blood pressure:** Exercise reduces the level of stress-related chemicals in the bloodstream that constrict arteries and veins, increases the release of endorphins, raises the level of HDL in the bloodstream, lowers resting heart rate (over time), improves the responsiveness of blood vessels (over time), and helps reduce blood pressure through maintenance of body weight.
- **Knee problems:** Exercise helps strengthen the structures attendant to the knee (muscles, tendons, and **ligaments**), thereby facilitating the ability of the knee to withstand stress.
- **Lung disease:** Exercise helps strengthen the muscles associated with breathing and helps boost the oxygen level in the blood.
- **Memory problems:** Exercise helps to improve cognitive ability by increasing the blood and oxygen flow to the brain.
- **Menstrual problems:** Exercise helps to control the hormonal imbalances often associated with premenstrual syndrome (PMS) by increasing the release of beta-endorphins.
- **Osteoporosis (fragile bones):** Exercise promotes bone density, thereby lowering an individual's risk of experiencing a bone fracture.

HEART DISEASE:
A term used to describe several different heart conditions.

LIGAMENTS:
Short bands of tough but flexible fibrous connective tissue connecting two bones or cartilages or holding together a joint.

THE FUTURE OF PERSONAL TRAINING AND FITNESS

The need for personal training services continues to grow. It is imperative that fitness professionals keep up with the evolving recommendations for health and physical fitness that have a direct application for fitness programs and exercise recommendations. With the emergence of the latest technologies, information regarding health and fitness is easily accessible. However, because of the plethora of confusing and conflicting health and fitness recommendations available, it is important that fitness professionals work to help clients, friends, and family members simplify the science, identify credible resources, and navigate the numerous fitness and nutrition myths.

As individuals who are committed to a long-term career in health and fitness, personal trainers will continue expanding their knowledge through additional courses in corrective exercise, corporate wellness, youth fitness, senior fitness, nutrition, and pre- and postnatal specializations to better serve their clients in achieving and living the fitness lifestyle. This lifelong commitment to learning is also reflected in the personal training recertification requirements that remain a standard in the industry. Individually and collectively, personal trainers have an inherent responsibility to positively influence and guide the health and fitness attitudes of those around them.

ISSA CERTIFIED PERSONAL TRAINER CODE OF ETHICS

Upon receipt of the ISSA certificate, members effectively become representatives of a leader in the fitness certification industry and thus are expected to conduct themselves according to the highest standards of honor, ethics, and professional behavior at all times. These principles are intended to aid ISSA members in their goal to provide the highest quality of service possible to their clients and the community.

Requirements for Certification

1. Certification will not be issued to any student/member/candidate who does not successfully complete or meet all pertinent qualifications or has not achieved passing scores on the relevant ISSA examinations.
2. Certification will not be issued to any student/member/candidate unless they have successfully completed a **cardiopulmonary resuscitation (CPR)** and **automated external defibrillator (AED)** certification as evidenced by a current and valid CPR/AED card.

Code of Ethics

1. The ISSA certified fitness professional shall maintain a professional client-trainer relationship at all times. Fitness professionals have the obligation to properly assess clients, program for their needs, and provide health care referrals as needed for the best interest of the client. They must respect the client's choices and decisions regarding their own health and provide accurate, factual information. They shall not misrepresent their education or credential(s) or work outside of their scope of practice.
2. The ISSA certified fitness professional shall not discriminate on the basis of sex, gender, race, religion, national origin, color, or any other basis deemed illegal.
3. The ISSA certified fitness professional shall maintain any and all primary and supplementary certifications (including CPR certification as required) that are necessary to execute their job. They will not misrepresent their status in regard to certification or qualification to ISSA, clients, or an employer.
4. The ISSA certified fitness professional shall uphold their social responsibility to promote inclusion and educate and inform within the scope of practice.
5. The ISSA certified fitness professional shall use their best judgment to maintain a safe training environment for clients. This includes the space being used and the movements being executed. At no time shall harm to others be intended.

CARDIOPULMONARY RESUSCITATION (CPR): An emergency procedure involving chest compressions and, often, artificial ventilation to circulate blood and preserve brain function in an individual in cardiac arrest.

AUTOMATED EXTERNAL DEFIBRILLATOR (AED): A portable electronic device that can identify and electrically correct heart arrythmias, ventricular fibrillation, and tachycardia.

CHAPTER 02

PSYCHOLOGY OF BEHAVIOR CHANGE

LEARNING OBJECTIVES

1 | Define behavior and behavior change.

2 | Explain the purpose of the stages of change and how they are applicable in fitness and wellness.

3 | Define motivation, the self-determination theory, and motivational interviewing.

4 | Describe the components of a SMART goal.

5 | Explain the scope of practice for psychology and behavior change for a personal trainer.

There are infinite reasons why individuals hire a personal trainer. The commonality, though, is that they have acknowledged that they want, or need, to improve their health or physical fitness. In other words, the client wants to change their current state to a more desirable state. The change sought by the client may be self-motivated, or perhaps it is a change directed by a medical professional (e.g., the client's doctor told them they need to increase their exercise level to manage their weight, lower their cholesterol levels, or decrease their risk for diabetes). Whatever the change needed and the reason for the change, the personal trainer will play a critical role. The client is hiring a personal trainer because they need help initiating the change, reinforcing the change, and maintaining the necessary behavior changes to reach their health and fitness goals.

It is well understood that personal trainers need to be experts on physical and physiological factors related to health and fitness. The success of a personal trainer, however, does not hinge on their knowledge and skill regarding physiological principles alone. For example, a trainer can design a quality training plan and be highly skilled in teaching and coaching techniques. But what happens if the client is lacking the motivation to engage in, and follow through with, the training plan? Success, such as the client's progress toward and achievement of their desired goal, will largely depend on the client's readiness and motivation to make the necessary changes. Therefore, another critical skill set for personal trainers is to understand the psychology of behavior change and be able to apply its principles to support their clients through the behavior change process.

BEHAVIOR CHANGE

Before discussing behavior change, it is important to first understand what is meant by the term "behavior." Simply put, a **behavior** is an action that can be observed, measured, and modified. Behavior can be further defined based on its context. For example, physical activity behavior is often defined as the movement of the body that requires energy expenditure, whereas exercise behavior is often defined as movements or actions that are planned and executed routinely for the purpose of increasing physical fitness. Within a client's health and fitness goals, there can be several behaviors that impact goal progress and achievement. Furthermore, some behaviors overlap to influence other potential behavioral targets.

BEHAVIOR:
An action that can be observed, measured, and modified.

For example, lack of sufficient sleep can influence a person's health, such as the increased risk of obesity, **type 2 diabetes**, and high blood pressure. Behaviors that can improve sleep include nutritional aspects (e.g., avoiding caffeine and high-caloric intake before bedtime) and exercise (e.g., daily physical activity can improve the onset of sleep).

TYPE 2 DIABETES:
A long-term metabolic disorder that is characterized by high blood sugar, insulin resistance, and relative lack of insulin.

SELECTING THE TARGET BEHAVIOR

Identifying the target behavior is the foundational step in the behavior change process. Based on the initial intake and assessment, the personal trainer and client can discuss which behavior(s) ought to be made the priority focus. Behavior change takes effort, energy, and time. Therefore, even if many of the client's current behaviors need to be adjusted, it is important to narrow the focus to just a few at a time so that the client is not overwhelmed. The decision of which behaviors to target first ought to be based on the impact that the behavior has in progressing the client from their current state to their desired state. Once the target behavior(s) are selected by the personal trainer and client, then the trainer can guide the client through a systematic goal-setting process, which will be discussed later in this chapter.

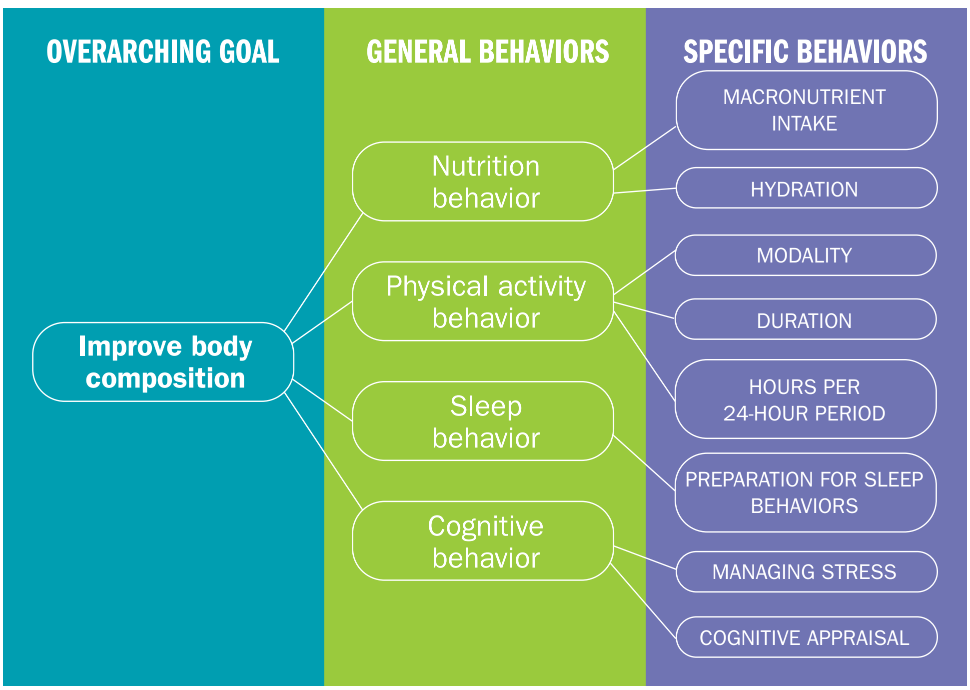


Figure 2.1 The Impact of Behavior on Health Goals

INFLUENCES ON BEHAVIOR

There are multiple influences on a person's behavior such as internal stimuli (i.e., a person's conscious and unconscious self-talk), external stimuli (i.e., environmental cues and triggers), and cultural or societal norms, to name a few. Thus, behavior change is a complex process that requires a skillful and multimodal approach. One of the most popular models of behavior change adopted by practitioners within the field of health and fitness is the **transtheoretical model (TTM)**.

TRANSTHEORETICAL MODEL (TTM):
A behavior change model focused on the stages of change, the process of changing behavior, self-efficacy, and the decision balance.

The TTM is a multifaceted framework that encompasses four key distinct but interrelated constructs:

1. Stages of change (i.e., a person's stage of readiness to engage in the healthier/ desired behavior)
2. Processes of change (i.e., the factors influencing how a person transitions from one stage to another)
3. **Self-efficacy** (i.e., the person's belief in their capability to enact the goal behavior)
4. Decisional balance (i.e., determination of whether the person deems the change process worth pursuing)

SELF-EFFICACY:
The certainty of one's ability to accomplish a particular task.

According to the TTM and the supporting research, satisfying the conditions within each of these four constructs is required for a client to make progress through the behavior change process.

To effectively help a fitness client make lifestyle changes that support their goals and promote longevity, a personal trainer should be able to:

- Determine their client's stage of change and identify the next steps to support healthy behavior change
- Understand the three underlying components of self-determined behavior to support program design and training session execution
- Use the **motivational interviewing (MI)** technique to foster internal motivation
- Use the tool of goal setting most effectively

MOTIVATIONAL INTERVIEWING (MI):
A collaborative, client-focused method of guiding a client toward a self-identified motivation for change.

STAGES OF CHANGE:
The series of temporal stages of readiness that a person progresses through during the behavior change process.

STAGES OF CHANGE

Behavior change is not an isolated event that happens all at once; it is a dynamic process that unfolds over time. According to the TTM, behavior change involves progressing through a series of stages. The five **stages of change** include pre-contemplation, contemplation, preparation, action, and maintenance. Individuals typically do not move through the stages in a linear fashion; instead, they tend to follow a cyclical path. That is, an individual may progress and regress through the various stages. Furthermore, an individual can spend weeks to months in any given stage. Just as a personal trainer must take inventory of a client's physical developmental needs, a trainer must also take inventory of their client's needs within the behavior change process.

This begins with identifying which stage of change the client is in. Although there are self-assessments (i.e., questionnaires) that exist to assess an individual's readiness to change, one of the best ways for personal trainers to determine the client's stage is through a personal interview. In this manner, personal trainers can meet with clients in a safe and private space to ask questions of their client for the purpose of evaluating information that may indicate their readiness to change.

Table 2.1 Stages of Change

STAGE OF CHANGE	DESCRIPTION	KEY INDICATORS
Pre-contemplation	In denial, or ignorant, that a change is necessary, possible, or worth the effort within the next six months	Lacks the belief they could change (quit a behavior or start a behavior), even if they wanted to Perceives no control over their behavior (e.g., resigned to their current state) Defeated by failed prior attempts to change
Contemplation	Contemplate making a change in the next six months but reluctant to commit	Aware of potential benefits of making a change but perceive the costs (e.g., time, effort, sacrifices) outweighing the benefits Procrastinating making efforts toward the behavior change
Preparation	Committed to make a change in the target behavior within 30 days; engages in preparation activities	Begins to take small steps toward the target behavior change (e.g., buys exercise apparel or equipment, signs up for a gym membership, collects information, initiates the hire of a personal trainer)
Action	Engaged in changed behavior for less than six months; new behavior is not fully stabilized	Actively doing things to change or modify behavior Structures their environment in ways that support their healthy behavior (e.g., avoids temptations that trigger the undesirable behavior)
Maintenance	Sustaining their new, healthy behavior for more than six months	New behavior becomes second nature Greater confidence in ability to maintain the new behavior Greater sense of control over their behavior

TEST TIP!

A personal trainer can use these client cues to help identify a client's stage of change.

STAGE	DESCRIPTION	CLIENT CUE(S)
Pre-contemplation	Not ready for change	"I won't." "I can't in the next six months."
Contemplation	Thinking about changing	"I may in the next six months."
Preparation	Preparing to make a change	"I will in the next month."
Action	Taking action to change	"I'm doing ____ now."
Maintenance	Maintaining positive behaviors	"I've been doing ____ for at least six months."

PROCESSES OF CHANGE

PROCESSES OF CHANGE: The strategies and techniques that can influence an individual's transition from one stage of change to the next.

According to the TTM, there are 10 **processes of change** (i.e., strategies and techniques) that can influence an individual's transition from one stage to the next. Personal trainers can use the processes of change to support the client's advancement through the stages and stabilize the behavior once the client reaches the maintenance stage. The processes are broken down into two categories: experiential and behavioral. Experiential processes influence behavior indirectly by focusing on the thoughts, perceptions, or feelings that an individual might have about the target behavior. Experiential processes include consciousness-raising, dramatic relief, self-reevaluation, environmental reevaluation, and social liberation.

Behavioral processes of change focus on active strategies and influence behavior directly by manipulating environmental, social, or situational cues to encourage the desired behavior. Behavioral processes of change include self-liberation, helping relationships, counterconditioning, reinforcement management, and stimulus control.

Table 2.2 The Experiential Process of Change

EXPERIENTIAL PROCESSES OF CHANGE	DESCRIPTION	PRACTICAL SUGGESTIONS
Consciousness-raising	**Getting the facts.** Increasing information about self and of the unhealthy, undesired behavior (current state of behavior) and/or their potential new behavior	Providing factual information and data relevant to the client's current behavior and target behavior
Dramatic relief	**Invoking emotions.** Experiencing and expressing emotional reactions to the idea of continuing the unhealthy behavior (e.g., staying the same) and to the idea of initiating a change (e.g., enacting the healthy behavior)	Using MI techniques to engage the client's emotions (e.g., engaging in supportive, empathetic listening to allow clients to express emotions without judgment or insinuating a need for them to stop or change the emotion)
Self-reevaluation	**Creating a new self-image.** Rethinking one's self-image to include the possibility of a successful behavior change	Helping clients clarify their core values, identifying healthy role models, and visualizing oneself reaching and maintaining the desired behavior change
Environmental reevaluation	**Realizing the effect on others.** Reflecting on how one's current behavior affects the physical environment and people around them to include those they care about	Asking the client to reflect on how their behaviors are impacting others around them; asking the client to consider another person's perspective on the impact of their behavior (e.g., increase empathy)
Social liberation	**Noticing societal acceptance.** Increasing awareness of how the healthy, desired behavior is supported by society	Helping clients realize how the desired, healthier behavior is valued within their social communities and society at large; helping bridge the client's motivational need of a sense of connectedness to others who actively engage in the target behavior, such as societal role models and/or people within the client's social circle

Table 2.3 The Behavioral Process of Change

BEHAVIORAL PROCESSES OF CHANGE	DESCRIPTION	PRACTICAL SUGGESTIONS
Self-liberation	**Committing with confidence.** Committing to take action with the belief that change is possible	Ensuring the training program/intervention accounts for motivational needs of autonomy and competence; for example, enhancing autonomy by providing multiple choices or options within the behavior change plan, and enhancing competence by engaging in self-efficacy strategies (e.g., vicarious experience—sharing relevant examples of success and testimonies of relatable individuals)
Helping relationships	**Generating social support.** Establishing relationships where one feels safe to share personal challenges and receive support such as encouragement and guidance	Helping clients connect to social groups or individuals with similar goals and values, virtually and/or in-person; encouraging clients to recruit accountability partners or small support groups
Counterconditioning	**Making substitutions.** Finding healthier alternatives for unhealthy behaviors	Helping clients identify healthier behaviors that can be substituted for less healthy or problem behaviors
Reinforcement management	**Using rewards and feedback.** Using rewards and feedback strategically to reinforce positive behavior and acting on one's values	Helping clients create a plan to celebrate small and big successes, such as using rewards for accomplishing short-term goals; providing feedback and positive reinforcement when client engages in positive behaviors; teaching clients to capitalize on self-monitoring techniques (e.g., smart apps, journaling)
Stimulus control	**Managing the environment.** Avoiding stimuli that trigger the unhealthy behavior and intentionally creating cues that trigger the healthy behavior	Helping clients identify purposeful cues in their environment to trigger the healthy, desired behavior (e.g., creating implementation intentions); helping clients identify ways to restructure their environment to remove or overcome stimuli that trigger the unhealthy, undesired behavior

How can a personal trainer determine which process(es) will have the greatest impact on the client's progress? Research is mixed on which processes may be most impactful at specific stages. For example, experiential processes have been found most effective in the early stages of change for individuals who are quitting unhealthy behaviors (e.g., smoking cessation), whereas behavioral processes have been strongly associated with enhancing healthy behaviors, such as increasing physical activity.

Furthermore, current research has indicated that using both experiential and behavioral processes of change may be most beneficial for increasing levels of moderate physical activity. The bottom line is that there is no one-size-fits-all approach. The most effective process of change at any given time (e.g., stage of change) will depend upon both the target behavior and the individual.

To select processes of change that are most relevant for the individual client, a personal trainer should consider the key barriers, concerns, and challenges that clients have communicated in regard to making the desired (or prescribed) behavior change. If a personal trainer encounters a client whose predominant barriers to committing to the behavior change stem from the way they think, feel, or perceive the behavior or their ability to successfully change their behavior, then the most effective processes to help the client progress may be experiential processes.

On the other hand, if a personal trainer encounters a client whose primary challenges are related to the client's environment, choices, or habitual responses, then the personal trainer may find that behavioral-based processes will be most effective in aiding the client's progress.

It is possible for an individual to relapse during the behavior change process and revert to an earlier stage. If this happens, supportive behaviors of a personal trainer include helping the client to effectively cope with the consequences. Also, personal trainers can help the client to reflect on the lessons learned through the experience and emphasize the growth as a result of the lessons learned. Lastly, the personal trainer can help the client determine what to do next, along with how to implement the lessons learned into their way forward.

Although there is much to consider regarding behavior change and each of the stages, there is a need to make sure the client is able to effectively navigate the stage they are currently experiencing. To best help the client, the personal trainer ought to be aware of strategies to support the client's motivation. Building upon the theme of getting to know the client, listening to the client, and having a lens of meeting their needs, the motivation strategies that will be discussed in this next section are focused on helping the client find the motivation for change within themselves.

MOTIVATIONAL THEORIES AND APPLICATIONS

It is no secret that motivation is a key ingredient to accomplishing one's goals. Therefore, an ideal client is one who is self-motivated. The self-motivated client follows the training plan to a T and shows up to each training session ready to work and give it all they've got. This, however, is more the exception than the norm. Therefore, personal trainers ought to be equipped with the knowledge, skills, and strategies to help clients acquire the motivation necessary to make positive behavior changes and achieve their personal goals.

Effectively motivating people to do what needs to be done to accomplish the goal is a common challenge for individuals in leadership positions, such as personal trainers, coaches, teachers, and businesspeople alike. Most leaders know that the carrot-and-stick approach (e.g., providing rewards or issuing punishment) doesn't produce lasting change but instead is a short-term strategy that requires constant work and attention on the leader's part. The quest to determine what motivates people, or how to better motivate clients, can be addressed by focusing on the basic psychological needs of humans and drawing upon the internal motivation of the clients. Therefore, this section will cover two theories regarding motivation: **self-determination theory (SDT)** and MI.

SELF-DETERMINATION THEORY (SDT):
A general theory of human motivation that suggests a person is motivated to change by three basic psychological needs of autonomy, competence, and relatedness.

MOTIVATION:
The reason(s) one has for behaving in a certain way.

INTRINSIC MOTIVATION:
The drive to execute behaviors that are driven by internal or personal rewards.

EXTRINSIC MOTIVATION:
The drive to perform certain behaviors based on external factors such as praise, recognition, and money.

FUNDAMENTALS OF MOTIVATION

Motivation includes two key components: direction of effort and intensity of effort. Direction is what a person is drawn to or trying to achieve, such as the target behavior. Intensity is the amount of energy and effort put forth toward the target.

When a person participates in a task or activity because they find it inherently enjoyable, then it is referred to as **intrinsic motivation**. For instance, someone who loves to run may engage in the activity for no other reason (e.g., weight management, aerobic fitness) other than because the person simply enjoys doing it. Unfortunately, intrinsic motivation toward healthy behaviors is not the case for all people. Many people will require **extrinsic motivation**—motivation to behave in a specific way that is driven by external factors such as recognition, money, or praise. For this precise reason, it can be difficult for a person to change from unhealthy behaviors to healthier ones because it requires a person to actively seek out and draw upon other sources of motivation.

Figure 2.2 Intrinsic and Extrinsic Motivation

Motivation can come from a variety of sources. It can come from external factors, such as listening to pump-up music, earning a reward, or hearing an inspiring pep talk. Motivation can also come from internal factors, such as one's core values and beliefs, basic human needs, and self-identity. Although external motivation (e.g., the carrot-and-stick approach) can be effective in the short term, fostering an internal motivation is much more effective when it comes to the lasting motivation required for successful behavior change.

SELF-DETERMINATION THEORY

Just as humans have basic biological needs such as oxygen, sleep, clean water, and nutrition, humans also have basic psychological needs. According to the *SDT*, there are three innate and universal psychological needs, which include autonomy, relatedness, and competence. Each plays an important role in a person's motivation, well-being, and life satisfaction. This section will review each component with particular emphasis placed on practical ways a personal trainer can incorporate each psychological need into the training environment and program design.

Table 2.4 Basic Psychological Needs

PSYCHOLOGICAL NEED	DESCRIPTION
Autonomy	The basic need to feel in control of one's own behavior and goals
Competence	The basic need to feel effective and capable in one's actions
Relatedness	The basic need to feel a sense of belonging and connection to others

Autonomy

AUTONOMY:
The need for self-governance and control over one's own behaviors.

Autonomy is the need to feel in control of one's own behavior and goals. Autonomy can also be described as a need for self-governance. An individual feels a sense of autonomy when they are given the opportunity to make choices and take actions in line with their interests and values. When autonomy is satisfied, a client is more likely to engage in the activity wholeheartedly rather than simply go through the motions.

TEST TIP!

Autonomy is important for most fitness clients! A personal trainer will educate clients during their training with the goal of giving them the autonomy to exercise and remain active and healthy on their own.

For example, a personal trainer can teach a client how to properly do a squat and help them make better nutritional choices.

Autonomy support from the trainer begins with the program design. Based on the client's goals, a personal trainer uses their expertise to create a solid training framework. Rather than dictating the client's behaviors within the plan and expecting compliance, a personal trainer ought to incorporate autonomy-supportive behaviors such as seeking input from the client. For example, a trainer may offer the client to select which specific exercises they prefer to do from a list of options. This approach can help strengthen the client's commitment to the plan and promote adherence.

Table 2.5 Autonomy-Supportive Behaviors

AUTONOMY-SUPPORTIVE BEHAVIOR	PRACTICAL EXAMPLES
Minimizing pressure	• Helping the client minimize self-imposed pressure (e.g., focusing on process-oriented goals over outcome goals) • Helping the client cope with perceived pressure from others (e.g., family member, sports coach, physician) • Setting and communicating realistic expectations of the client
Avoiding controlling behavior	• Coaching the client to be an active participant in the goal-setting process • Avoiding the use of “guilt” or “shame” as a tool to motivate behavior • Minimizing the use of external rewards
Acknowledging the client’s feelings	• Allowing the client to express their emotions or feelings • Listening with empathy and acceptance • Validating their feelings

A personal trainer may work with some clients who did not voluntarily sign up for training. In other words, some clients may feel they are not given a choice in the targeted behavior change. For example, a youth client may be participating in the training sessions due to parental force, or an adult client may be participating in training sessions because of their doctor’s orders. In these situations, it is even more important that trainers allow the client to be involved in the decision-making process whenever possible.

TRAINER TIP!

Scenario: Autonomy-support in action

Instructions: The trainer should read the scenario that pertains to implementing autonomy within a personal training session. Then, the personal trainer should consider possible actions to take if faced with the situation and how the different actions could impact the client's motivation in the moment, as well as over the long run.

Scenario: Sue, the client, has set a goal to be able to accomplish 10 strict pull-ups by the time she turns 30, which is in 12 weeks. She currently can do five strict pull-ups. Sue and her personal trainer, Coach Molly, have developed a training program that incorporates pull-ups twice a week into her strength training regimen. Sue shows up for her training session with Coach Molly and says that she does not want to do pull-ups, even though it is on the training plan for the day. What should Coach Molly do? How can Coach Molly ensure Sue makes progress toward her goal while also honoring Sue's need for autonomy?

Possible solutions: There is no one-size-fits-all solution to this scenario. The best solution will depend upon many factors such as the trainer-client relationship and the trainer knowing when and how to push their client past their comfort zones and when to adjust plans to accommodate the client's requests. In this scenario, Coach Molly engaged Sue in conversation about her resistance to do pull-ups. Coach Molly asked why Sue was not wanting to do them on this particular day, showed empathy, and then gave Sue some alternative exercises to choose from that could target the same muscle groups and keep Sue on track for progressing toward her goal of 10 strict pull-ups. Fundamentally, the key for personal trainers is to care for the client and let their voice be heard. Allowing the client a greater sense of control over their actions can lead to more enjoyment and satisfaction and sustain motivation over time.

Competence

COMPETENCE:
The basic need to feel a sense of mastery and operate effectively within the environment.

Competence is the need to feel effective when operating within the environment. Clients will be more motivated to take actions that help them achieve their goals if they believe they have the knowledge, skills, and abilities for success. Lack of perceived competence can impact the behavior change process by decreasing motivation.

For example, some clients who are new to exercise may feel intimidated to go to the gym. It can be uncomfortable to be in a new environment and not know what to do or not feel capable of performing the exercises correctly. Perhaps of all three of the basic psychological needs, personal trainers are most familiar with and best trained for supporting the need for competence. A standard expectation of the personal trainer is to help the client develop their competence in health-related behaviors. Even still, there is more to it than teaching proper form or developing a program that leads to health and fitness improvements.

There can sometimes be a discrepancy between the client's actual (i.e., demonstrated and measured) competence and the client's perceived competence. For instance, a client may have the physical skill to perform an exercise such as the hang clean, but they may not have the confidence in their ability to perform the hang clean. Although personal trainers are not expected to engage in psychological skills coaching with the client, it is within the scope of practice for trainers to help clients realize their actual potential and become more self-aware of their actual abilities. The perceived competence can be conditioned through consistent and specific positive feedback and asking the client to self-identify what they did well.

Table 2.6 Competence-Supportive Behaviors

COMPETENCE-SUPPORTIVE BEHAVIOR	PRACTICAL EXAMPLES
Providing structure and routine	• Being consistent with the structure and routine of training sessions so clients know what to expect • Encouraging clients to adopt routines into their exercise regimen
Providing the optimal level of challenge	• Matching skill level with task difficulty to provide opportunities for success • Encouraging performance goals that are challenging yet feasible • Breaking down complex movements into manageable parts
Providing the opportunity to learn and master new skills	• Teaching proper physical technique (e.g., strength training exercises, running, stretching) • Teaching proper mental techniques (e.g., where to focus or what to focus on, how to cope with failed reps)
Providing feedback	• Providing constructive and informative feedback when correcting behavior • Providing effective praise to reinforce positive behaviors

Competence is closely related to the concept of self-efficacy, which is the certainty of one's ability to accomplish a particular task. Self-efficacy is one of the four constructs within the TTM. There is a subtle difference, though, between self-efficacy as described in the TTM and competence as described by the SDT. Self-efficacy represents acquired or learned cognitions pertaining to the belief in one's ability to accomplish specific future tasks, whereas the need for competence represents an innate motive for behavior pertaining to a more general experience. Simply put, self-efficacy can be trained by targeting one's cognitions (or perceptions), but competence is a need that is met by personal trainers engaging in competence-supportive behaviors.

Relatedness

RELATEDNESS:
The need to feel connected to and supported by others as well as a sense of belonging within a group.

Relatedness is the need to feel connected to and supported by others, as well as a sense of belonging within a group or community. In the context of exercise and health behavior, the need for relatedness is often overshadowed by the need for autonomy and competence; however, research has demonstrated that there is a positive association between relatedness and exercise behavior. For real-world examples, one may consider two leading exercise modalities within the fitness industry, CrossFit and Peloton. Both fitness regimens capitalize on connectedness, community, and a sense of belonging. Satisfying the innate need for relatedness should not be overlooked.

Personal trainers are typically hired because of the value they bring to the client's goal pursuit; however, trainers who appreciate the value added by the client will more fully satisfy the client's need for relatedness. A client's sense of belonging can be amplified when they feel they have something to contribute to the relationship or group.

Enhancing your effectiveness as a trainer relies on consistent learning and growth. Clients can often be the trainer's best teacher. For example, clients can provide feedback as to what elements of the training session or program worked well for them and what didn't. Clients may also suggest creative solutions to behavior change challenges that a trainer hadn't thought of before. Lastly, clients can offer their professional and life experiences to their personal trainer, which can facilitate the trainer's personal and professional growth. Acknowledging that value can be added by both the trainer and the client to enrich the working relationship.

Table 2.7 Relatedness-Supportive Behaviors

RELATEDNESS-SUPPORTIVE BEHAVIOR	PRACTICAL EXAMPLES
Allowing for meaningful interpersonal interactions	• Building rapport with the client; getting to know one another within professional bounds • Allowing for informal socialization between clients or between client and trainer before and after the workout • Introducing the client to others (i.e., gym staff members, other clients)
Promoting positive emotions to strengthen connections	• Starting and ending each session with a positive tone • Making training sessions "fun" • Engaging with a sense of humor
Promoting camaraderie and cohesion	• Encouraging clients to join social groups (social media or in-person at the gym or within the community) that support the target behavior or relate to the client's goals and values • Avoiding making social comparisons; using competitive tactics sparingly
Engaging in effective communication	• Providing positive feedback • Clearly communicating expectations and boundaries • Using active listening

Although the innate psychological needs outlined by the SDT are each unique, they are not mutually exclusive. For instance, personal trainers who engage in autonomy-supportive behaviors will likely also tap into the client's need for relatedness. Additionally, allowing the client to share about areas in their lives, of which they have high levels of competence, can be a motivating factor for the client to adhere to the training schedule and attend their training sessions. People are motivated when they feel and can express their competence.

MOTIVATIONAL INTERVIEWING

Each client has unique personalities, experiences, and circumstances that influence their motivation for change, specifically their progress through the stages of change (e.g., pre-contemplation to contemplation to preparation to action to maintenance). An effective method for personal trainers, then, is to help the client discover the unique motivation that lies within them. This can be done by using the MI method.

Motivational Interviewing is a collaborative, client-focused method of guiding a client toward a self-identified motivation for change. The underlying aim of MI is to elicit the client's own change talk. Change talk is self-motivating speech; it is the verbal expression of one's desire for change, ability to change, or reasons one needs to change. Through appropriate questioning and listening, trainers then work to reinforce the client's own arguments and motivations for initiating, or progressing through, the behavior change. The **OARS model**, which includes four communication skills or techniques, provides tangible actions that trainers can take to increase MI effectiveness. This model supports a communication style that can increase motivation as well as build the client-trainer relationship known as **rapport**.

OARS MODEL:
A communication model for motivational interviewing that includes open-ended questions, affirmations, reflective listening, and summarizing.

RAPPORT:
A close, harmonious relationship in which all parties involved understand one another's feelings and communicate well.

Table 2.8 The OARS Model

TECHNIQUE	HOW TO	EXAMPLE
O: Open-ended questions	Using "what" or "how" questions instead of "why" questions to gain clarifying information and avoid the client responding with justification for behavior	"How important is it for you to make a change?"
A: Affirmations	Affirming a personal strength or ability of the client; affirming what the client has already done or done well	"I am so glad you came to the gym today—it isn't always easy to prioritize your health."
R: Reflective listening	Listening with the intent to understand, observe client body language and behavior, and offer a reflection of what was said	"You're feeling upset because you didn't achieve your nutrition goals last week."
S: Summarizing	Providing a collective summary of what was talked about, making connections between client's own responses, or summarizing the plan of action moving forward	"So let's go over what we have talked about so far."

MI can be especially effective in the earlier stages of change. That being said, MI is not a method of convincing, persuading, or coercing a client into change. The MI method does not generate the motivation; it reveals it. For clients who demonstrate a readiness for change, the method of MI may not be necessary because the client already possesses self-motivation and has sought out a trainer ready to learn and improve their health and fitness. In fact, the use of MI could potentially limit the progress of the client.

TEST TIP!

The goal of MI is to guide someone toward solving their own problems and uncovering their reasons for any mixed feelings or contradictory feelings (ambivalence). A personal trainer gives them autonomy over the process but does NOT come up with a solution for them!

Exceptions could occur, though, where trainers may choose to use the MI method with clients in advanced stages of change. For example, a trainer's job is to consistently challenge the client outside of the client's comfort zone. As a client improves their fitness level, the trainer may introduce a new behavior (i.e., advanced technique) or raise the intensity expectation (e.g., increase weight resistance) to adequately challenge the client and yield continued fitness improvement. In these situations, a client may demonstrate a resistance to the changes within the program. If so, then trainers can engage in the MI method to work through the client's resistance.

The method of MI has grown over the past quarter of a century. More and more professionals and practitioners have incorporated MI into their work, without guided oversight or accountability to its integrity, which has led MI to be misconstrued at times. Clearing up misconceptions about MI is important to ensure that personal trainers have an accurate understanding of when and how to use the interviewing method and for what purposes.

Table 2.9 Misconceptions and Facts of MI

MISCONCEPTION	FACT
1. MI is a technique with prescribed steps.	MI is a method that involves a set of communication skills to engage in to effectively respond to the moment-to-moment changes in what the client says.
2. MI is a natural communication style; it doesn't take effort.	MI is a skill that is learned and mastered with consistent practice over time.
3. Trainers can use MI to convince or persuade a client to make important changes to their health.	MI does not generate a client's motivation; it reveals the motivation that already exists within the client.
4. Constructing a decisional balance (e.g., pros and cons) is an essential step of MI.	The focus of MI is to elicit change talk (e.g., pros) rather than place emphasis on counterchange talk (e.g., cons); for some clients, constructing a decisional balance can reinforce their own reasons to not make a change.
5. MI can be used for selling purposes (e.g., sell training services or gym memberships).	Using MI for selling purposes is unethical and compromises trust and respect between the trainer and client, which damages rapport.

Behavior change isn't easy; it takes work. It is often easier to stay the same. Therefore, it is common, and expected, for a person to experience resistance to change. The greater the resistance, the less likelihood that change is made. Resistance is a form of energy in which personal trainers can either lessen or intensify. Minimizing resistance is not as simple or cut-and-dry as a trainer might think. The MI method, though, can help guide the process of minimizing resistance.

MI is the integration of many skills used together as necessary per any given moment. There is not a set structure for what to do, just as there is never a set pattern of words and content that one person says, let alone every single person. The focus of MI is on the client. Therefore, the strategy and skills used in any moment will change based on what the person needs in the moment. There are four guiding principles of MI that can assist a personal trainer in using the method effectively:

- Not trying to “fix” a client or their behavior
- Understanding the client’s motivations
- Listening to the client
- Empowering the client

RESISTING THE URGE TO “FIX”

During trainer-client communications, clients often share challenges, problems, or reasons why they are resistant to make a behavior change. When this happens, a personal trainer must resist the urge to try to actively “fix” the client’s problems by telling the client what to do. For example, a client may tell their personal trainer that changing their nutrition behavior has been challenging due to their love for potato chips, and the trainer’s immediate response is to suggest that the next time the client wants something crunchy that they should reach for celery instead. How might this affect the conversation moving forward? How might this impact the client’s nutritional behavior moving forward?

Offering expertise and suggestions (i.e., providing quick “fixes”) is a natural urge, given that personal trainers are passionate and knowledgeable about improving health and well-being. Although well-meaning, telling clients what to do, such as why to change or how to change, is ineffective. If it were as easy as that, then the Centers for Disease Control and Prevention recommendations for healthy behaviors (e.g., exercise, nutrition, and sleep) would be enough to motivate behavior change, and the US would not be faced with an obesity epidemic. But most experienced personal trainers will attest that giving clients information or statistics does not translate into action. Resisting the urge to “fix” the client’s resistance will allow the conversation to continue, which allows the client to discover solutions for themselves that produce a greater commitment to the behavior change process, which is the whole premise of MI.

UNDERSTANDING THE CLIENT’S MOTIVATION TO CHANGE

The second key principle of MI is understanding the client’s motivation to change. Some clients may say the reason they have hired a personal trainer is because they need motivation. Motivation is a general term. The client may mean they need direction, or they might mean they need willpower. It is within the realm of MI to ask for clarification of what the client means. This would also help to clear up any unrealistic expectations of the trainer.

It may be worth sharing with the client that despite the trainer’s effort to motivate the client, by using external motivators such as offering rewards for short-term goals or delivering an enthusiastic pep talk each training session, this is not the type of motivation that sustains positive behavior. A personal trainer can help the client appreciate that it is their own personal reasons for change that create the motivation to initiate and sustain a behavior change. Educating the client about the psychology of behavior change may help them take more ownership of the process.

OPEN-ENDED QUESTIONS:
Questions that require more than a yes or no answer and encourage the client to communicate the "how" and "why."

Trainers influence the client's internal motivation to change by asking quality, **open-ended questions**—questions that require more than a yes or no answer and encourage the client to communicate the "how" and "why." Following the client's response, a trainer can provide a reflection or summary of what the client has shared, emphasize the change talk that the trainer hears the client speak, and ask for clarification. As the personal trainer draws out the client's arguments or reasons for change, it creates a discrepancy between the client's present behavior and their goals and values. When the client gains greater awareness of the discrepancy, it is likely to decrease their resistance for change and ultimately enhance their personal decision to make a change.

LISTENING TO THE CLIENT

The third principle of MI is listening to the client. To fully understand the client's motivation, a trainer needs to listen to what the client has to say. The quality of listening matters too. For clients to be willing to explore their innermost motivations and verbally express them to the personal trainer requires more than just active listening; it requires listening with **empathy**. Empathy is the ability to understand and share in the feelings of others. Listening with empathy involves looking at the situation from the client's point of view.

EMPATHY:
The ability to understand and share in the feelings of others.

Along with empathy, clients may be seeking (or needing) validation. Validation is a response that shows acceptance of the other person's feelings and point of view. Validating the client's thoughts, feelings, and behavior can be done, even if a trainer doesn't agree or approve of them. A simple validating statement, such as "I can see how that could be so difficult for you," can go a long way in helping the client to feel heard. When a client feels heard, they are more likely to be open to listen in return.

EMPOWERING THE CLIENT

The fourth principle of MI is empowering the client to make the change. Clients feel empowered to make a change when they play an active role in developing and implementing the plan. Therefore, trainers who engage the other three principles of MI and incorporate need-supportive behavior to promote autonomy, competence, and relatedness will positively contribute to the client's sense of power and control over their choices and their actions, and ultimately their behavior change.

A client's belief in their ability to make progress in the behavior change process or accomplish a goal (e.g., self-efficacy) is a key factor in whether a person transitions from the pre-contemplation stage to the contemplation stage of change. Even at the later stages of change, self-efficacy plays a pivotal role because the client will be challenged throughout the whole process. Specifically, the behavior change process will challenge clients physically and mentally.

For example, there will be physical behaviors that clients must engage in according to their fitness program, such as engaging in strength exercises and/or meal planning. Likewise, clients must engage in mental behaviors such as coping with setbacks (e.g., temporary relapses). The personal trainer's role is to help the client develop the knowledge, skills, and abilities to successfully execute these behaviors. When clients feel equipped with the requisite tools, then they are more likely to feel empowered to make a change.

PROVIDING INFORMATION IN MI

When using MI, the trainer's role is to draw out information from the client. This role requires that a trainer resist the urge to provide certain information to the client, such as reasons the client should make a change or solutions to the client's obstacles. This behavior can be challenging for a trainer who is used to being in the "expert" role, providing health and fitness information, advice, and guidance. However, most experienced trainers can attest that giving expert advice does not automatically lead to the client making the advised changes. Advice and expertise alone will not inspire change unless the client is ready and willing to receive it.

There is a time and place for trainers to impart their expertise onto the client, but it will require self-regulated, purposeful behavior on the trainer's part. The developers of the MI method, William Miller and Stephen Rollnick, suggest using the elicit-provide-elicit approach to providing information to clients. Using the elicit-provide-elicit technique can help clients be more receptive to the expert advice offered by a trainer and, thus, have a better likelihood of the client acting on the advice.

Table 2.10 The Elicit-Provide-Elicit Approach

STEPS	EXAMPLES
Elicit: exploring the gaps in the client's knowledge on the relevant health or fitness topic and asking permission to provide information to determine if the client is interested and open to receiving it	Trainer: "Would you like me to give you some strategies to support your goal to improve your body composition?"
Provide: providing information using common, relatable language and in small, manageable chunks	Trainer: "Increasing your water intake may be a good place to start for you; sometimes, the hunger sensation is a sign of dehydration. Consuming adequate water may help decrease your caloric intake."
Elicit: checking for understanding	Trainer: "How does that sound?"

BLENDING SDT AND MI

With an understanding of the SDT and MI, it is evident that there is some level of overlap. Mainly, both methods place priority on the client, such as the client's needs to have a sense of control over their choices and actions along with the ability to discover their means (i.e., motivations) for control that can effectively produce a change. As with most psychological theories and areas within the field, the number of options available to integrate and the possibility of nuances across clients are unending.

Although a selection of practical suggestions has been given, it would be impractical to provide a complete how-to guide. Any attempt to do so would undoubtedly fail at encompassing enough variance to satisfy the needs of both trainer and client. Rather than specific examples, a trainer should consider the intent of the two concepts and how they can be blended to amplify the motivational effect.

Although the focus has been on supporting the behavior change of clients, it has likely also indirectly encouraged behavior change within personal trainers. For example, this section on motivation alone has drawn attention to behaviors that trainers can engage in to positively influence the client's behavior. Just like a client, a trainer may have resistance to initiating or engaging in some of the behaviors discussed. In certain cases, a personal trainer may see MI as a daunting task that isn't worth the effort. If so, the trainer might consider how engaging in MI does or does not align with their values, desires, and who they are as a person. The trainer may also look toward their own needs of autonomy, competence, and relatedness. The trainer can take the concepts learned from this chapter and choose how to implement them, which will support their need for autonomy.

The personal trainer might also consider their competence and perhaps seek additional information or someone who could provide them feedback on their skill of MI or their need-supportive behaviors. Strengthening connections with a mentor or other professionals in the field may help to satisfy the trainer's need for relatedness while simultaneously increasing the trainer's capacity to satisfy their client's need for relatedness.

A fitness professional is encouraged to routinely self-assess their trainer behaviors to determine which behaviors of SDT and MI the trainer may already be incorporating and in which areas they have room for improvement or expansion. A trainer will naturally have strengths and weaknesses. Although it is common to target weaknesses, it can be just as valuable to engage in strength-based behavior. As the client begins to embody one method, it can make it easier to embody the other. The focus of either approach is on the client. It is up to the client—via the questions, empathy, and care demonstrated by the trainer—to identify what they can do to enable change and therefore support their own success.

SETTING GOALS THAT MOTIVATE BEHAVIOR

Goal setting, when done properly, is one of the most impactful strategies for motivating behavior because goals provide clients with a sense of purpose, direction, and energy. Goal setting within health and fitness is the client-directed process of identifying their ideal or desired state, determining their current state in relation to the desired state, and defining the actions that must be taken to close the gap. An effective goal plan includes processes to increase the probability of goal achievement. Therefore, a trainer's competence in the fundamental components of goal setting will help the trainer use this tool more effectively with their clients. The fundamental components of goal setting that will be covered in this section include using long-term and short-term goals, SMART goal intentions, implementation intentions, and monitoring and feedback processes.

GOAL SETTING:
The process of identifying the client's ideal state, determining their current state, and defining the actions that must be taken to close the gap.

Table 2.11 Fundamental Components of Effective Goal Setting

FUNDAMENTAL COMPONENTS
Complementary long-term and short-term goals
SMART goal intentions
Implementation intentions
Monitoring
Feedback

It is human nature for there to be resistance whenever a person is told what to do. Therefore, it is critical that clients play a central role in the goal-setting process. When the client constructs their own goals, with the support and guidance from the trainer, then this will foster ownership over the training program and create more buy-in.

Trainers should guide the client to set both long-term goals and short-term goals. Long-term goals refer to the desired outcome the client wishes to achieve. Long-term goals can have a timeline of one year or more. Identifying a meaningful long-term or **outcome goal** provides a sense of purpose. Meaningful goals are those that align with a client's values and priorities. A clear, meaningful outcome goal also promotes an openness to try new strategies and find creative solutions to obstacles.

OUTCOME GOAL:
A goal where the end result is a specific desired outcome.

Short-term goals are those that a client wants to achieve in the near future. Short-term goals can have a timeline from a few days to weeks to months or up to a year. Establishing short-term goals provides direction and effort toward actions that will lead a person closer to realizing their outcome goal. Long-term goals and short-term goals complement one another—long-term goals provide motivation for a client to engage in short-term goals, and short-term goals are the steppingstones toward the long-term goals.

Goals can also be categorized as process or outcome goals. Similar to short-term goals, a **process goal** is a smaller goal that must be achieved in an attempt to reach a larger result. The modifications to the process help lead clients to their ultimate end goal—for example, "I want to exercise for 30 minutes per day for the next six months." On the other hand, an outcome goal is a goal that is associated with a specific end result. "I want to lose 15 pounds before December 20" is an outcome goal. Clients should set both process and outcome goals for long-term success.

PROCESS GOAL:
A goal where the focus is on the process or action that will lead to the desired end result.

SMART GOALS

One of the most popular methods for setting effective goals is to follow the **SMART principle**, which stands for:

SMART PRINCIPLE:
Acronym to enable goals to be more objective; S—specific, M—measurable, A—achievable, R—relevant, T—time-bound.

Specific: The goal is well-defined and clear as to what the client intends to do. The example goal, however, directs specific behavior to be taken.

Measurable: The goal provides three specific criteria to follow. It clearly identifies the extent to which the action needs to occur, such as two miles, 36 minutes, three times a week.

Achievable: The achievability will depend upon the individual client, particularly the client's time constraints, physical abilities (i.e., fitness level), and mental abilities (i.e., self-efficacy).

Relevant: The goal demonstrates relevance because it addresses an important health behavior (e.g., exercise) for weight management. An additional check for relevance is to ensure that short-term goals align with the client's long-term/outcome goals.

Time-bound: The goal has a clearly defined time frame: within one week's time (e.g., seven days), the client plans to walk three times. Having a timeline prevents procrastination and creates a sense of urgency. Other goals may incorporate a deadline or date to which the goal will be achieved (e.g., "I will lose five pounds by February 1").

Figure 2.3 SMART Goals

SUBJECTIVE GOAL:
A goal based on a subjective outcome that will be dependent on the interpretation of the individual client.

OBJECTIVE GOAL:
A goal based on objective, quantifiable data that can be measured and evaluated.

SMART goals transform a **subjective goal** (e.g., "I want to feel better about my weight") into an **objective goal** (e.g., "I want to improve my body composition by 3 percent within three months"). A subjective goal means there is room for interpretation as to whether the person achieved the goal or not. Although there is some value to subjective goals, objective goals offer the ability to measure and quantify the amount of progress made toward the goal.

Objectivity is advantageous for both long-term goals and short-term goals. Other advantages to creating objective goals include:

- Provide data, facts, and information that can lead to greater awareness for the client and trainer alike, so adjustments can be made, if necessary
- Minimize faulty perceptions or interpretation as to whether the client is engaging in the right behaviors, at the right amount, and with the right intensity and commitment to achieve the goal
- Provide clear markers for when a goal is achieved and can be celebrated
- Increase accountability of the client

For a client who is 50 pounds overweight and currently engaged in moderate activity, a subjective goal, one that would be less likely to motivate behavior change, might be "I will do more cardio." While doing more cardio could benefit the client, this goal is too ambiguous. Instead, a strong short-term goal following the SMART principle might be "I will walk two miles under 36 minutes at least three times a week."

IMPLEMENTATION INTENTION

It is true that objective, SMART goals can motivate and direct behavior; however, even a SMART goal can fail if the client does not follow through on it. This is especially true if the client has low self-regulation skills. Too often, people rely on "feeling motivated" or "being inspired" to engage in their goal behaviors. It can be frustrating for a trainer to hear a client say they did not engage in the target behaviors because they "just didn't have the motivation this week." How, then, can a personal trainer help a client to act upon the goal? The answer is to leverage the client's situational cues and automate goal behavior. This can be done by incorporating implementation intentions within the goal-setting process.

IMPLEMENTATION INTENTION:
A preset plan that links critical situations (e.g., anticipated obstacles or opportunities) to goal-directed responses.

An **implementation intention** is a preset plan that specifies when or where to act on the goal behavior. Implementation intentions link critical situations (e.g., anticipated obstacles or opportunities) to goal-directed responses and, thus, leverage the power of cues. The general framework of implementation intentions is stating the situation (e.g., "When _______ arises") followed by the goal-directed action or behavior (e.g., "then I will _____"). This is called a "when/then" statement.

Let's revisit the goal "I will walk two miles under 36 minutes at least three times a week." The target behavior is walking. An implementation intention that demonstrates linking an opportunity with a goal-directed response is "When I finish my morning coffee, I lace up my shoes and head out the door." An implementation intention that demonstrates linking an obstacle with a goal-directed response is "When I want to hit the snooze button, I visualize the outcome of achieving my goal." The trainer and client can work together to determine how to integrate SMART goals and implementation intentions within the goal plan. Perhaps the client would benefit from having one implementation intention to go with each SMART goal. On the other hand, the client may create one implementation intention to support their priority behavior for the week.

MONITORING

A critical piece to the goal-setting process is monitoring progress toward the goal. **Monitoring**, also referred to as tracking, is the process of observing and taking notice of routine behaviors that impact goal progress and achievement. Monitoring ensures that the goal and the goal plan (e.g., prescribed training plan) remain priorities to the client because they require attention to be given to one's behaviors on a routine basis. There are various mechanisms that can be used to monitor progress, such as self-monitoring and using technology (e.g., smartwatches or mobile applications).

MONITORING:
The process of observing and taking notice of routine behaviors that impact goal progress and achievement.

Self-Monitoring

When working with clients, personal trainers should encourage clients to engage in self-monitoring, which is the process of documenting one's own daily actions and behaviors that influence goal progress. For example, a personal trainer may ask the client to record the work performed between training sessions, such as the frequency of training (e.g., days per week) and the amount of work performed (e.g., number of repetitions and sets; the weight used for each exercise). Another example is asking the client to keep a daily nutrition log. Trainers should foster autonomy by providing the client with options of how to monitor and track their behaviors and progress. Some clients may prefer paper and pen (e.g., journal or calendar) while others may prefer electronic or technological tracking methods.

The information that the client and trainer collect is useful feedback that can be used to evaluate the efficacy of the training program. Furthermore, monitoring increases client accountability to follow through with the plan and engage in target behaviors that impact goal progress. Trainers can check with the client to determine the role they want or need the trainer to play in the accountability process. The feedback received through the monitoring process can help both trainer and client to make improvements, if necessary, as well as reinforce positive behaviors and celebrate small wins.

Use of Technology

The use of technology, such as fitness trackers (e.g., smartwatches) and mobile applications (apps), has increased in popularity over the past decade. Not only are fitness trackers and mobile apps more frequently used, but research has demonstrated positive results such as increased engagement in exercise and greater physical activity levels compared to nonusers. Yet even technology has its limitations. When the novelty of the technology wears off, then there is typically a drop in motivation that leads to low retention rates.

According to the motivational technology model, the most effective technological methods for tracking or monitoring health and fitness behaviors are those that fulfill a person's psychological needs outlined by the SDT. The most effective tracking devices and mobile apps, therefore, in sustaining health behaviors incorporate features that promote autonomy (e.g., self-determined goals; choice of modality), competence (e.g., exercise instruction; visible progress such as graphs and metrics), and relatedness (e.g., interactivity within a social support network; a sense of belonging to a community).

Clients may turn to personal trainers for recommendations as to which mobile app or fitness tracker to use. Therefore, trainers must be diligent to evaluate and screen for ones that are accurate (i.e., valid information and metrics), relevant to the individual and target behavior, and user-friendly. The table below presents practical strategies for personal trainers to evaluate and screen health and fitness technology before making recommendations to clients.

Table 2.12 Evaluation of Fitness Technology

STRATEGY	OBJECTIVE
Reviewing scientific literature and app clearinghouse websites	To assess the credibility, validity, and reliability of the technology. For example, is the app/tracker supported by evidence-based research? Does the app/tracker provide accurate, reliable measures and metrics?
Reviewing app descriptions, user ratings, and user reviews	To gain insight of the positive and negative experiences from current or past users to include satisfaction with the usability as well as the effectiveness in supporting one's goals or target behavior. Additionally, consumers provide feedback that can help determine if the paid versions are worth the financial investment for the client.
Piloting the technology firsthand	To evaluate the accuracy of the information provided and assess whether the functions and features adequately address the target behavior and elements of the behavior change process. Firsthand experience using the interface can also provide the trainer with insight into how user-friendly it is and enable a trainer to answer specific questions from clients.
Seeking feedback from the trainer's professional or social network	To discover what peers are recommending (or not recommending).
Eliciting feedback from clients	After a trainer recommends an app or tracker or becomes aware that a client is using a specific technology, then the trainer ought to follow up to assess how well the technology is working for that specific client. Usefulness will vary based on the individual's preferences, target behavior, and technological savviness. Even if it is a quality app, it does not guarantee it will be deemed useful for every client.

Feedback

The feedback given from the personal trainer to the client is also a factor that contributes to a client's perceived competence. For the client to develop their proficiency in exercise movements and/or fitness level, the client must operate within a feedback loop for growth. The personal trainer's role is to provide quality feedback such as constructive criticism and effective, specific praise that can directly increase the client's competence.

Correcting mistakes is essential for growth and development; through constructive criticism, the client can learn what adjustments must be made to ensure safety and movement effectiveness. For the feedback to increase the client's competence level, though, criticism needs to be delivered constructively. When a trainer identifies and communicates what was specifically done incorrectly and provides clear instruction on how to make the appropriate corrections, then the client can gain confidence in their ability to do it right next time. If the criticism is too general (e.g., "You're doing it wrong") or pervasive in nature (e.g., claiming the client is lazy or uncoordinated), then it can negatively impact the client's perceived competence and decrease the client's motivation to put forth the effort to try again.

Many personal trainers focus only on giving corrections. Praising positive behaviors can be just as effective in developing the client's skill if it is done in a specific manner. Although cheering a client on with "good job" and "way to go" after a successful set of an exercise is not discouraged, this generic praise does not directly reinforce the desired behaviors. Conversely, when a trainer identifies and communicates the specific behavior that the client did well, then the client knows what to repeat for future success. Identifying specific moments of success via effective, specific praise enables for greater consistency of successful effort.

Table 2.13 Examples of Constructive Criticism and Effective Praise

EXERCISE/ BEHAVIOR	GENERIC CRITICISM	CONSTRUCTIVE CRITICISM
Back squat: poor form	"You're still allowing your knees to track in front of your toes."	"Your weight is too far forward; shift your weight to your heels and hinge at your hips."
Client failed to track behaviors (e.g., nutrition log or exercise) last week	"If you don't track your behavior, then you'll never make progress."	"I see you didn't track your behavior last week. Moving forward, try to make this a priority because doing so will help you get the most out of working with a trainer and, ultimately, help you to achieve your goal."
Mindset: client says, "This is too hard."	"Don't be so negative."	"That mindset will hold you back. Focus on learning the technique I've just shown you; you'll get better with practice."
EXERCISE/ BEHAVIOR	**GENERIC PRAISE**	**EFFECTIVE PRAISE**
Lunge: completed a set with good form	"Good job."	"Good job; you maintained a strong core and got the full range of motion."
Client tracked behavior (e.g., nutrition log or exercise) three out of seven days last week	"Something is better than nothing."	"I'm proud of you for tracking your behavior three days last week. I know tracking takes time and effort, so this shows commitment to your goal."
Mindset: client says, "I did it; that felt good!"	"Yeah, awesome!"	"Yes! I noticed you were really focused and got your mind and body dialed in for the set. It worked!"

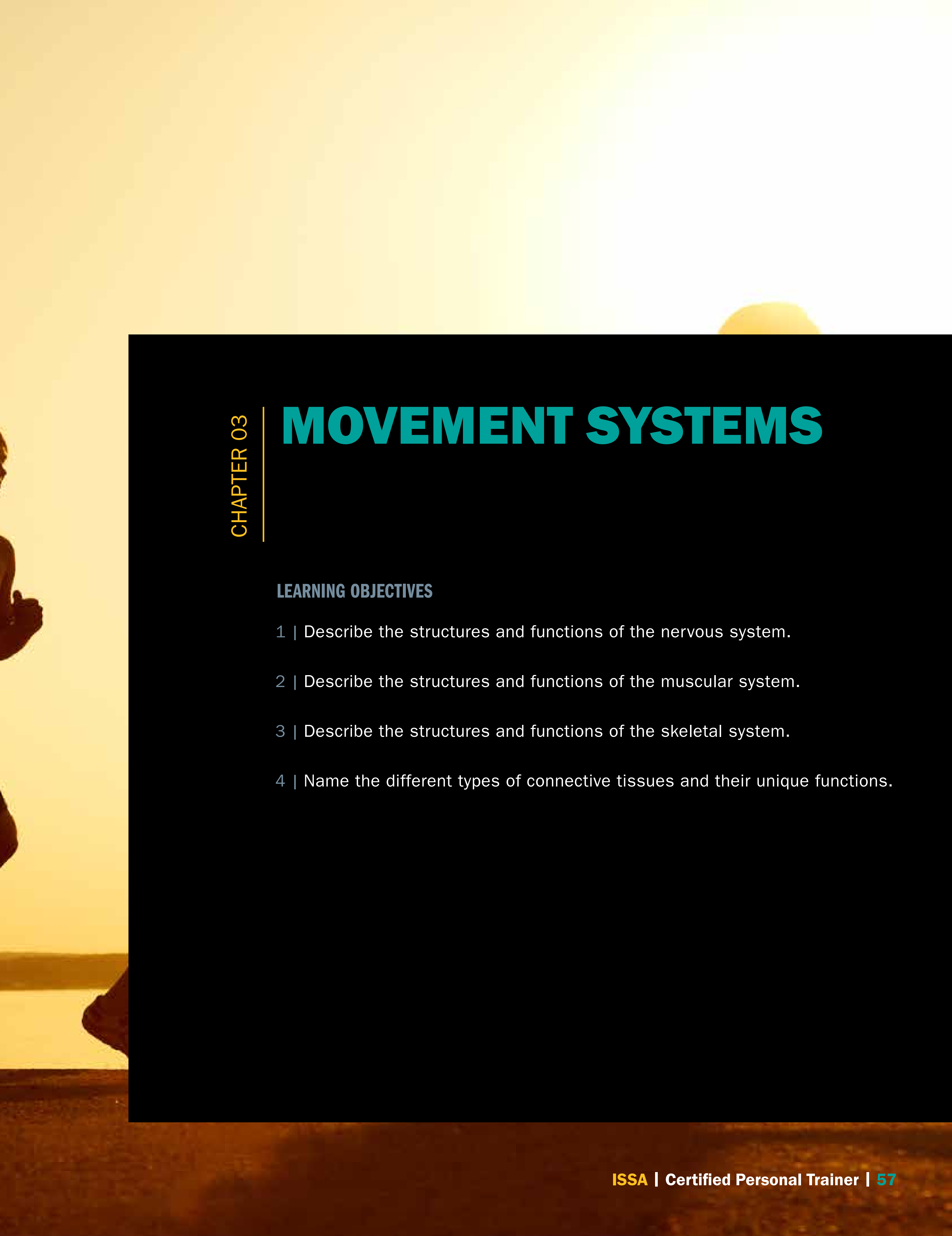
The effective praise strategy can further be elevated when it is connected to the long-term goals of the client and their overall ability. Identifying the specific action within a squat that went well is powerful for success, especially when adding in that the overall progression of learning the complex movement is impressive and powerful to experience. The trainer who communicates specific growth in the client and the progress made toward the client's goals enables a greater sense of competence and motivation from the client.

SCOPE OF PRACTICE

This chapter has provided practical knowledge of the psychology of behavior change within the health and fitness domain. It has also presented actions that personal trainers can take within their scope of practice, such as identifying their client's motivational needs, accounting for the client's motivational needs within the program design, and creating a motivational climate that best supports the client's progress through the behavior change process. As described in this chapter, the role of a personal trainer does include coaching clients through psychological processes; however, trainers must be aware of their boundaries of ethical practice and not cross over into the role of professional psychologists. If or when a personal trainer encounters a situation that exceeds their competency or comfort, then the trainer should refer the client to the appropriate professional, such as a licensed clinical psychologist or an exercise and sport psychology practitioner.

Table 2.14 When to Refer to an Appropriate Psychology Professional

PRACTITIONER	EXERCISE AND SPORT PSYCHOLOGY PRACTITIONER	LICENSED CLINICAL PSYCHOLOGIST
Goal or issue	Increasing self-confidence Decreasing exercise anxiety Increasing self-motivation Optimizing energy levels Performing under pressure (e.g., for athletes or fitness competitors)	Diagnosing and treating clinical depression Diagnosing and treating clinical anxiety Emotional/mood disorders Eating disorders Substance abuse



CHAPTER 03

MOVEMENT SYSTEMS

LEARNING OBJECTIVES

1 | Describe the structures and functions of the nervous system.

2 | Describe the structures and functions of the muscular system.

3 | Describe the structures and functions of the skeletal system.

4 | Name the different types of connective tissues and their unique functions.

The human body is organized in levels of increasing complexity. At the microscopic level, there are subatomic particles (protons, neutrons, electrons), which make up atoms. Atoms group together to form molecules. Molecules make up organelles, which are small cellular structures that perform specific functions within the human cell. Cells aggregate into the various tissues that make up organs and **organ systems**. Finally, the organ systems, as a collective, comprise the organism that is the human.

ORGAN SYSTEMS:
A group of organs working together to perform biological functions.

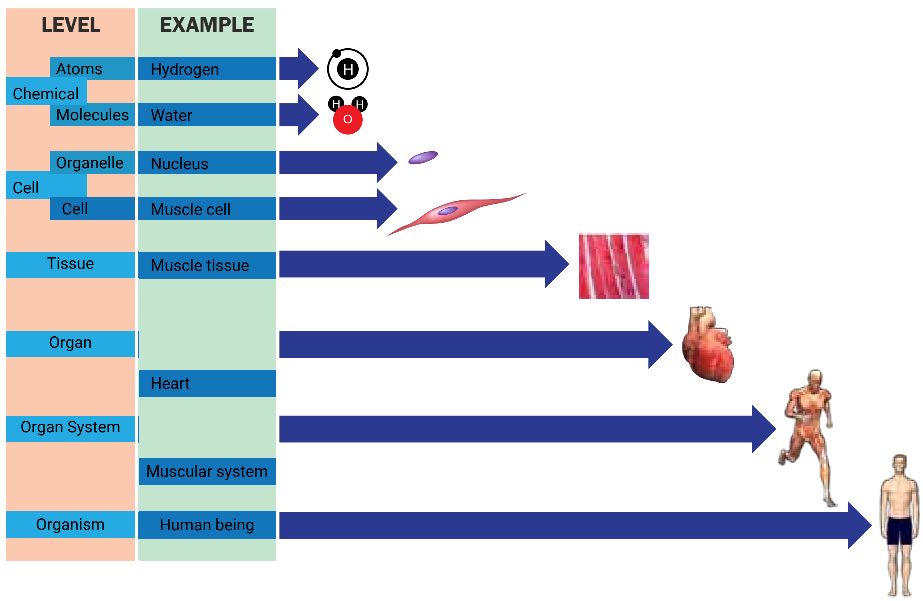
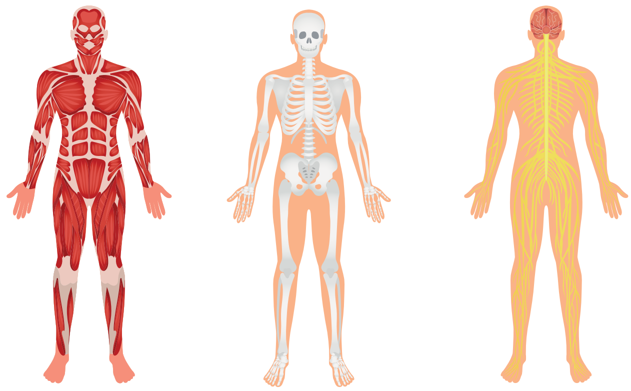


Figure 3.1 The Organizational Levels of the Human

Human movement happens when multiple organ systems work together in an interrelated way. The body has 11 organ systems operating to keep us alive and healthy. Of those 11 systems, the nervous system, muscular system, and skeletal system are the 3 most prominent organ systems responsible for human movement. They execute specific functions in concert with one another to create movement. The skeletal system provides most of the physical support for the body, and the muscular system operates to make voluntary movements (playing the piano, exercise) and involuntary movements (heartbeat, digestion) based on signals from the nervous system.



Of the three primary organ systems involved in human movement, the nervous system is the most important—it is the command center of the body. All movement (for exercise, sport, and daily activities) is dictated by the nervous system. Training adaptations and physical fitness cannot be fully understood without knowledge of how the human nervous system generates, propagates, and interprets neural signals. Therefore, it's essential to understand and work to develop this system of the body when designing training programs.

THE NERVOUS SYSTEM

The nervous system consists of the brain, spinal cord, and nerves and is responsible for controlling the voluntary (conscious or deliberate) and involuntary (automatic) functions of the body and the mind. The entire system is of an intricate network that controls and coordinates many body movements and functions via chemical signaling.

Nervous tissue: plays a key role in the nervous system's ability to sense, analyze and interpret information, and respond appropriately. There are three types of nervous tissue:

Neurons: responsible for transmitting signals to and from other neurons, muscles, or glands. They communicate with chemical messengers across a synapse, or neural junction, which is the site where the message is relayed from one neuron to the next.

NERVOUS TISSUE:
Tissue found in the brain, spinal cord, and nerves that coordinates body activities.

NEURONS:
The most fundamental component of the brain and nervous system capable of transmitting information to and from other neurons, muscles, or glands.

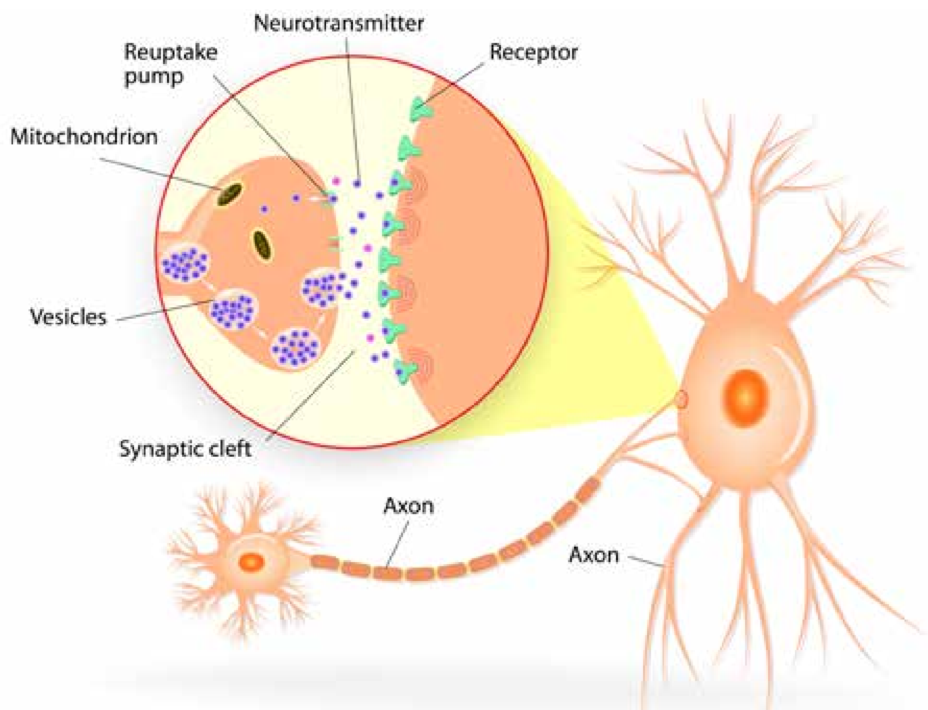


Figure 3.2 Neural Synapse

NEUROGLIA:
Cells in the brain and spinal cord that form a supporting structure for the neurons and provide them with insulation.

NEUROSECRETORY TISSUES:
Neurons that translate neural signals into chemical stimuli.

CELL BODY:
The core and central structure of a neuron containing a nucleus and other specialized organelles that aid in nervous system function.

AXON:
The thin tail-like structure of a neuron that generates and conducts nerve impulses.

DENDRITES:
Rootlike structures branching out from the cell body that receive and process signals from the axons of other neurons.

Neuroglia: also known as glial cells, these are neural tissues that support, insulate, and protect neurons.

Neurosecretory tissues: translate neural signals into chemical stimuli. These tissues make neurohormones, hormones produced and released by nerve cells, that are released into the bloodstream.

A neuron or nerve cell is the most fundamental component of the brain and nervous system. They are electrically excitable with the capability of transmitting information to and from other neurons, muscles, or gland cells. It is through these neurons that the human body can receive sensory information from the outside world and communicate motor commands to our muscles for both voluntary and involuntary movements.

The three main components of a neuron are the cell body, axon, and dendrites. The **cell body** is the core of the neuron. It contains a nucleus, maintains the structure of the neuron, and provides energy to drive actions. The **axon** is the thin tail-like structure that connects to the cell body of the neuron and conducts nerve impulses. **Dendrites** are the receiving part of the neuron. They are like roots that branch out from the cell body, receiving and processing signals from the axons of other neurons.

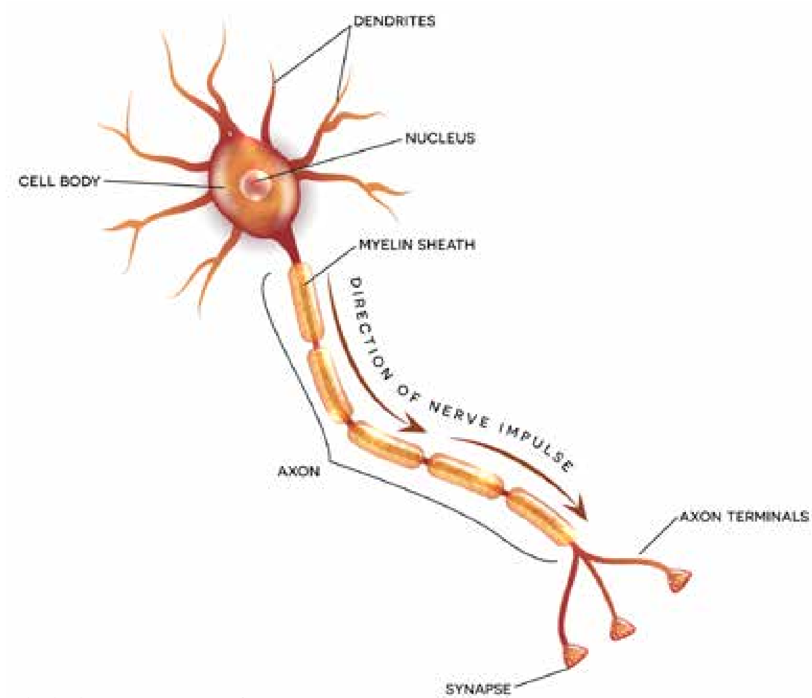


Figure 3.3 Structures of a Neuron

Neurons are typically separated into one of three classifications based on their function: sensory neurons, motor neurons, or interneurons.

Sensory neurons send information to the brain and spinal cord in response to tactile (sense of touch), auditory, or visual stimuli. **Motor neurons** receive information from the brain or spinal cord to produce muscular contractions or activate glands. **Interneurons** connect neurons to other neurons often communicating signals between motor and sensory neurons.

SENSORY NEURONS: Nerve cells involved in communicating tactile, auditory, or visual information.

MOTOR NEURONS: Nerve cells that initiate muscle contraction or activate glands.

INTERNEURONS: Nerve cells that connect neurons to other neurons.

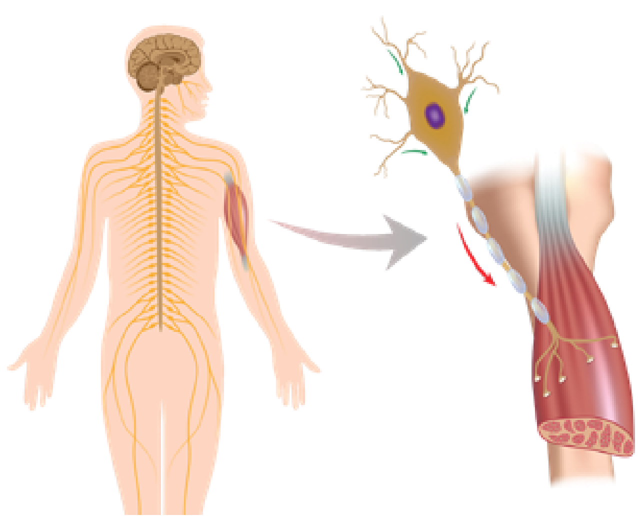


Figure 3.4 The Neuromuscular Connection

CENTRAL NERVOUS SYSTEM (CNS):
The part of the nervous system consisting of the brain and spinal cord.

PERIPHERAL NERVOUS SYSTEM (PNS):
The nerves and ganglia (relay areas for nerve signals) outside of the brain and spinal cord.

CEREBRUM:
The uppermost and largest part of the brain consisting of a left and right hemisphere; responsible for receiving and processing sensory information and controlling the body.

CEREBELLUM:
The region of the brain responsible for conscious motor coordination.

BRAIN STEM:
The trunk of the brain, consisting of the medulla oblongata, pons and midbrain that continues downward to form the spinal cord.

CEREBRAL CORTEX:
The part of the brain where most neural integration occurs.

MIDBRAIN:
The brain region responsible for motor movement and processing auditory and visual information.

CENTRAL NERVOUS SYSTEM

The nervous system is separated into two different divisions, the **central nervous system (CNS)** and the **peripheral nervous system (PNS)**. The CNS consists of the brain and spinal cord and is the control center of the body and mind. The CNS receives sensory input and functions to organize, analyze, and process information. The PNS consists of all of the other nervous tissue outside of the CNS, including all the cranial and spinal nerves that run throughout the body. The PNS is responsible for conveying motor commands, carrying sensory information to the CNS and regulating involuntary functions.

The Brain and Brain Stem

The human brain is composed of three main parts, the **cerebrum**, **cerebellum**, and the **brain stem**. The cerebrum is the largest part of the brain, consists of two hemispheres, and is generally responsible for receiving and processing sensory information and controlling the body. The **cerebral cortex** is the outer portion of the cerebrum and is where most information processing happens. The cerebellum is positioned below the cerebrum and controls conscious motor coordination.

The brain stem consists of the **midbrain**, **pons**, and the **medulla oblongata**. The midbrain plays an important role in motor movement and the processing of auditory and visual information. The pons links the medulla oblongata to the **thalamus** and helps control sleep, breathing, facial expression and movement, and posture. The medulla oblongata plays a prominent role in involuntary functions like coughing, sneezing, and swallowing, along with functions of the heart, and is located at the base of the brain stem.

The cerebrum is divided into two hemispheres—the left hemisphere and the right hemisphere. The right hemisphere controls movements on the left side of the body, and the opposite is true for the left hemisphere. For example, if someone suffers an injury to one side of the brain, motor function on the opposite side will be affected. This “crossover” is known as **decussation** and occurs at the junction of the medulla oblongata, the lowest part of the brain stem, and the spinal cord.

Although both hemispheres of the brain are distinct and associated with specific functions, they are closely intertwined with each other to create the basis of how each individual moves, thinks, and functions.

Table 3.1 Brain Hemispheres and Functions

LEFT HEMISPHERE	RIGHT HEMISPHERE
Language	Spatial perception
Logical processing	Creativity
Science and math	Intuition
Controls muscles on right side	Controls muscles on left side

Each hemisphere is divided into four lobes: frontal, parietal, temporal, and occipital.

The **frontal lobe** is at the front of the brain and is involved in motor control, emotion, and language. The frontal lobe contains the **motor cortex**, which is responsible for the planning and coordination of movement. The **prefrontal cortex**, responsible for problem-solving, impulsivity, attention, and language, is also located in the frontal lobe.

The **parietal lobe** is directly behind the frontal lobe and is involved in processing sensory information. It is home to the **somatosensory cortex**, which processes sensations like pain, temperature, and touch.

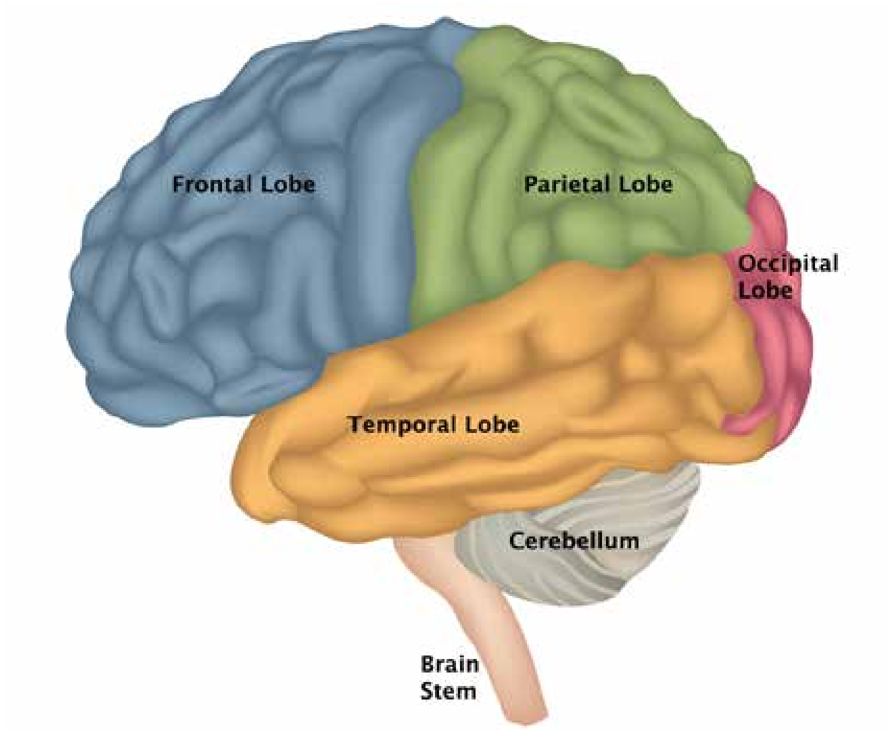


Figure 3.5 Lobes of the Human Brain

PONS: The brain region responsible for posture, facial movement, and sleep.

MEDULLA OBLONGATA: The base of the brain stem, responsible for involuntary functions like swallowing, sneezing, and heart function.

THALAMUS: The brain region responsible for relaying sensory and motor signals and regulating consciousness.

DECUSSATION: The point of crossover of the nervous system in vertebrates located between the medulla oblongata and the spinal cord.

FRONTAL LOBE: The brain lobe involved in motor control, emotion, and language.

MOTOR CORTEX: The region of the frontal lobe that plans and coordinates movement.

PREFRONTAL CORTEX: The part of the frontal lobe responsible for high-level thinking and language.

PARIETAL LOBE: The brain lobe involved in processing sensory information.

SOMATOSENSORY CORTEX: The region of the parietal lobe responsible for processing sensations like pain, temperature, and touch.

TEMPORAL LOBE:
The lateral lobe of the brain responsible for hearing, memory, and emotion.

AUDITORY CORTEX:
The region of the temporal lobe responsible for hearing.

OCCIPITAL LOBE:
The posterior lobe of the brain responsible for vision.

VISUAL CORTEX:
The specific region of the occipital lobe responsible for sight and visual perception.

The **temporal lobe** of the brain is on the sides (literally meaning "near the temples") and processes hearing, memory, emotion, and some parts of language. The **auditory cortex**, responsible for hearing, is located here.

The last lobe is the **occipital lobe**, which is located at the very back of the brain. It contains the **visual cortex**, responsible for processing visual information.

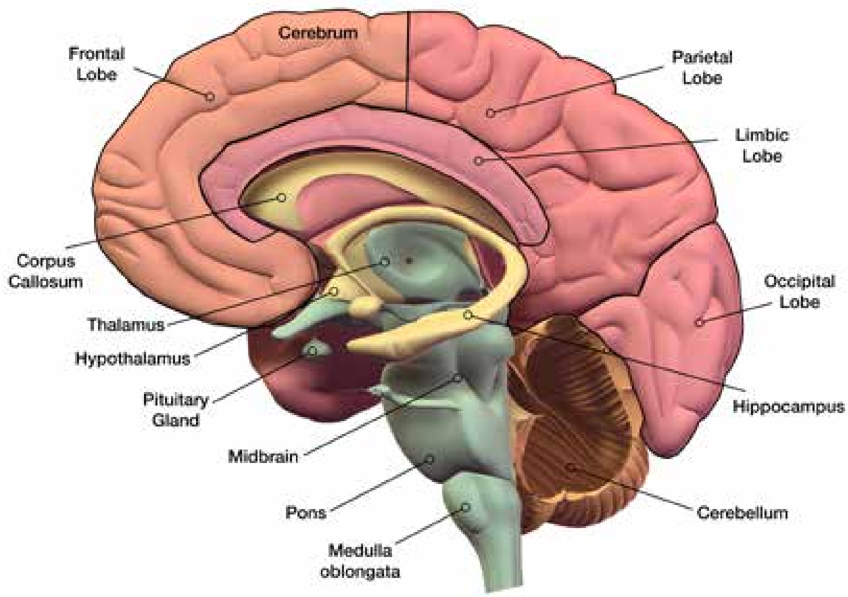


Figure 3.6 The Regions of the Human Brain

HYPOTHALAMUS:
The region at the base of the brain responsible for maintaining homeostasis.

HOMEOSTASIS:
A self-regulating process by which the body maintains the stability of its physiological processes for the purpose of optimal function.

SPINAL CORD:
The neural tissue extending from the medulla oblongata to the lumbar region (lower back) of the vertebral column.

The **hypothalamus** plays a key role in maintaining **homeostasis**, or the body's automatic tendency to maintain a constant internal body environment through various processes, including pH (measure of acidity or alkalinity), temperature, blood glucose (blood sugar) levels, and blood pressure.

The Spinal Cord

The **spinal cord** is a tube of nervous tissue that extends from the brain to the bottom of the spine. It is the connection point between the brain and the body—all nerve impulses travel through the spinal cord to and from the brain. The spinal cord is incredibly important and is carefully protected by the vertebrae (bones of the spine), meninges (membranes that enclose the brain and spinal cord), and cerebrospinal fluid (fluid that acts as a cushion and protects the brain and spinal cord).

THE PERIPHERAL NERVOUS SYSTEM

The second part of the nervous system is the peripheral nervous system (PNS). The PNS is made up of nervous tissue that exists outside of the brain and spinal cord. Its primary purpose is to connect the CNS to the rest of the body via the extensive network of nerves that serve the limbs and organs of the body.

There are 12 **cranial nerves**—nerves extending directly from the brain—and 31 **spinal nerves** that extend from the CNS to the peripheral organs and muscles. The cranial and spinal nerves serve two main functions: receiving sensory information along with sending and relaying motor and autonomic signals between the brain, spinal cord and the body. It's important to note that reflexes are not processed by the brain. Reflexes are involuntary reactions to a stimulus that is processed directly within the spinal cord.

Ganglia are structures containing collections of bodies of nerve cells. They act as a relay for nerve signals, where nerves enter and deliver a signal while another nerve within the ganglia receives the signal and moves that signal on from the ganglia to the next site.

CRANIAL NERVES:
The 12 sensory and motor nerves extending directly from the brain.

SPINAL NERVES:
Bundles of nerves connected to the spinal cord carrying information toward the periphery.

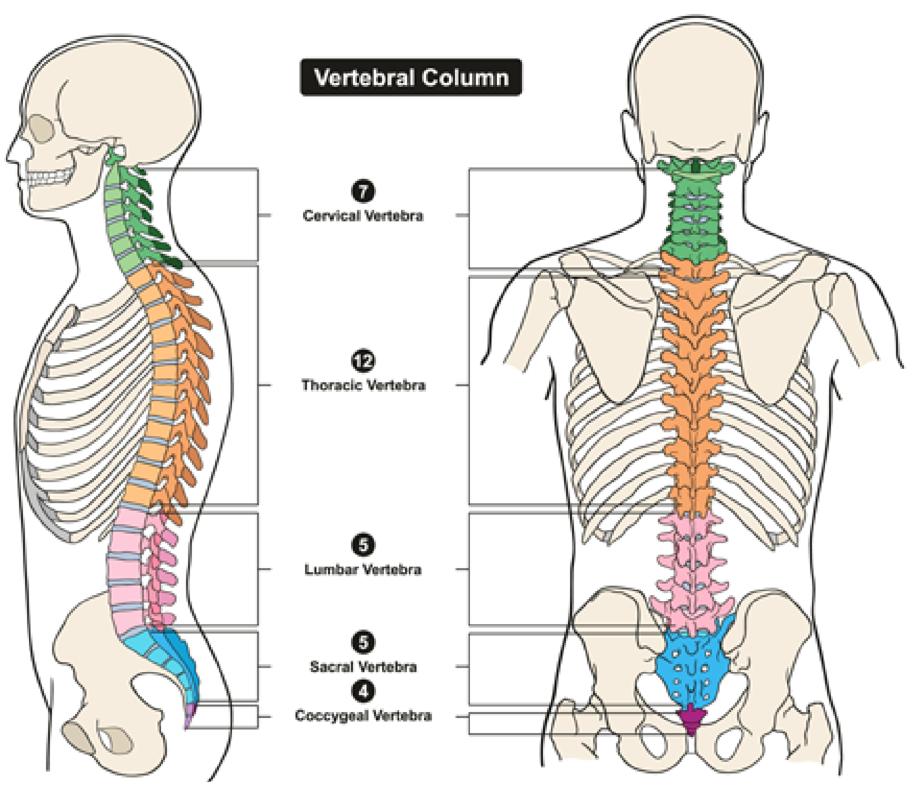


Figure 3.7 Regions of the Spine

EFFERENT NEURONS: Motor neurons sending information from the CNS to the muscles to generate movement.

AFFERENT NEURONS: Sensory neurons sending information from a stimulus to the CNS.

SOMATIC NERVOUS SYSTEM: The part of the nervous system in charge of controlling voluntary movement.

AUTONOMIC NERVOUS SYSTEM: The part of the nervous system responsible for involuntary functions and movement.

SYMPATHETIC NERVOUS SYSTEM: The autonomic system responsible for "fight-or-flight."

PARASYMPATHETIC NERVOUS SYSTEM: The autonomic system responsible for "rest and digest."

Table 3.2 Spinal Nerves

NUMBER OF SPINAL NERVES				
Cervical spine	Thoracic spine	Lumbar spine	Sacral spine	Coccyx
8 pairs	12 pairs	5 pairs	5 pairs	1 pair

The PNS is comprised of afferent and **efferent neurons**. The **afferent neurons** are sensory, sending information, or stimuli, from the body toward the CNS. Efferent neurons are motor neurons responsible for carrying signals from the CNS to the muscles to generate movement.

TEST TIP!

Afferent **signals Arrive at the CNS. Both afferent and arrive start with the letter A.**

Efferent **signals Exit the CNS. Both efferent and exit begin with the letter E.**

Voluntary and Involuntary Neural Control

The PNS is divided into two divisions: the sensory division and the motor division. The motor division further divides into the **somatic nervous system** and the **autonomic nervous system**, which control voluntary and involuntary movement. The somatic nervous system controls voluntary movement, such as exercise, chewing, and waving. Involuntary movement, such as cardiac function, breathing, and digestion, is controlled by the autonomic nervous system. The autonomic nervous system is further divided into the sympathetic and parasympathetic systems.

The **sympathetic nervous system** is activated by stress-related activities and is often referred to as the "fight-or-flight" system because it elevates heart rate and increases cellular metabolism (energy use). On the other hand, the **parasympathetic nervous system** is associated with control of the body systems while at rest. The parasympathetic nervous system is often described as "rest and digest" as it slows the heart rate and controls digestion.

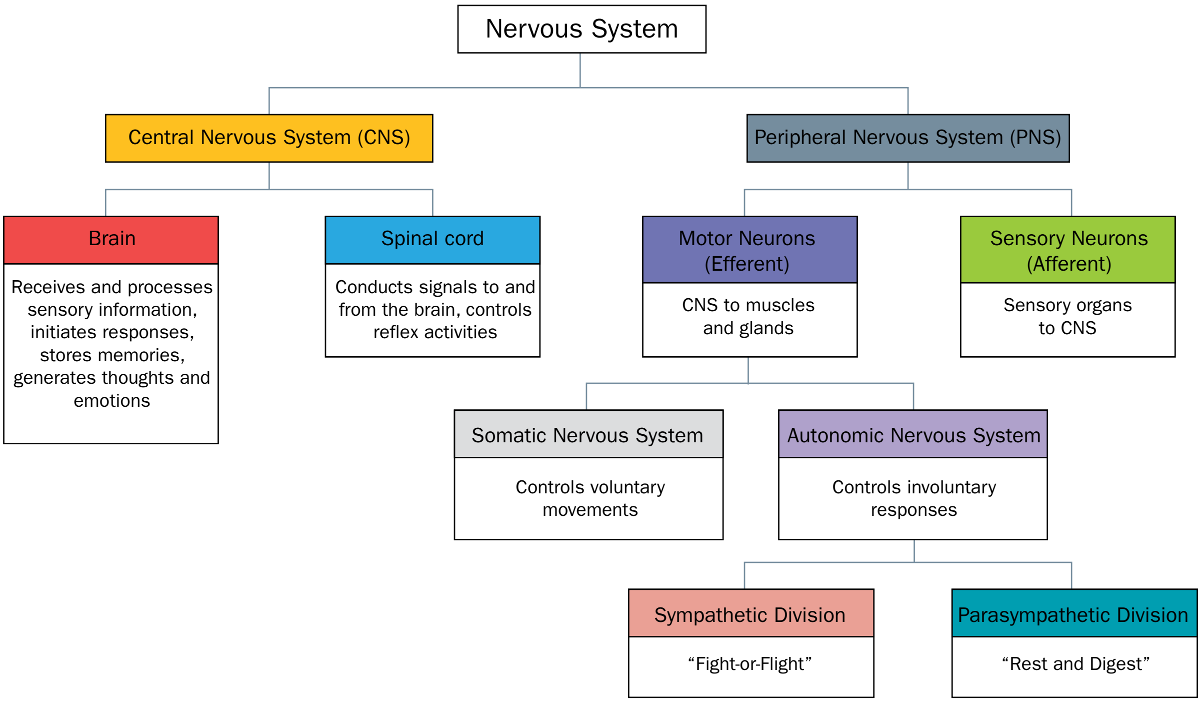


Figure 3.8 Divisions of the Nervous System

FUNCTIONS OF THE CENTRAL NERVOUS SYSTEM

The CNS controls and regulates all systems of the body as well as fosters communication among and between those systems.

Sensory Impulses

Millions of sensory receptors throughout the body are constantly perceiving and communicating stimuli. **Internal stimuli** are changes happening inside the body, including changes in internal temperature, pH (acidity or alkalinity), carbon dioxide concentration, or electrolyte levels. **External stimuli**, messages from outside the body, may include fluctuations in environmental temperature, light, or sound. Collectively, the information the body receives for processing, whether internal or external, is called sensory input.

Sensory input from receptors known as **mechanoreceptors** transmit information via the somatic nervous system to control voluntary movement. Along with sensory input, the brain must have a sense of body position as it moves. Perception or awareness of body movement and position in space is known as **proprioception**.

INTERNAL STIMULI: Sensory input from within the body.

EXTERNAL STIMULI: Sensory input from external sources.

MECHANORECEPTORS: Nervous system receptors responding to mechanical stimuli such as sound or touch.

PROPRIOCEPTION: Perception or awareness of body movement or position.

MYELIN SHEATH:
The insulation of neuron axons, made of proteins and fats, which propagates neural impulses.

NERVE IMPULSES:
The electrical signals used for nerve communication.

SENSORY INTEGRATION:
The way the brain works to affect responses to neural input.

MOTOR UNIT:
A single motor neuron and the muscle fibers it controls.

MOTOR UNIT POOL:
A group of motor units that work together.

MECHANICAL WORK:
The amount of energy transferred by a force, the product of force and distance.

EXTRAFUSAL MUSCLE FIBERS:
The standard skeletal muscle fibers involved in creating mechanical work.

ALPHA MOTOR NEURONS:
Motor neurons originating in the brain stem and spinal cord that initiate muscle contraction.

Mechanoreceptors relay information concerning sensory stimuli such as touch, pressure, vibration, and skin tension to the CNS. There are three types of mechanoreceptors:

- Tactile receptors: collect and communicate sensations of touch.
- Proprioceptors: communicate the position of the body and movement.
- Baroreceptors: collect and communicate changes in blood pressure.

The **myelin sheath** around the axon of a neuron insulates the pathway (much like the insulation around electrical wire) and increases the speed at which impulses are sent and received. Mechanoreceptors have large myelinated axons, and because of this myelination, the axons of mechanoreceptors are termed low-threshold axons. Low-threshold axons are typically large, conduct faster, and are easier to stimulate electrically. In other words, they are sensitive to stimuli and send rapid feedback to the CNS. High-threshold axons, on the other hand, conduct more slowly and are less sensitive to electrical stimulus.

Integration of Sensory Input

The input collected by receptors is translated into electrical signals or **nerve impulses**. The brain interprets these impulses to perceive sensations, have thoughts, or form memories. The brain makes decisions based on the sensory input it receives at every moment. The way the brain works to affect responses to neural input is known as **sensory integration**.

Motor Function

When sensory input has been integrated by the CNS, efferent signals are sent to the tissues of the body to, for example, generate a muscle contraction or secrete a hormone. These actions are known as motor function.

Motor function includes both voluntary and involuntary muscle contractions. These contractions occur in part because of the firing of a **motor unit**. A motor unit is a single motor neuron that corresponds to a group of contractable muscle fibers. A **motor unit pool** describes a group of motor units that work in conjunction to cause muscle action. When muscle contraction and, thus, **mechanical work** is created, the name given to the standard skeletal muscle fibers is **extrafusal muscle fibers**. The neurons that innervate (supply with nerves) these fibers are called **alpha motor neurons**. These neurons originate in the brain stem and spinal cord and work specifically to initiate muscle contraction.

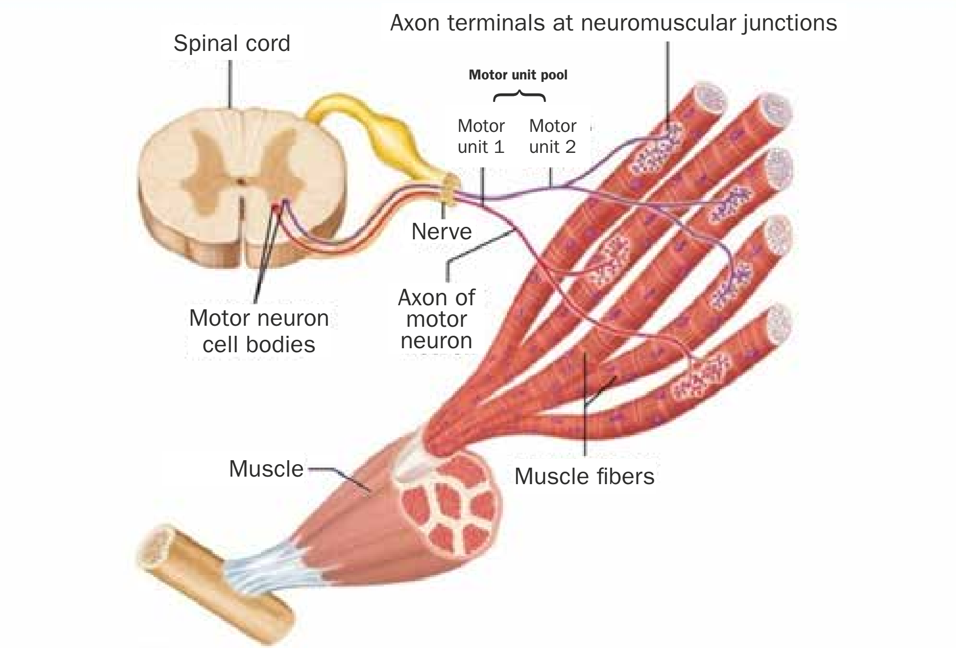


Figure 3.9 Motor Unit Function

The motor units and the skeletal muscles they innervate (supply with nerves) make up the structural elements that create movement. The physiological process they must go through to turn an electrical impulse into a mechanical response is called **excitation-contraction coupling**. A nerve impulse sent to skeletal muscle fibers is called an **action potential**. The action potential causes an interaction between a motor neuron and its associated muscle fibers.

The amplitude—or strength—of a nerve's action potential is independent of the strength—or magnitude—of the stimulus. This is referred to as the **all-or-none principle.** Any stimulus above the neuron's threshold will trigger the same action potential and propagate an electrical signal. In other words, a nerve either fires or it does not. For example, performing a bicep curl with a 5-pound weight, an external stimulus, would initiate a response from the nervous system to fire as many motor neurons needed to lift the 5-pound weight. If the 5-pound weight were to be exchanged for a 10-pound weight, the nervous system response would need to recruit additional motor neurons in order to lift the additional weight. All recruited motor neurons fire at a maximal strength, regardless of the number recruited.

EXCITATION-CONTRACTION COUPLING:
The physiological process of converting a neural impulse into a mechanical response.

ACTION POTENTIAL:
An explosion of electrical activity caused by a neural impulse.

ALL-OR-NONE PRINCIPLE:
The principle stating the strength of a neural electrical signal is independent of the magnitude of the stimulus so long as the neural threshold is achieved.

THE MUSCULAR SYSTEM

Under the control of the motor neurons is the muscular system. There are more than 600 named muscles in the human body contributing to locomotion. They can only pull via contraction and are often found in pairs or groups to allow for the dynamic movement humans can create. These groupings of muscles can work together or in opposition to one another. The speed and intensity of muscle contractions depend upon the type of muscle fiber comprising each muscle.

TYPES OF MUSCLE TISSUE

There are three different types of muscle tissue: cardiac, smooth, and skeletal. All three vary in their cellular structure, location, and function.

Cardiac Muscle Tissue

CARDIAC MUSCLE:
Striated involuntary muscle tissue found in the heart.

Cardiac muscle tissue (striated involuntary muscle tissue) composes the wall of the heart. It functions to contract the heart and pump blood throughout the body. Cardiac muscle cells are often branched and fuse into one another. And their nuclei are more centered compared to skeletal tissue. Fortunately, cardiac muscle tissue does not fatigue easily; the period of rest in between contractions is all it needs. Even during periods of intense exercise, it is the skeletal muscle tissue that fatigues first.

Smooth Muscle Tissue

SMOOTH MUSCLE:
Muscle tissue in the gut and internal organs that is involuntarily controlled.

Certain organs and organ systems in the body need to contract to push food or other substances around the body. **Smooth muscle**, sometimes called visceral muscle, makes up most of these organs. The blood vessels, stomach, intestines, and bladder are all made of smooth muscle tissue. These muscle tissues contract slowly, operate involuntarily, and do not fatigue easily.

Contractions of smooth muscle are triggered by hormones, neural signals from the autonomic nervous system, and local factors. For example, humans do not have to think about pushing food from the stomach to the large intestine; it happens automatically. In some cases, stretching the muscle can trigger contraction.

Skeletal Muscle Tissue

SKELETAL MUSCLES:
The voluntary muscles attached to bones via tendons (thick fibrous connective tissue) that produce human movement.

Skeletal muscles are the most common muscle type in the human body. Skeletal muscle tissue (striated voluntary muscle tissue) is found attached to bones, in extrinsic eyeball muscles, and in the upper third portion of the esophagus (tube that connects the throat to the stomach). This tissue functions to move the bones and eyes. It also moves food during the first part of swallowing. Skeletal muscle tissue is made up of long muscle cells (muscle fibers) that bear the unique characteristic of being multinucleate (containing many nuclei). Characteristically, skeletal muscle tissue fatigues easily and cannot sustain prolonged maximal-effort contractions.

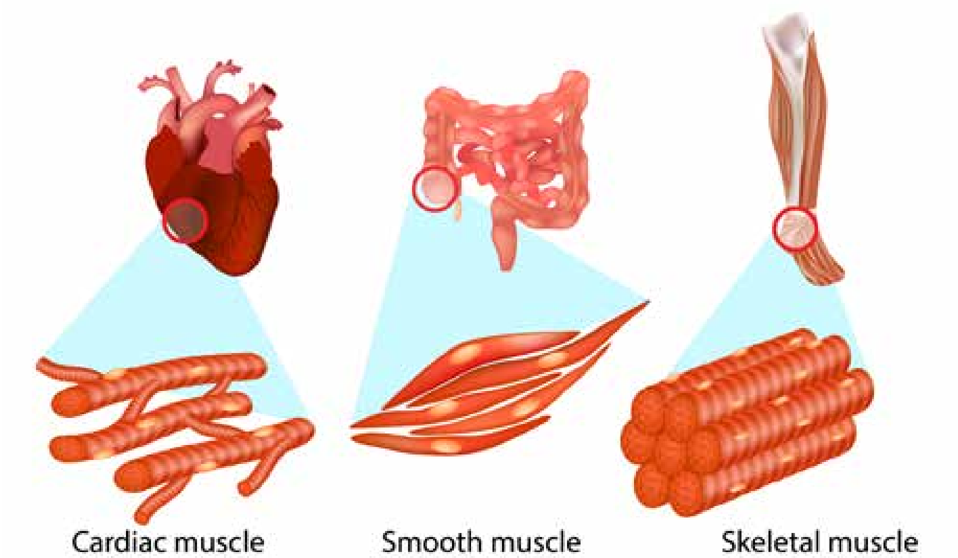


Figure 3.10 Types of Muscle Tissue

STRUCTURE OF SKELETAL MUSCLE

Skeletal muscle is what allows a person to move, exercise, and perform **activities of daily living**. It is made of muscle tissue, **connective tissue**, nerve tissue, and vascular tissue. Muscle fibers are the individual cells making up the muscle.

Most cells in the body are filled with a thick solution inside called cytoplasm; however, muscle cells have **sarcoplasm**, which contains more oxygen-binding proteins and granules of stored **glycogen**. Most of the sarcoplasm within muscle cells is made of **myofibrils**, cylindrical bundles consisting of two types of **myofilaments**:

1. **Actin** filaments have a thin diameter and are made of spirals of actin protein.
2. **Myosin** filaments have a thick diameter and are made of several hundred molecules of myosin protein.

ACTIVITIES OF DAILY LIVING:
The tasks usually performed in the course of a normal day in a person's life, such as eating, toileting, dressing, bathing, or brushing the teeth.

CONNECTIVE TISSUE:
Tissue that supports, connects, or binds other tissues or organs.

SARCOPLASM:
The cytoplasm of a muscle fiber.

GLYCOGEN:
The stored form of glucose found in the liver and muscles.

MYOFIBRILS:
Parallel filaments that form muscle.

MYOFILAMENTS:
The filaments of myofibrils composed of actin and myosin.

ACTIN:
The thin filaments of muscle myofilaments where myosin bind to contract muscles.

MYOSIN:
The thick filaments of myofilaments with a fibrous head, neck, and tail that bind to actin.

SARCOMERE:
The contractile unit of muscle tissue.

Z LINE:
The lateral boundary of the sarcomere where the myofilament actin attaches.

Myofibrils are organized like a chain. Each link in the chain is a contractile unit called a **sarcomere**. The length of a muscle fiber depends upon the length of a sarcomere and the position of the thick and thin filaments. The boundary at either end of the sarcomere is the **Z line**. Actin attaches to the Z line, and it is at the Z line that force transmission occurs.

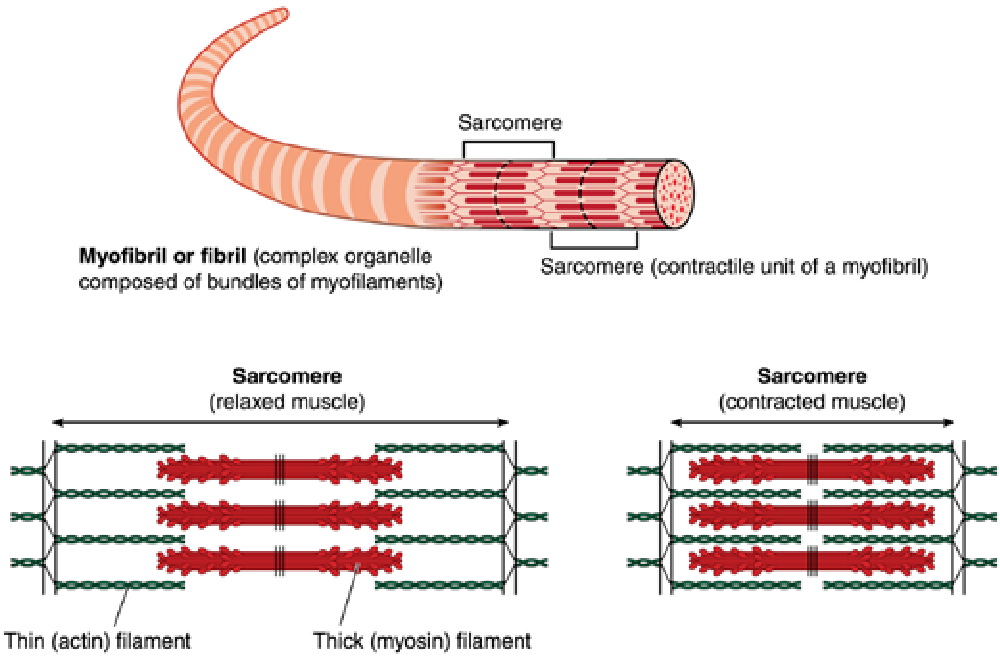


Figure 3.11 The Sarcomere of Skeletal Muscle

ENDOMYSIUM:
The connective tissue covering each muscle fiber.

A skeletal muscle can have hundreds or thousands of muscle fibers. Fibers are bundled together with connective tissue to give support and structure. Each individual muscle fiber is covered by a connective tissue called the **endomysium**. The endomysium helps to create the appropriate environment for the chemical exchange required for muscle contraction. At the molecular level, calcium, sodium, and potassium are exchanged for muscle contraction. Capillaries and nerves also exist in the endomysium to deliver nutrients and remove waste products.

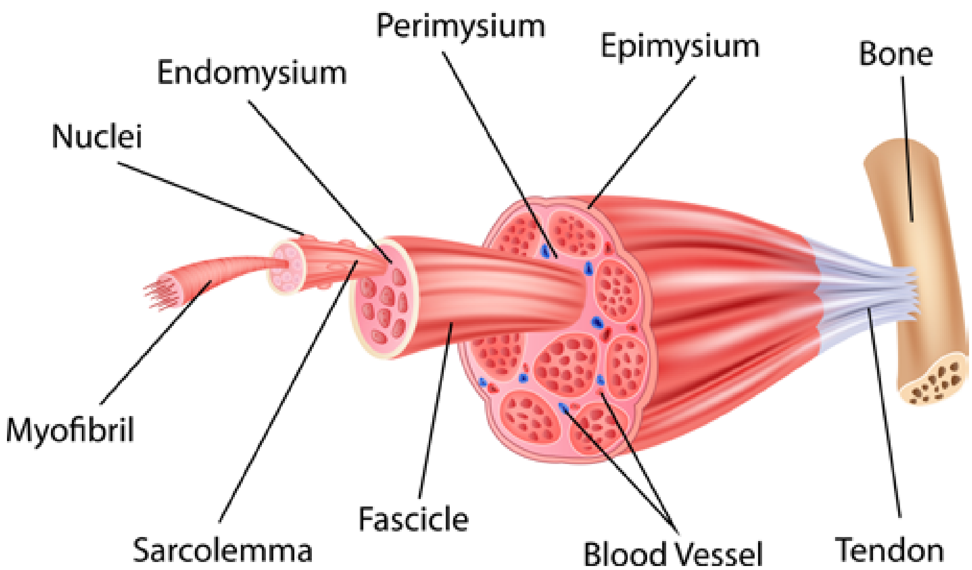


Figure 3.12 The Structure of Skeletal Muscle

The **epimysium** is a fibrous elastic tissue that surrounds a muscle. Within the muscle there are bundles of muscle fibers called **fasciculi**. These bundles are made up of up to 150 individual muscle fibers and are surrounded by a layer of connective tissue called the **perimysium**.

Each connective tissue within the muscle body meets at the site of connection between the muscle and **tendon**, called the myotendinous junction. From here, the tendon extends to the bone for attachment to the **periosteum**.

SKELETAL MUSCLE CONTRACTION

For the musculature of the musculoskeletal system to contract, it must receive a signal from the CNS. These signals (action potentials) travel along the nervous system and eventually connect with muscles via motor neurons. The motor neurons meet with the muscle cell at a synapse called the **neuromuscular junction**, and a unique **neurotransmitter** called **acetylcholine** is released.

EPIMYSIUM:
Fibrous elastic tissue that surrounds a muscle.

FASCICULI:
Bundles of muscle fibers; the singular is "fascicle."

PERIMYSIUM:
The connective tissue that covers a bundle of muscle fibers.

TENDON:
A strong, fibrous cord made of collagen that attaches muscle to bone.

PERIOSTEUM:
A dense layer of vascular connective tissue enveloping the bones except at the surfaces of the joints.

NEUROMUSCULAR JUNCTION:
The space between a motor neuron and muscle fiber.

NEUROTRANSMITTER:
A chemical messenger that transmits messages between neurons or from neurons to muscles.

ACETYLCHOLINE:
The neurotransmitter released by an action potential at the neuromuscular junction.

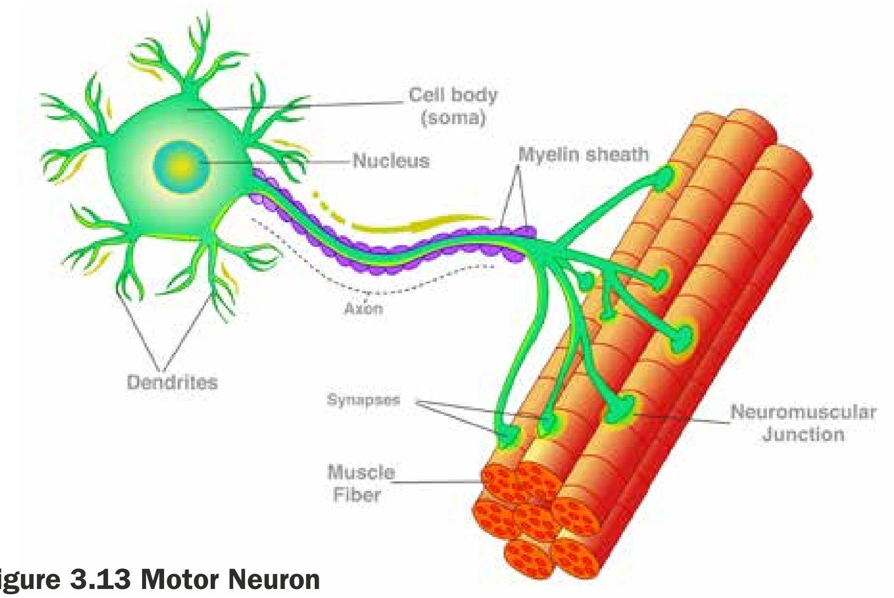
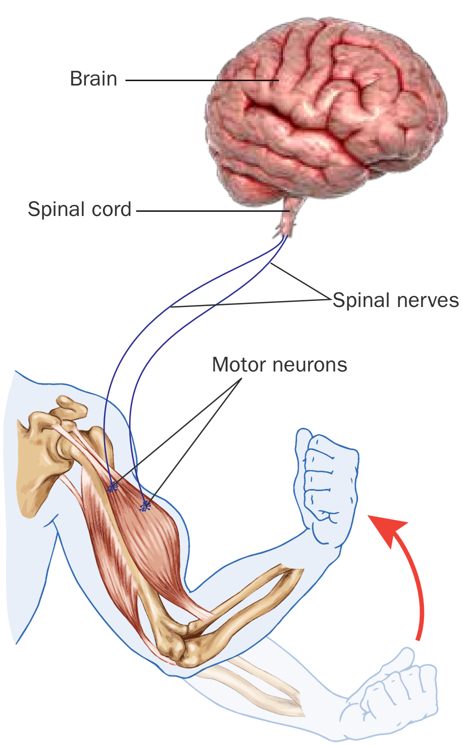


Figure 3.13 Motor Neuron

Acetylcholine attaches to receptors on the outside of the muscle fiber, which starts a multistep chemical reaction, releasing calcium into the muscle cells of the fibers. The presence of calcium and adenosine triphosphate, or ATP (the main energy molecule in cells), is the driving factor for the binding of actin and myosin for muscle contraction.



1. Brain sends out electrical signal
2. Signal travels through the spinal cord
3. To the spinal nerves
4. To the motor neurons
5. Resulting in the propagation of an electrical current through the muscle fiber
6. Electrical signal triggers the release of calcium inside the muscle fiber
7. The released calcium binds to the contractile protein ACTIN
8. This permits its interaction with the MYOSIN contractile protein
9. ATP provides the energy that permits the "walking" of MYOSIN across the ACTIN
10. This pulling action of the MYOSIN across the ACTIN results in the shortening of the muscle fiber during MUSCLE CONTRACTION.

Figure 3.14 Muscle Contraction

An electrical impulse, or action potential, stimulates the release of calcium into the muscle cell, which binds to the actin filaments. This allows interaction and binding with myosin. The myosin can now pull on the actin to begin shortening the muscle. Through a series of contractions, the myosin head pulls across the actin filament, the filaments slide past each other, and this results in muscle contraction. This is known as the **sliding-filament theory** of muscle contraction. The action potential is a limiting factor, which means when the impulse subsides, so does muscular contraction.

SLIDING-FILAMENT THEORY:
The interaction of actin and myosin that describes the process of muscle contraction.

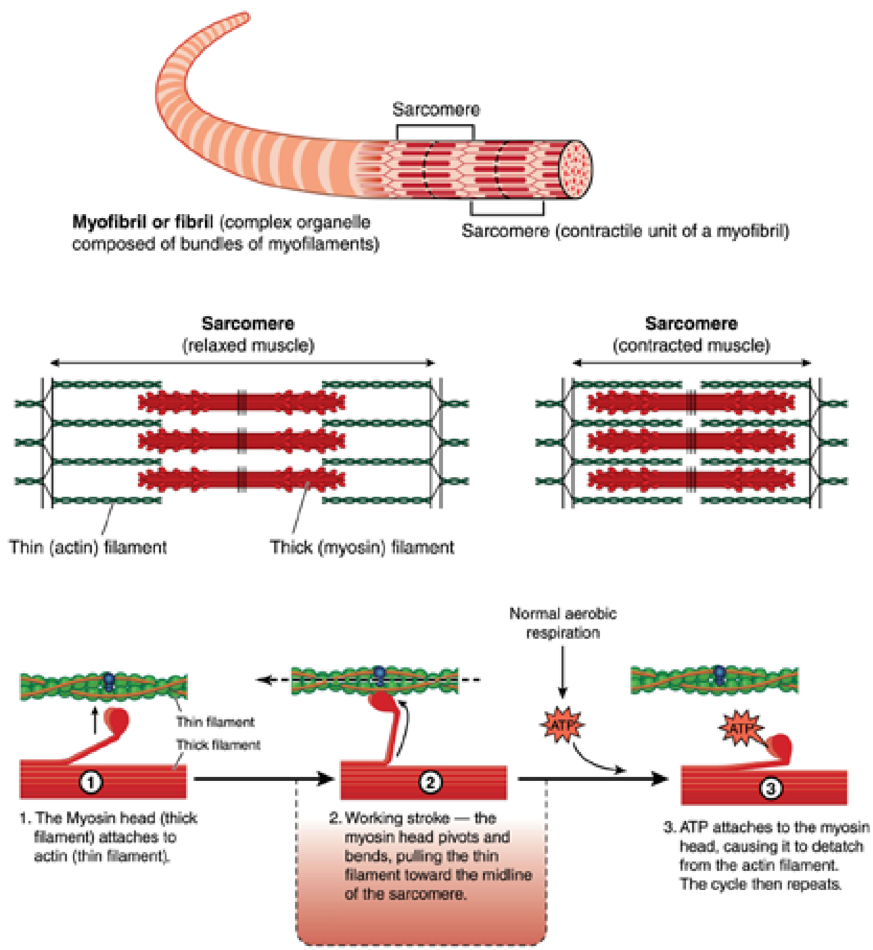


Figure 3.15 Sliding Muscle Filaments

TYPES OF MUSCLE FIBERS

There are two categories of skeletal muscle fibers with different energy needs, capabilities, and purposes in human movement. These two categories are slow-twitch muscle fibers and fast-twitch muscle fibers. The activity, and the intensity of the activity, determines which muscle fiber type is utilized most.

Slow-Twitch Muscle Fibers

TYPE I FIBERS:
Slow-twitch, fatigue-resistant muscle fibers with high mitochondrial density.

MITOCHONDRIA:
An organelle with a double membrane and many folds inside responsible for generating the chemical energy needed for biochemical reactions.

Slow-twitch or **type I fibers** have a lot of **mitochondria**, the component of a cell that is most noted for energy production and sometimes referred to as "the powerhouse of the cell," and a high concentration of myoglobin (an oxygen-storing protein in muscle) and other oxygen-metabolizing enzymes. Slow-twitch muscle fibers derive energy from aerobic metabolism (energy made in the presence of oxygen) and are ideal for endurance and low-intensity activities of longer duration. Often called oxidative fibers, type I fibers contract relatively slowly, and are highly fatigue resistant.

Fast-Twitch Muscle Fibers

TYPE IIA FIBERS:
Fast-twitch, moderately fatigable muscle fibers with moderate mitochondrial density.

TYPE IIX FIBERS:
Fast-twitch, fast-fatigable muscle fibers with low mitochondrial density.

Fast-twitch fibers contract quickly and with greater force than slow-twitch fibers. Fast-twitch muscle fibers are further divided into **type IIa fibers** and **type IIx fibers**. They are selectively recruited for high-intensity activities requiring strength and power. Type IIa fibers fatigue relatively quickly but have a moderate mitochondrial density, meaning they can contract through most intermittent athletic activity and recover well. They derive energy from anaerobic metabolism (energy made without the presence of oxygen), do not require oxygen to function, and are ideal fibers for longer bouts of anaerobic movement.

Type IIx muscle fibers are also fast-twitch fibers that fire with great power and strength. Known as super fibers, these type II fibers fatigue slightly faster than IIa fibers. Type IIx fibers have a much lower capillary density (giving them a white color versus the pink color of the type IIa fibers) and a low mitochondrial density, which contributes to their high fatigue rate.

Individuals who participate in endurance activities generally have more type I muscle fibers, while those who participate in power and intermittent sports have more type II muscle fibers.

Table 3.3 Sports and Muscle-Fiber Recruitment

TYPE I MUSCLE FIBER DOMINANT ATHLETES	TYPE II MUSCLE FIBER DOMINANT ATHLETES
Cross-country runners	Weightlifters
Triathletes	Gymnasts
Distance swimmers	Baseball players
Cyclists	Paddle sport players
Nordic skiers	Wrestlers

Size Principle of Motor Recruitment

The force (strength or energy) output of a muscle is related to the stimulus it receives. Different muscle fibers have different liability to recruitment. This liability refers to how easily and quickly muscle fibers can be recruited. The higher the liability, the more likely a muscle fiber will fire more easily and quickly when compared to a lower liability muscle fiber. Type I fibers, also known as slow-twitch fibers (i.e., the smaller slower fibers) have high liability to recruitment, while type IIa and IIx, also known as fast-twitch fibers (i.e., larger, faster fibers) have a moderate liability. The **size principle of fiber recruitment** (also called the Henneman principle) states that fibers with a high level of liability are recruited first and that those with lower levels of liability are recruited last. According to the size principle, motor units are recruited in order according to their recruitment thresholds and firing rates. In other words, motor units will be recruited in order from smallest and slowest firing rate to largest and fastest firing rate. Since most muscles contain a range of type I and type II fibers, force production can be very low or very high. Therefore, to get to a high-threshold motor unit, all the motor units below it must be sequentially recruited first. Picking up the phone versus curling a 75-pound dumbbell exemplifies this principle. The lower-threshold motor units are recruited to pick up the phone. In order to pick up the 75-pound dumbbell, the higher-threshold motor units must be recruited in addition to the low-threshold motor units.

SIZE PRINCIPLE OF FIBER RECRUITMENT: Principle stating that motor units are recruited in order according to their recruitment thresholds and firing rates.

MUSCLE FIBER ARRANGEMENT

The arrangement of skeletal muscle fibers, or the direction in which they run, influences the action they have on the skeleton and the movement they create.

Fusiform muscle are spindle-shaped with a large muscle belly like the biceps muscle, while **convergent muscle** (also called triangular muscle) is broad on one end with fibers converging and narrowing on the other end, like the pectoralis major (chest). **Circular muscle** surrounds external openings of the body, which are sometimes referred to as sphincters.

FUSIFORM MUSCLE: Spindle-shaped muscle.

CONVERGENT MUSCLE: Muscle fibers converging from a broad origin (fixed point where the muscle attaches closest to the torso) to a single tendon of insertion (fixed point where the muscle attaches furthest from the torso).

CIRCULAR MUSCLE: Muscle fibers surrounding an opening in the body.

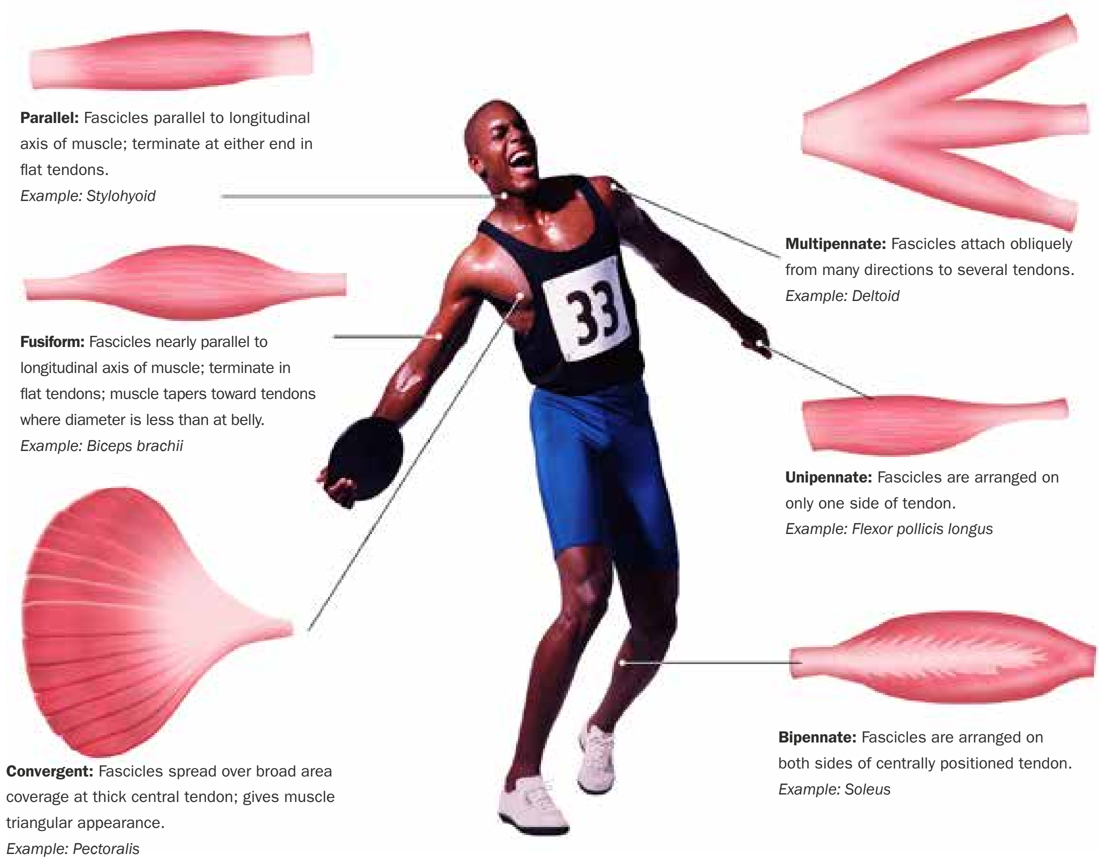


Figure 3.16 Patterns of Muscle Fiber Arrangement

PARALLEL MUSCLE:
Muscle fibers running parallel to the axis of the muscle.

PENNATE MUSCLES:
Muscles with fascicles that attach obliquely (diagonally).

PENNIFORM:
Muscle fibers that run diagonally in respect to the tendon similar to a feather.

UNIPENNATE MUSCLE:
Muscle fibers extending from one side of a central tendon.

BIPENNATE MUSCLE:
Muscle fibers extending from both sides of a central tendon.

MULTIPENNATE MUSCLE:
Muscle fibers extending from both sides of multiple central tendons.

Parallel muscle fibers run parallel along the axis of the muscle, like the sartorius, a long muscle in the thigh. There are also several forms of **pennate muscles** that attach to a central tendon at an oblique (diagonal) angle. Some fibers are **penniform** and run diagonally in respect to the tendon that runs through its fibers. This arrangement allows for high force production and muscles that produce great power. **Unipennate muscle** has muscle fibers that only attach on one side of the central tendon. **Bipennate muscle** has muscle fibers extending from both sides of the central tendon in a feather-like pattern. Finally, **multipennate muscle** has multiple central tendons with muscle fibers extending from each in both directions.

MUSCLE ACTIONS

The muscles of the human body are capable of three types of **muscle actions**: concentric, eccentric, and isometric. These are often referred to as muscle actions instead of types of contractions simply because the definition of a contraction does not apply to eccentric and isometric contractions. **Concentric muscle action** is an overall shortening of a muscle as it is producing tension (acceleration of a movement), while **eccentric muscle action** is the overall lengthening of a muscle as it is producing tension (deceleration of a movement). An **isometric muscle action** results in no change in length of a muscle as it produces tension (stabilization of a movement). In order of strength, from strongest to weakest, these contractions are eccentric, isometric, and concentric.

MUSCLE ACTIONS:
Force production by a muscle that can result in a change of length (i.e., shortening or lengthening) or no length change at all.

CONCENTRIC MUSCLE ACTION:
When the length of a muscle shortens as tension is produced.

ECCENTRIC MUSCLE ACTION:
When the length of a muscle increases as tension is produced.

ISOMETRIC MUSCLE ACTION:
When the length of a muscle remains constant as tension is produced.

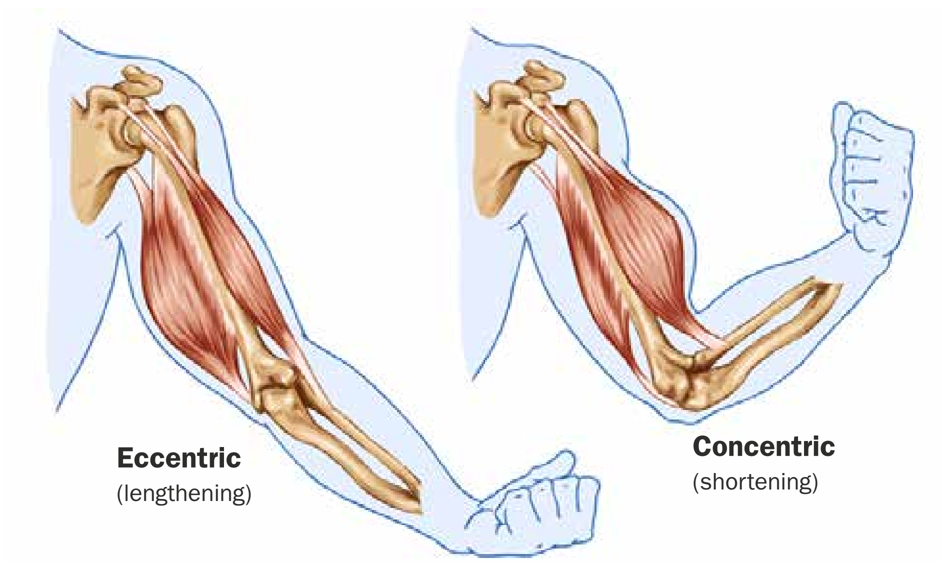


Figure 3.17 Types of Muscle Actions

Muscle tissue has a built-in mechanism that can amplify the concentric muscle action—the **stretch-shortening cycle (SSC)**. Because of the SSC, muscle tissue can load and release force through the elastic properties of the soft tissue - this is like the energy a rubber band can release when quickly stretched and released. There are three phases to the SSC. First is the eccentric or loading phase, followed by the amortization phase (transition phase) and then immediately followed by the concentric phase. When given the right stimulus, skeletal muscle can gain the ability to take advantage of the additional energy created in the loading phase (stretching the rubber band) and release it in the concentric phase. The SSC contributes greatly to explosive movement like jumping, and it can be enhanced with the proper plyometric training.

STRETCH-SHORTENING CYCLE (SSC):
The cycling between the eccentric (stretch) action of a muscle and the concentric (shortening) action of the same muscle.

THE SKELETAL SYSTEM

JOINT:
An articulation between two bones in the body.

The last major organ system involved in human movement is the skeletal system. Structure and support for the human body come from the skeleton and its 206 individual bones. These bones provide a framework for the attachment of muscle tissue, which generates the **joint** movement required for locomotion.

In a fetus, bones begin to form around six weeks gestation, and portions of the skeleton do not stop growing until around 25 years of age. Throughout the lifespan, bones gain and lose density in response to the demands placed on the body, aging, and nutrition.

Figure 3.18 Skeletal System of the Human Body

AXIAL SKELETON:
The bones of the head, trunk, and vertebrae.

APPENDICULAR SKELETON:
The bones of the shoulder girdle, pelvic girdle, and limbs.

THE AXIAL SKELETON

The human skeleton is divided into two parts: the **axial skeleton** and **appendicular skeleton**. The axial skeleton has 80 bones, including the bones of the skull, spine, and ribs.

Figure 3.19 Appendicular Skeleton and Axial Skeleton

Table 3.3 The Bones of the Axial Skeleton

SKULL		
Parietal (2)	Temporal (2)	Frontal (1)
Occipital (1)		
AUDITORY OSSICLES (SMALL BONES OF THE EARS)		
Malleus (2)	Incus (2)	Stapes (2)
FACIAL		
Maxilla (2)	Zygomatic (2)	Mandible (1)
Nasal (2)	Platine (2)	Inferior nasal concha (2)
Lacrimal (2)	Vomer (1)	
VERTEBRAL COLUMN		
Cervical vertebrae (7)	Thoracic vertebrae (12)	Lumbar vertebrae (5)
Sacrum (1)	Coccyx (1)	
THORACIC CAGE		
Sternum (1)	True ribs (7)	False ribs (5)

THE APPENDICULAR SKELETON

There are 126 bones that make up the appendicular skeleton. They include the bones of the shoulder girdle, pelvic girdle, and limbs.

Table 3.4 The Bones of the Appendicular Skeleton

SHOULDER GIRDLE		
Clavicle (2)	Scapula (2)	
PELVIC GIRDLE		
Hip bones (ilium, ischium, pubis) (3)		Sacrum (1)
Coccyx (1)		
UPPER EXTREMITY		
Humerus (2)	Radius (2)	Ulna (2)
Carpals (16)	Metacarpals (10)	Phalanges (28)
LOWER EXTREMITY		
Femur (2)	Tibia (2)	Fibula (2)
Patella (2)	Tarsals (14)	Metatarsals (10)
Phalanges (28)		

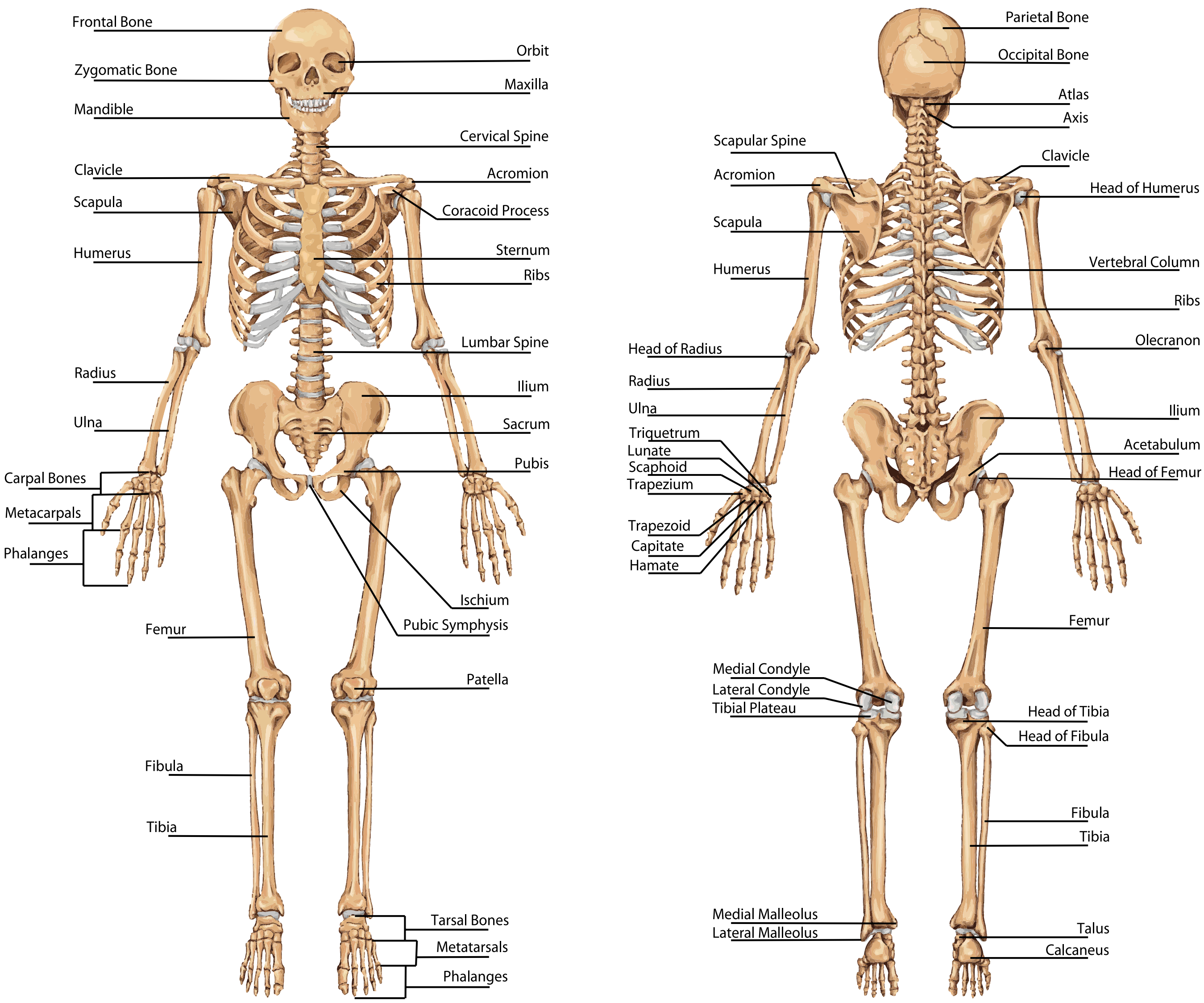


Figure 3.20 Full Human Skeleton

CATEGORIES AND FUNCTIONS OF BONE

The skeletal system plays several important roles within the body. Bones provide support and protection for organs, produce blood cells, store and release minerals and lipids, and provide leverage for movement. There are five types of bone in the human skeleton, each with its own specific function:

1. **Flat bones** protect the internal organs and provide a large surface area for muscles to attach. They are somewhat flat and thin but may be curved, as in the ribs.
2. **Short bones** in the body are cube-shaped and provide stability and a limited

amount of movement. Examples include the carpals (bones in the wrist) and tarsals (bones in the ankle).

3. **Long bones** support body weight and facilitate movement. The long bones are longer than they are wide, a cylinder shape. Examples include the femur (thigh bone), the tibia and fibula (bones of the lower leg), and the humerus (upper arm bone between the elbow and shoulder)
4. **Sesamoid bones** are small and round. Found in the joints and within tendons, they reinforce and protect tendons from stress and wear and tear. The patella (kneecap) is an example of a sesamoid bone.
5. **Irregular bones** serve a variety of purposes, including protecting vital organs. They have complex shapes, like the vertebrae.

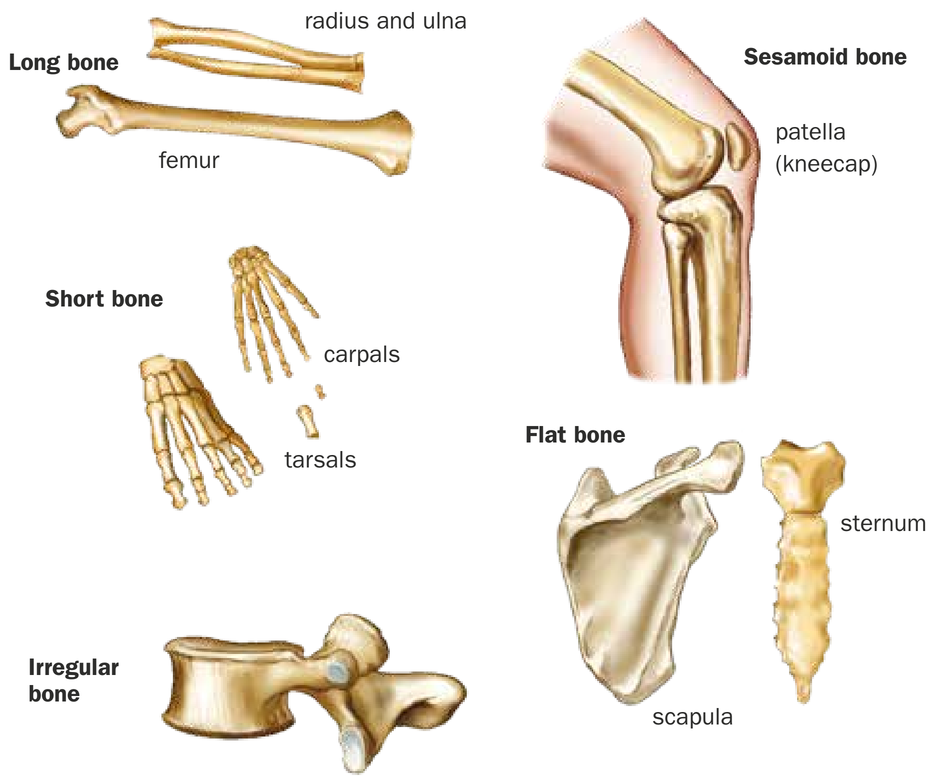


Figure 3.21 Bone Classifications

Table 3.5 Human Bones: Shape, Structure, and Function

	FLAT BONES	SHORT BONES	LONG BONES	SESAMOID BONES	IRREGULAR BONES
Function	Protect organs and provide a large surface area for muscles to attach	Provide stability and limited movement	Support body weight and facilitate movement	Reinforce and protect tendons from stress and wear	Protect organs
Shape	Somewhat flat and thin but may be curved	Cube-shaped	Cylindrical, longer than they are wide	Small and round	Complex and irregular
Location and name	**Skull** Occipital Parietal Frontal Nasal Lacrimal Vomer **Thoracic cage** Sternum Ribs Clavicle **Pelvis** Coxal **Shoulder** Scapula	**Wrist** Scaphoid Lunate Triquetral Hamate Pisiform Capitate Trapezoid Trapezium Carpals **Ankles/Feet** Calcaneus Talus Navicular Cuboid Lateral cuneiform Intermediate cuneiform Medial cuneiform Tarsals	**Lower extremity** Tibia Fibula Femur Metatarsals Phalanges **Upper extremity** Humerus Radius Ulna Metacarpals Phalanges	**Knee joint** Patella **Musculotendon** Flexor tendon of foot Flexor tendon of thumb	**Spinal column** Vertebrae Pelvis Pubis Ilium Ischium

BONE STRUCTURE

Bone is composed of 50 to 70 percent minerals, 20 to 40 percent organic matrix, 5 to 10 percent water, and less than 3 percent lipids (fats). The way bone is structured allows it to provide support and protection as well as store calcium and **bone marrow**.

BONE MARROW:
The soft, spongelike tissue in the center of most bones containing stem cells of red or white blood cells or platelets.

Bone marrow, the spongy tissue in bones, is either red or yellow. Red bone marrow holds stem cells that develop into red blood cells, white blood cells, and platelets, which aid in blood clotting. Yellow marrow stores fat cells for energy. **Cancellous bone** is also known as spongy bone. Spongy bone, however, is not as flexible as the name implies. Rather, this type of bone has open spaces that may house bone marrow. Cancellous bone also supports shifts in weight distribution.

CANCELLOUS BONE:
The meshwork of spongy tissue (trabeculae) of mature adult bone, typically found at the core of vertebral bones and the ends of the long bones.

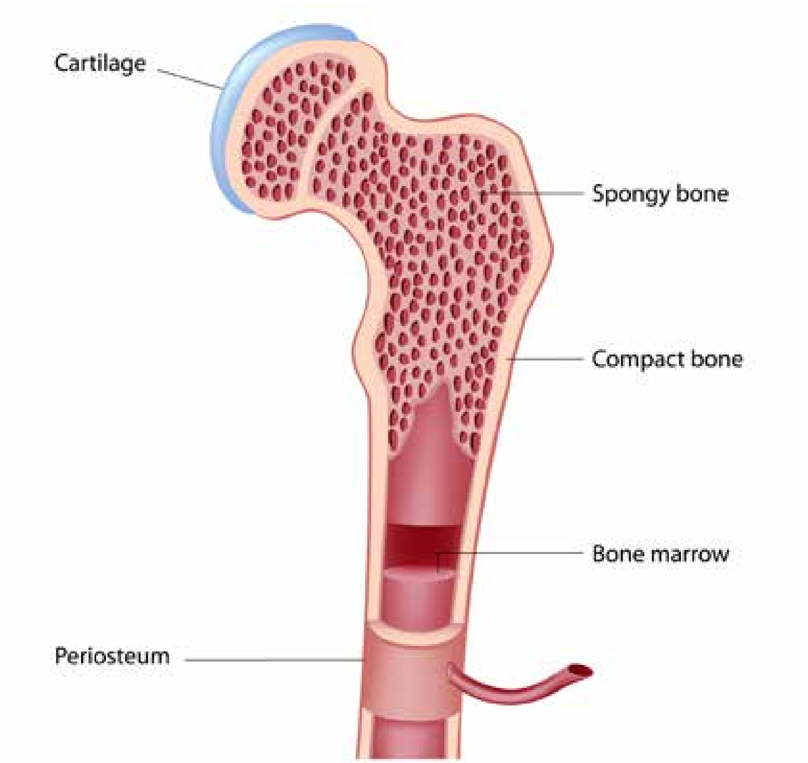


Figure 3.22 Anatomy of Bone

The next layer of bone is dense, porous **compact bone**. Also called cortical bone, compact bone is made of calcium and minerals and can withstand compressive forces. The fibers in compact bone are arranged in a honeycomb pattern, which allows nerves and blood vessels to pass through the honeycomb and supply the bone with oxygen and nutrients. Lastly, covering each bone everywhere except the joints is the periosteum. This is a vascular connective tissue responsible for repairing, protecting, and growing bones.

COMPACT BONE:
A denser material, also known as cortical bone, making up the hard structure of the skeleton.

BONE FORMATION

Bone formation is a constant process. Throughout life, old bone is continually replaced with new bone. This process of bone remodeling or formation is called **osteogenesis**. Cells called osteoblasts play a significant role in this process by depositing new bone material.

OSTEOGENESIS:
The process of bone formation or remodeling.

Some changes in bone are caused by acute trauma like a break or fracture. **Myositis ossificans** occur when bone tissue forms within a muscle or other soft body tissue as a result of a traumatic injury. However, it is not only trauma or injury that can cause bone remodeling. During human growth, bone can be formed as a replacement of connective tissue or to replace **cartilage** based on when and where the formation occurs in the body. Exercise is also considered a stressor and can affect how bone reacts. The added loads and resistance from regular exercise can help to increase bone mass and density in humans. This bone adaptation is explained by **Wolff's law**, which states that changes in form and function of a bone will be adaptive to the loads placed upon it. In other words, strength training helps to build stronger bones.

MYOSITIS OSSIFICANS:
A condition when bone tissue forms within a muscle or other soft tissue as a result of trauma or injury.

CARTILAGE:
Firm, flexible connective tissue that pads and protects joints and structural components of the body.

WOLFF'S LAW:
The explanation for bone adaptations as a result of the loads placed on them.

JOINTS IN THE HUMAN BODY

One additional and crucial component of human movement is the articulation point between two bones—a joint. The joints in the body are what allow movement to occur. Joints are classified by the type of tissue they contain: fibrous, cartilaginous, or synovial.

Fibrous joints are connected by dense connective tissue made of collagen. They allow for very little movement. Fibrous joints can be further divided into three types:

FIBROUS JOINTS:
Joints with fibrous connective tissue joining two bones that allow for very little movement.

1. **Sutures or synarthrodial joints:** This type of joint is found in the skull. During birth, sutures are flexible to allow the baby to pass through the birth canal, and they become more rigid with age.
2. **Syndesmoses:** found between some long bones like the tibia and fibula.
3. **Gomphosis joints:** attach teeth to the sockets of the maxilla and mandible.

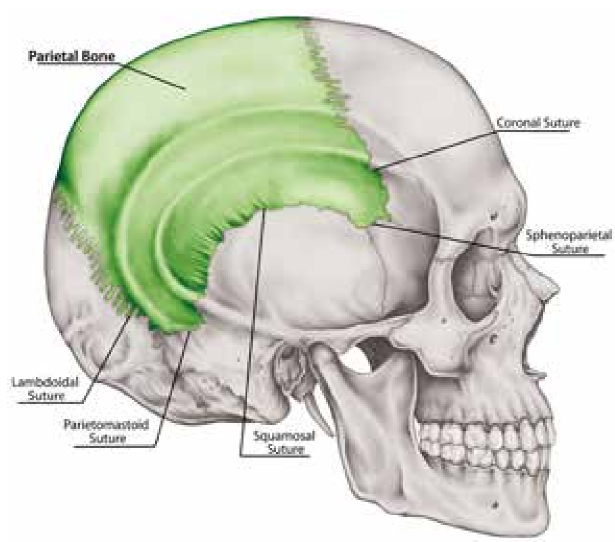


Figure 3.23 The Sutures of the Skull

CARTILAGINOUS JOINTS:
Moderately movable joints made of fibrocartilage or hyaline cartilage.

Cartilaginous joints are joined by either fibrocartilage, the most rigid and strong cartilage, or hyaline cartilage, which is softer and more widespread. Cartilaginous joints are slightly movable and are further divided into primary and secondary joints:

1. **Primary:** epiphyseal (growth) plates
2. **Secondary:** intervertebral discs (layers of cartilage between vertebrae)

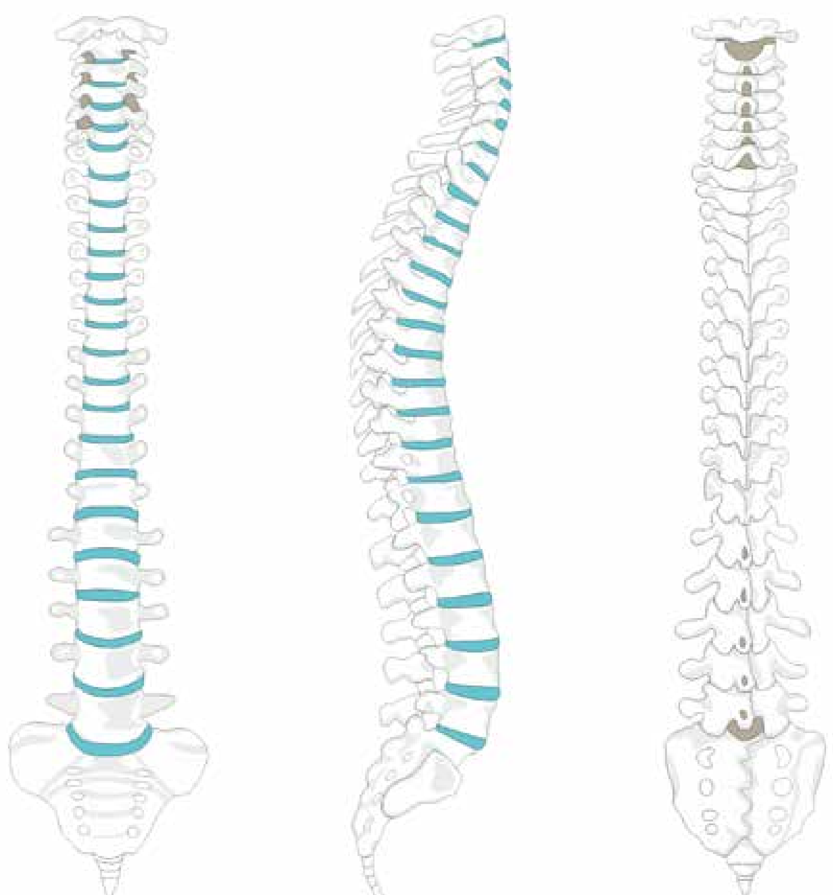


Figure 3.24 Cartilaginous Joints: Intervertebral Discs (Blue)

SYNOVIAL JOINTS:
Fluid-filled joints found between bones that move against one another.

NON-SYNOVIAL JOINTS:
Joints that lack a fluid junction.

ARTICULAR CAPSULE:
The envelope surrounding a synovial joint.

SYNOVIAL FLUID:
A viscous fluid found in the cavities of synovial joints.

The most common and movable joints in the human body are **synovial joints**, also known as diarthrodial joints. **Non-synovial joints**, or synarthroses, are fibrous and cartilaginous and do not allow for much movement. This allows them to provide greater structural integrity. In synovial joints, bones are separated by a synovial joint cavity made of dense, irregular connective tissue. The outside of the cavity, known as the **articular capsule**, is part of the periosteum. The cavities are filled with **synovial fluid** to reduce friction and form a film over joint surfaces, and they are lined by a synovial membrane.

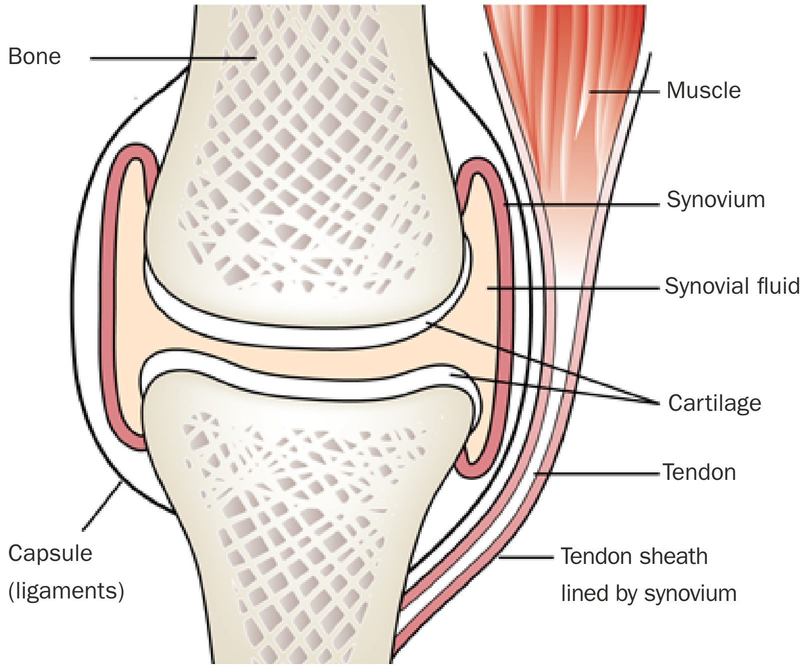


Figure 3.25 The Synovial Joint of the Knee

CLASSIFICATIONS OF SYNOVIAL JOINTS

Synovial joints permit movement and are categorized by the type of movement they allow, known as **arthrokinematics**. Synovial joints are classified into six categories:

> **ARTHROKINEMATICS:**
> The broad term meaning joint motion that can be used in reference to all joint motions.

1. **Ball-and-socket joint:** Also known as an enarthrodial joint, this joint allows a wide range of movement in many directions. Examples are the shoulder and hip joints.
2. **Saddle joint:** The sellar or saddle joints are like ball-and-socket joints but cannot rotate. Examples include the trapezium and the first metacarpal joint (joint between the thumb and wrist).
3. **Hinge joint:** The hinge joints include the elbows, ankles, and knee joints. They allow a wide range of movement in one plane (direction).
4. **Gliding joint:** The arthrodial or gliding joints of the body include the tarsals and metatarsal of the foot. In these joints, two flat bones press up against each other.
5. **Pivot joint:** Trochoidal or pivot joints rotate around a long axis (line that runs parallel to the joint). The radioulnar joint of the forearm is a pivot joint.
6. **Condyloid joint:** Also known as an ellipsoid joint, these joints move in two directions—one direction primarily with a small range in another direction. Rotation is not allowed in these joints. The radiocarpal joint at the wrist is a prime example.

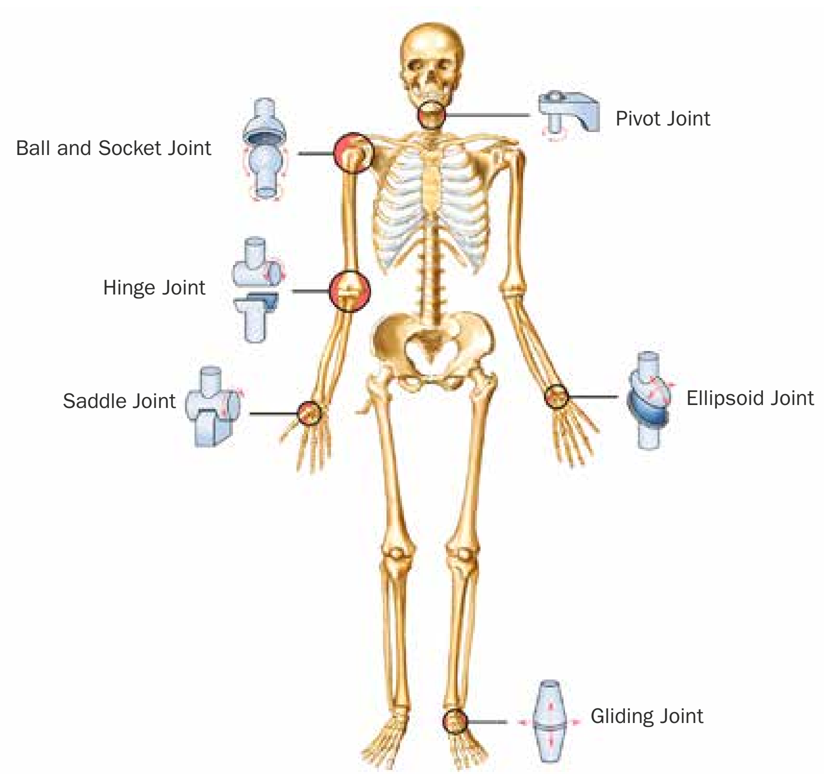


Figure 3.26 Types of Joints

OTHER JOINT CATEGORIES

The relative location of a joint can classify it into one of three other categories: proximal, middle, and distal. Proximal joints, meaning closest to the midline of the body, are the foundation for the legs and arms. Examples include the shoulder and hip. Middle joints are generally hinge joints with a motion primarily moving forward and backward like the knee. Lastly, distal joints, or those joints that are farther from the midline of the body, create a variety of intricate movements. The wrist is an example of a dynamic distal joint.

CLOSE-PACKED JOINT POSITION:
The most stable joint position, when the connective tissue is taut and neighboring bones have the most contact.

LOOSE-PACKED JOINT POSITION:
The less stable joint position represented by any other joint position other than close-packed.

JOINT POSITION

The movability of joints makes them dynamically stable or unstable. The position where bones make contact with one another is referred to as a joint position. In a **close-packed joint position**, a joint is the most stable, connective tissue is taut, and the articulating bones have the greatest area of contact with one another. Full extension of the knee puts the knee joint in a close-packed position. **Loose-packed joint position** describes any possible joint position other than the closed-packed position. This is often during movement when the joint capsule is lax and neighboring bones are not aligned.

TENDONS

Tendons connect muscle to bone and serve as a mechanical bridge to transmit the force created by muscle contraction. When the muscle shortens or contracts, the tendon transfers that force to the bone at an attachment site. The angle and length of attachment of the tendon to the bone affect how the muscle acts on the affected bone.

Tendons are strong, relatively inflexible, and can withstand the force generated by heavy loads without being injured. For example, the flexor tendons of the foot can support a load of more than eight times one's body weight. A muscle alone could not withstand the same amount of tension.

Receptors in the joints, muscles, and tendons provide information to the brain regarding the location in space and speed and force of movement. To prevent injury, tendons contain a proprioceptive sensory organ called the **Golgi tendon organ**. This organ responds to changes in muscle tension. It prevents the overstretching or tearing of a muscle by sensing the rate and force of muscle tension and inhibits muscle action in the same muscle through a **feedback loop**. This differs from the proprioceptive sensory organ within muscle fibers called the **muscle spindle**, which detects the rate and force of muscle stretch but promotes muscle contraction instead of inhibiting it. However, these sensory organs work closely together controlling flexibility and muscle control.

GOLGI TENDON ORGAN:

The proprioceptive sensory organ that senses muscle tension in a tendon and inhibits muscle action.

FEEDBACK LOOP:

The return of a system's output as input for a future action.

MUSCLE SPINDLE:

The proprioceptive sensory organ that senses muscle stretch in a muscle and promotes muscle action.

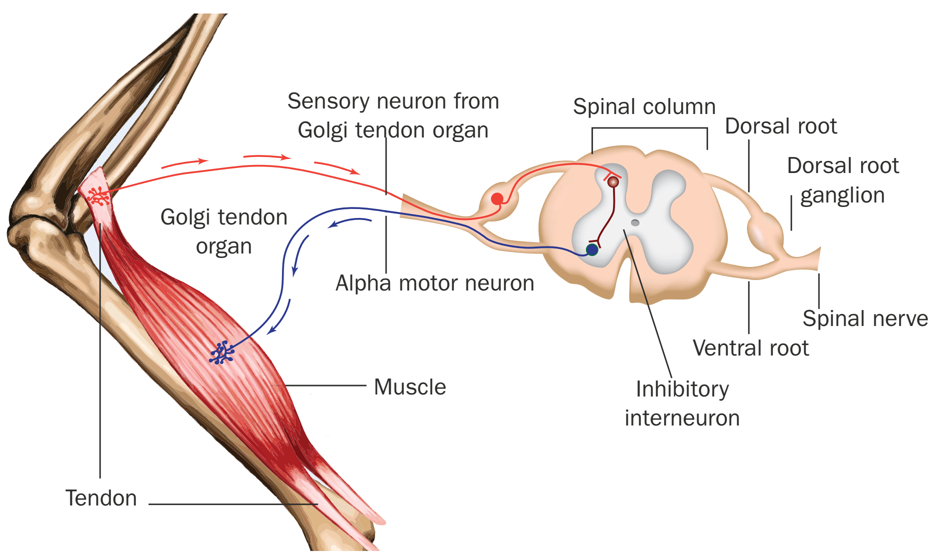


Figure 3.27 Feedback Loop

Tendons appear in many different shapes and sizes in the body, based on their function. Long, thin tendons help with fine motor skills like writing, while short, wide tendons help with power and endurance movements.

LIGAMENTS

LIGAMENTS:
Short bands of tough but flexible fibrous connective tissue connecting two bones or cartilages or holding together a joint.

ELASTIN:
A highly elastic connective tissue allowing many tissues to retain their shape.

VARUS:
An abnormal joint movement away from the midline of the body (i.e., bowlegged).

JOINT CAPSULE:
A thin, strong layer of connective tissue containing synovial fluid in freely moving joints.

VALGUS:
An abnormal joint movement toward the midline of the body (i.e., knock-kneed).

Ligaments are tough bands made of collagen and **elastin** connecting bone to bone, forming joints. They help prevent excessive movement within a joint that may cause damage. The knees, ankles, elbows, and shoulders are all supported by ligaments. If a ligament is injured, torn, or disconnected, the associated joint will become highly unstable.

The location of a ligament can be extrinsic, intrinsic, or capsular with respect to the joints. The knee joint can serve as an example, given it contains all three types of ligaments:

1. **Extrinsic ligament:** This type of ligament is located on the outside of the joint. An example is the lateral collateral ligament (LCL), which resists abnormal movement away from the midline, termed **varus** stress.
2. **Intrinsic ligament:** the anterior cruciate ligament (ACL) and posterior cruciate ligament (PCL) are situated inside the knee joint to resist anterior and posterior (forward and backward) movement of the tibia, respectively.
3. **Capsular ligament:** The medial collateral ligament (MCL) is a capsular ligament, so called because it is continuous with the **joint capsule**. It resists **valgus** stress at the knee by keeping the joint approximated.

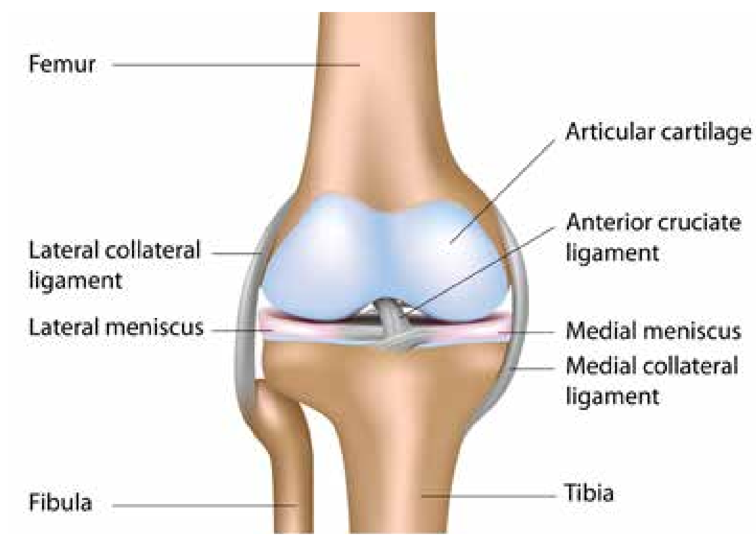


Figure 3.28 The Ligaments of the Knee

Overall, tendons and ligaments are imperative for protecting the body during the demands of a sport. They absorb energy during activities like jumping and cutting and are designed to withstand tension. Both tendons and ligaments can only exert a pulling force, and their tensile strength can be improved with proper training.

CARTILAGE

Cartilage resists compressive forces, makes bones more resilient, and offers support and flexibility in some areas. There are no nerves or blood vessels in cartilage, making cartilage injury recovery a long, arduous process. Removal of waste and absorption of nutrients from and within the tissue happens via diffusion with surrounding tissues.

Like bone, cartilage is covered by a specialized fibrous tissue. The **perichondrium** has an inner layer that forms chondroblasts, which are cells that play a role in making new cartilage, and an outer layer with fibroblasts, which are cells that produce collagen for growth.

Articular cartilage is a connective tissue covering the end of long bones and provides smooth bone-on-bone contact in freely moving joints. When the cartilage is degraded or lost from overuse or aging, bone-on-bone contact results in pain and stiffness at the joint.

The periosteum and endosteum coverings of bone contain pain-sensitive nerve endings called **nociceptors**. Since joint motion should not be painful, articular cartilage covers the ends of moving bones to block the pain signal and reduce compressive stress.

All cartilage is made up of dense collagen fibers embedded in a firm, gelatinous substance. This gives it the consistency of plastic to provide tensile strength while still being more pliable than bone. There are three types of cartilage in the body:

1. **Hyaline cartilage**: This deformable but elastic type of cartilage is the most widespread. It is found in the nose, trachea, larynx, bronchi, and the ends of ribs as well as at the ends of bones in the form of articular cartilage.
2. **Fibrocartilage**: This tough tissue is found in the intervertebral discs and at the insertions of tendons and ligaments. It also forms the lateral or medial **meniscus** in the knee.
3. **Elastic cartilage**: This is the most pliable form of cartilage. It gives shape to the external ear, the auditory tube of the middle ear, and the **epiglottis**.

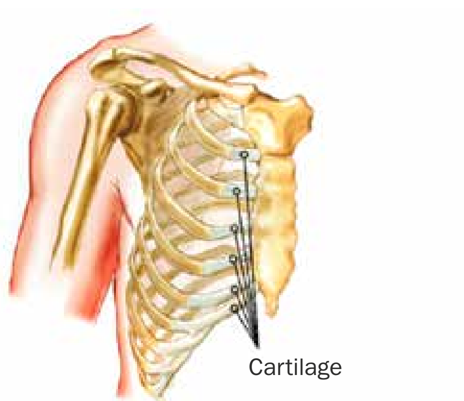


Figure 3.29 Cartilage

PERICHONDRIUM:
The connective tissue enveloping cartilage everywhere except at a joint.

ARTICULAR CARTILAGE:
A form of hyaline cartilage located on the joint surface of bones.

NOCICEPTORS:
Pain-sensitive nerve endings.

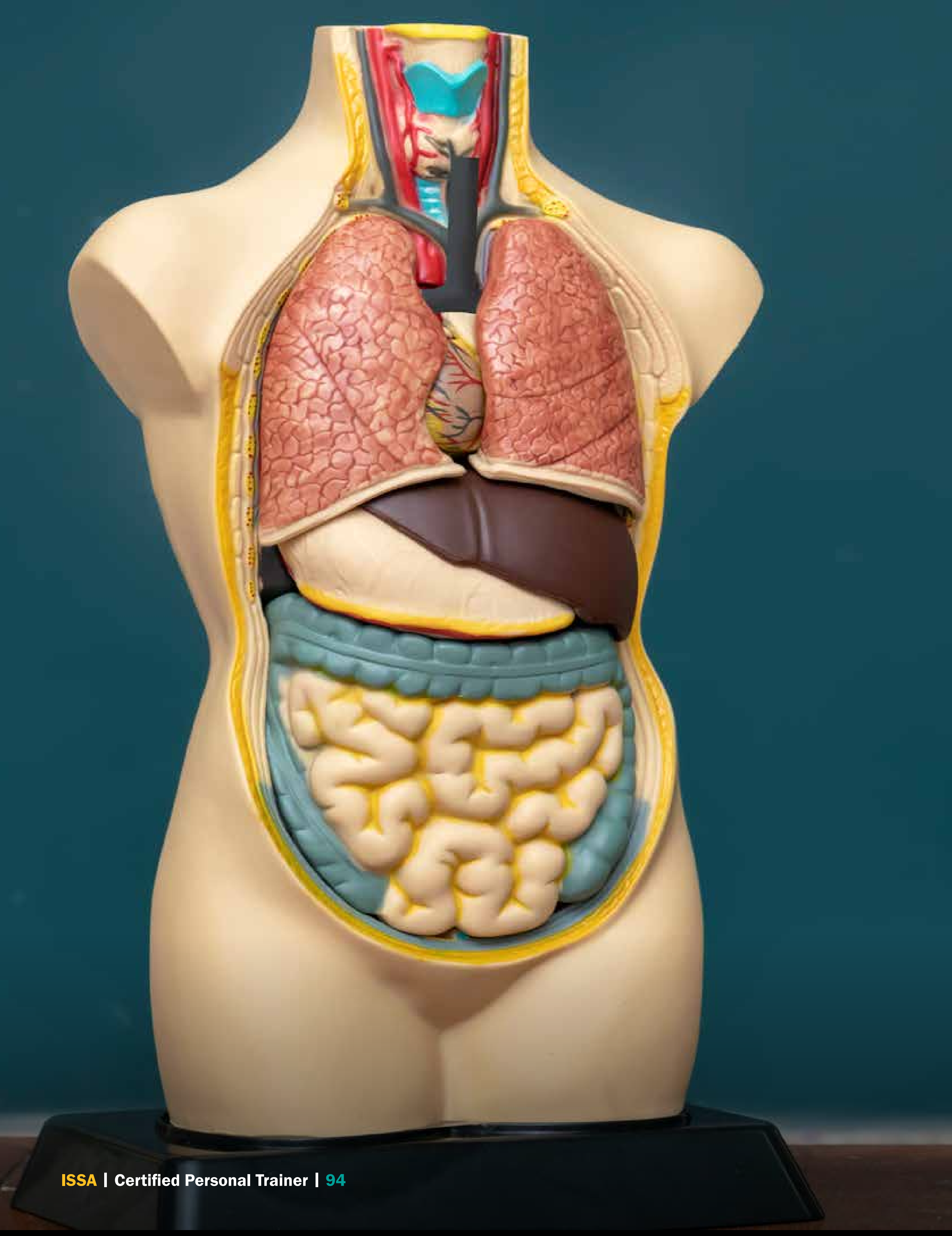
HYALINE CARTILAGE:
A transparent cartilage found on most joint surfaces and in the respiratory tract, which contains no nerves or blood vessels.

FIBROCARTILAGE:
An elastic and tough tissue containing type I and type II collagen.

MENISCUS:
A form of fibrocartilage present in the knee, wrist, acromioclavicular, sternoclavicular, and temporomandibular joints.

ELASTIC CARTILAGE:
Flexible cartilage present in the outer ear, inner ear, and epiglottis.

EPIGLOTTIS:
A piece of elastic cartilage in the throat that opens during breathing and closes during swallowing.



CHAPTER 04

SUPPORTING SYSTEMS

LEARNING OBJECTIVES

1 | Name and describe the body's supporting organ systems outside the nervous, skeletal, and muscular systems.

2 | Differentiate between the types of respiration the body can perform.

3 | List the endocrine hormones and their functions.

4 | Identify the organs of the digestive system and their individual functions.

The human body is a complex and interconnected synergy of 11 organ systems. All organ systems have unique functions that are necessary for proper body function. The nervous, muscular, and skeletal systems work together to generate human movement. However, a fitness professional must also understand the body's other organ systems to understand their importance in overall function, health, and wellness.

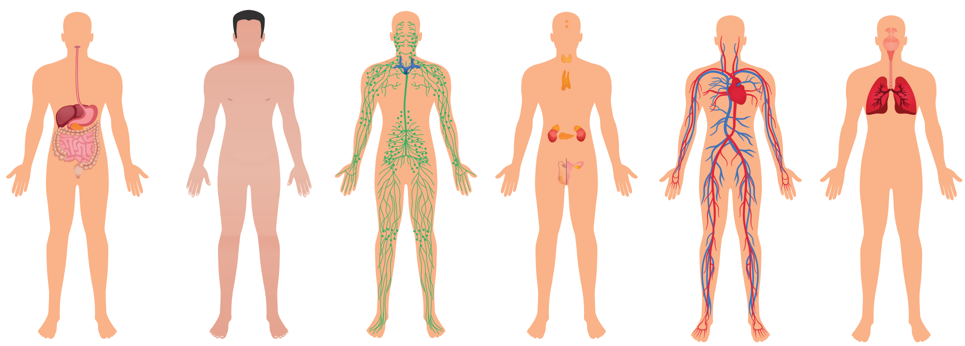


Figure 4.1 Human Organ Systems

Although all organ systems play a critical role in the overall functioning of the human body beyond human movement, systems such as the respiratory, circulatory, and endocrine systems have a direct impact on the responses and adaptations to physical activity and exercise. Organ systems like the reproductive and urinary system are less applicable to the work of a fitness professional.

THE CIRCULATORY SYSTEM

The **circulatory system** consists of the heart, arteries, veins, capillaries, and blood and is responsible for circulating blood throughout the body. The primary function of the circulatory system is to facilitate the exchange of oxygen and carbon dioxide, thereby transporting oxygen from the lungs to the body tissues and moving carbon dioxide from the tissues to the lungs to be excreted. Moreover, this system is considered a **closed system**, circulating the blood within its own vascular system, and, therefore, maintaining blood flow within the organ system itself.

In addition, the circulatory system is also responsible for the transport of nutrients from the digestive system to body tissues and serves as a clearing house for the biochemical waste products resulting from physical activity, such as weight training or aerobic exercise. The **arteries** carry oxygenated blood away from the heart and to the tissues, **veins** carry blood toward the heart to remove waste and pick up more oxygen, and **capillaries** transport nutrients and oxygen or carbon dioxide at the sites of exchange (extremities, organs, and bone marrow).

CIRCULATORY SYSTEM:
A closed system circulating blood through the body, consisting of the heart, blood vessels, and blood.

CLOSED SYSTEM:
A physical system that does not allow for the movement of matter into or out of the system.

ARTERIES:
Blood vessels carrying oxygenated blood away from the heart and to the tissues.

VEINS:
Blood vessels carrying blood toward the heart to remove waste and pick up more oxygen.

CAPILLARIES:
Fine-branching blood vessels forming a network between the arterioles and venules, where transport of nutrients and oxygen or carbon dioxide occurs on a microscopic scale.

Blood vessels are elastic, smooth muscle tissues that expand and contract to facilitate the flow of blood throughout the body. Healthy blood vessels maintain their elasticity and allow blood to flow easily, whereas unhealthy blood vessels lose their elasticity, impede blood flow, and increase the risk for blood clots. However, regular and consistent cardiovascular exercise can help preserve the overall function of the blood vessels.

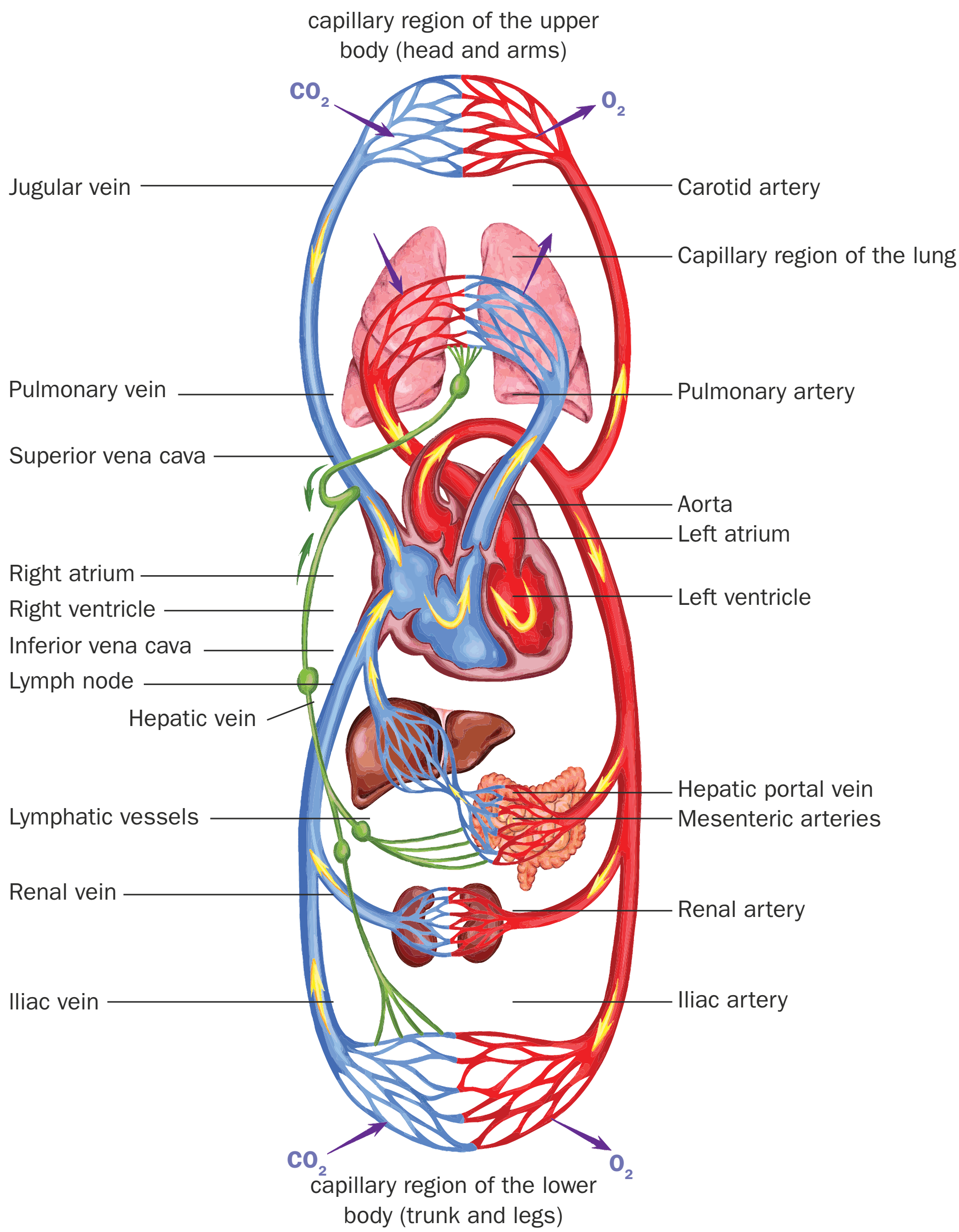


Figure 4.2 Circulatory System

THE CARDIOVASCULAR SYSTEM

The main structures of the cardiovascular system are the blood vessels and the heart. "Cardio" comes from the Greek word "kardia," meaning "pertaining to the heart." "Vascular" comes from the Latin term "vascularis" and means "pertaining to vessels that circulate fluids."

Blood Vessels

ARTERIOLES:
The smaller branches of the arteries leading to the capillaries.

VENULES:
The small branches of the veins gathering blood from the capillaries.

There are five types of blood vessels found in the body. The blood vessels that carry oxygenated blood away from the heart to the body's tissues are the arteries. As the arteries narrow and blood moves farther away from the heart, it enters smaller branches of the arteries called **arterioles**. The arterioles provide approximately 80 percent of the total resistance of blood throughout the body as they further distribute blood to the capillaries. These vessels are so small that a single red blood cell can barely pass through them. After the oxygen has been moved into the body's tissues for cellular use, oxygen-poor blood is transported back to the heart through increasingly larger **venules** before reaching the veins.

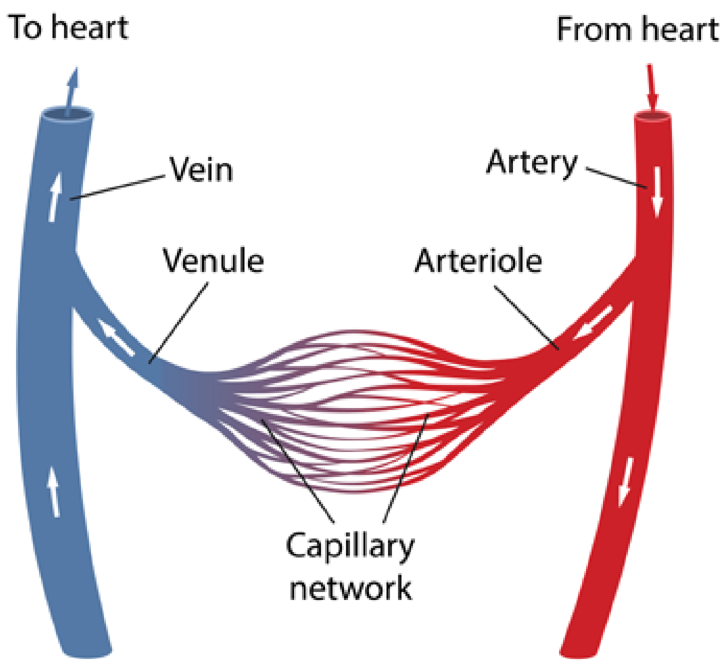


Figure 4.3 The Blood Vessels

The Heart

The heart is a four-chambered organ made of cardiac muscle that is referred to as the myocardium. The left **atrium** and right atrium are the two upper chambers of the heart, while the left **ventricle** and the right ventricle are the two lower chambers of the heart. The right atrium receives deoxygenated blood from the body. It then moves on to the right ventricle, where it is pumped via the **pulmonary arteries** to the lungs to receive oxygen. This oxygenated blood then returns from the lungs via the **pulmonary veins** to the left atrium, where it is moved into the left ventricle through the **aorta** and out to the rest of the body. The aorta is the main artery in the body that supplies oxygenated blood to the circulatory system. Circulation within the heart is known as **pulmonary circulation**, whereas blood flow between the heart and the rest of the body is defined as **systemic circulation**.

The heart beats about 100,000 times per day. For every minute of work, the heart pumps five to six quarts of blood around the body, which is roughly 2,000 gallons of blood pumped per day.

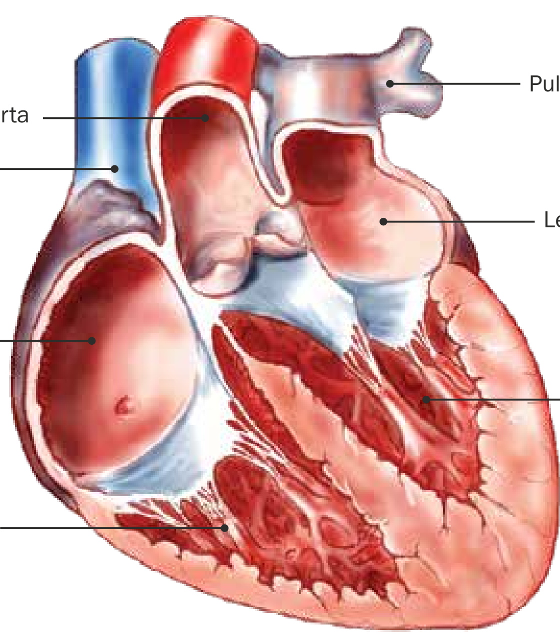


Figure 4.4 Interior View of the Heart

ATRIUM:
One of the two upper cavities of the heart passing blood to the ventricles. The plural is “atria.”

VENTRICLE:
One of the two lower cavities of the heart passing blood to the body or to the lungs.

PULMONARY ARTERIES:
Blood vessels moving blood from the heart to the lungs.

PULMONARY VEINS:
Blood vessels returning oxygenated blood to the heart from the lungs.

AORTA:
The main artery in the body that supplies oxygenated blood to the circulatory system.

PULMONARY CIRCULATION:
The blood flow between the heart and the lungs.

SYSTEMIC CIRCULATION:
The blood flow between the heart and the rest of the body.

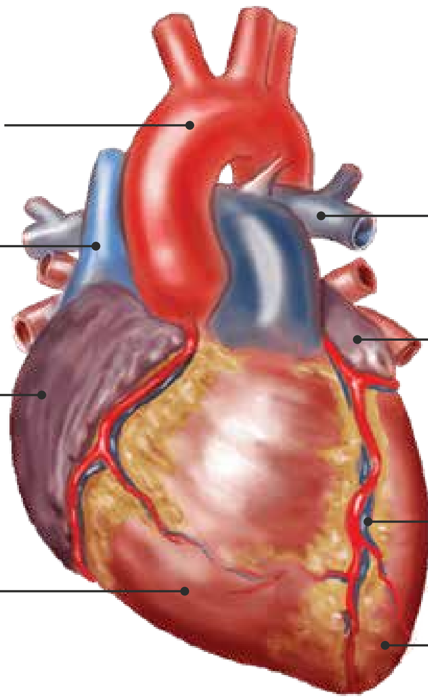


Figure 4.5 Vascularization of the Heart

Oxygen-rich blood returning from the lungs flows from the pulmonary vein into the left atrium of the heart. The atrium contracts, pushing blood down into the left ventricle. When the ventricle contracts, the blood moves through the aorta and out into the body for circulation.

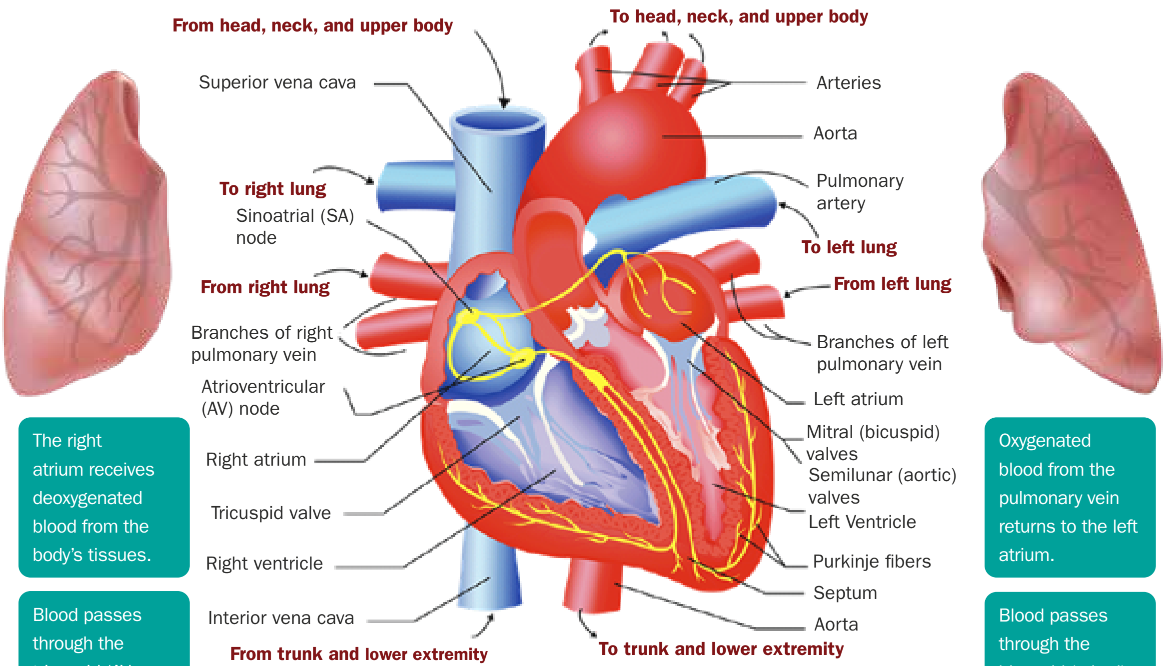
Blood returns from the body to the heart via the **superior vena cava** and the **inferior vena cava**. The superior vena cava carries deoxygenated blood from the arms, head, and upper body, while the inferior vena cava carries deoxygenated blood from the lower body to the aorta. The returning blood is oxygen poor, having distributed oxygen to cells throughout the body to support **metabolism**. The right atrium fills with the deoxygenated blood, which then flows into the right ventricle. From the right ventricle, the blood leaves the heart via the pulmonary artery and travels to the lungs to pick up oxygen and diffuse carbon dioxide out of the body. Between each atrium and ventricle are **atrioventricular (AV) valves** (also called cuspid valves), which keep the blood flowing in one direction.

SUPERIOR VENA CAVA: The blood vessel moving blood from the upper body and head to the heart.

INFERIOR VENA CAVA: The blood vessel moving blood from the lower body to the heart.

METABOLISM: All of the chemical processes that occur in the body to support life including converting food into energy.

ATRIOVENTRICULAR (AV) VALVES: Valves between the atria and ventricles preventing the backward flow of blood during cardiac contractions.



The right atrium receives deoxygenated blood from the body's tissues.

Blood passes through the tricuspid (AV valve) to the right ventricle.

The right ventricle pumps blood into the pulmonary artery.

Oxygenated blood from the pulmonary vein returns to the left atrium.

Blood passes through the bicuspid (mitral) valve to the left ventricle.

The left ventricle ejects blood through the aortic (semilunar) valve into the aorta for transport in the systemic circuit.

Figure 4.6 Chambers of the Heart

TEST TIP!

The heart anatomy can be confusing. Use these tips to remember how blood flows through the heart:

The atrium (plural: atria) receives blood; ventricles pump it out.

Blood leaving the right ventricle will be right back—it moves to the lungs for oxygen before returning to the heart.

Blood leaving the left ventricle has left—it is headed out to the body.

"Tri before you bi"—the tricuspid valve is on the right side of the heart and the bicuspid valve is on the left side. Blood passes through the "tri" before the "bi"—right side, then left.

CARDIAC CYCLE:
The action of the heart from the start of one heartbeat to the beginning of the next.

SYSTOLE:
The heartbeat phase where muscle contraction moves blood from the heart chambers to the arteries.

DIASTOLE:
The heartbeat phase where the cardiac muscle relaxes and the heart chambers fill with blood.

SINOATRIAL (SA) NODE:
The pacemaker of the heart that generates the first electrical signal of a heartbeat and stimulates the atria to contract.

ATRIOVENTRICULAR (AV) NODE:
The nerve node between the right atrium and right ventricle that propagates the electrical signal from the SA node to more distal heart nerves that cause ventricular contraction.

The heartbeat that moves blood throughout the body and through the lungs is an intricate rhythm between the atria and ventricles. A **cardiac cycle** is one alternating cycle of contraction and relaxation of the heart during one heartbeat. The contraction phase is known as **systole**. When the ventricle contracts, it increases the pressure in the blood vessels. The relaxation phase is known as **diastole**. Systole and diastole are controlled by a pathway of nerves that create the consistent, rhythmic heartbeat. Inside the right atrium is the **sinoatrial (SA) node**. The SA node initiates the heartbeat by generating an electrical signal that causes the atria to contract. The electrical signal moves through atria through the nerve pathway to a junction located between the right atrium and right ventricle called the **atrioventricular (AV) node**. When excited, the AV node excites additional nerve branches (bundle of His and the Purkinje fibers) and causes the subsequent contraction of the ventricles. Since the SA node contracts first and its electrical stimulation cascades to cause the ventricular contraction of the heart, it is considered the natural pacemaker of the heart.

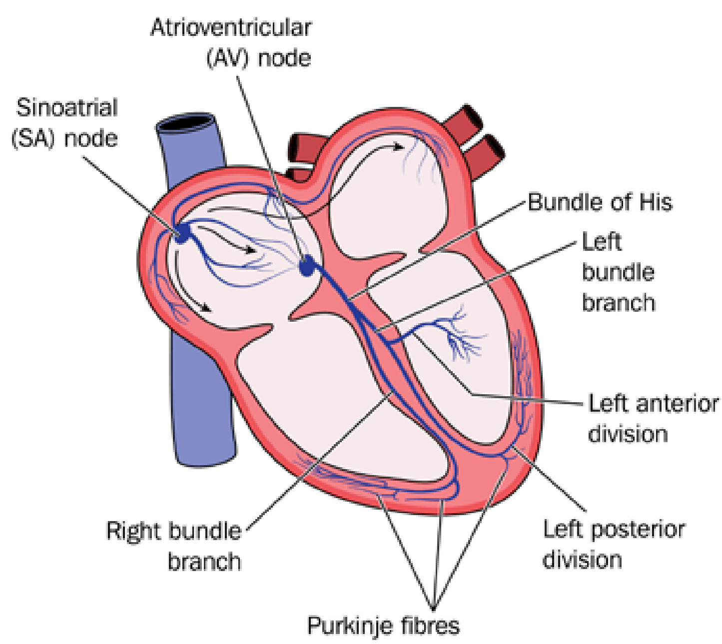


Figure 4.7 The Nerves of the Heart

STROKE VOLUME:
The amount of blood pumped by the left ventricle of the heart in one contraction.

HEART RATE:
The number of heartbeats per minute.

The amount of blood the left ventricle pushes out in one heartbeat is known as **stroke volume**. Exercise strengthens the smooth muscles of the heart and increases stroke volume. The physiological adaptation occurring with cardiovascular exercise causes the heart to beat more efficiently (more slowly) when circulating blood, thus lowering the **heart rate**. The heart rate is the number of beats per minute of the heart. Changes in heart rate are facilitated in the cardiac center of the brain—the medulla oblongata. Here, sympathetic and parasympathetic messages are interpreted, and heart rate is adjusted to meet the oxygen and energy demands of the body. Factors beyond the sympathetic and parasympathetic nervous system such as emotions, ion concentration (e.g., sodium), level of conditioning, and body temperature also influence heart rate.

In unconditioned individuals, stroke volume will likely be lower, while the heart rate both at rest and during activity will likely be higher. This means the heart must beat more times to pump the same volume of blood, and it is pumping faster, which can, over time, lead to weakening of the heart muscle or even heart failure. When the heart pumps faster as with an increased heart rate, this allows less time for the ventricle to fill with blood after each heartbeat, which also reduces stroke volume.

TEST TIP!

Application of Heart Rate and Conditioning

The American Heart Association norms state that resting heart rates can range between 60 beats per minute (bpm) and 100 bpm, depending on the person. A more conditioned individual will have a lower resting heart rate in general. Assuming two people were at complete rest for 24 hours, a comparison of their heart rates may look like this:

Conditioned person:

60 bpm x 60 minutes = 3,600 beats per hour (bph)

3,600 bph x 24 hours = 86,400 beats per day (bpd)

Deconditioned person:

80 bpm x 60 minutes = 4,800 bph

4,800 bph x 24 hours = 115,200 bpd

Even at rest, a deconditioned individual's heart is beating nearly 30,000 more beats per day than a more conditioned person. However, no one is completely at rest 24 hours a day. Ordinary activities of daily living along with additional deliberate exercise will cause the deconditioned heart to beat proportionately faster than a conditioned heart during the same activity. Over the life of the individual, the additional work and strain on the heart of a deconditioned person can be detrimental.

PULSE:
A rhythmical throbbing of the arteries as blood is propelled through them.

BLOOD PRESSURE:
The force of blood pushing against the walls of the arteries during the two phases of the cardiac cycle.

The **pulse** is the rhythmic expansion of the blood vessel each time blood is pushed from the left ventricle. It can be found anywhere an artery is close to the surface of the skin and rests against something solid like a bone, tendon, or ligament. The most common sites to take a pulse are at the radial artery in the wrist and the carotid artery in the neck. **Blood pressure** is a measurement of the force of blood flow within the blood vessels. It is measured using a sphygmomanometer.

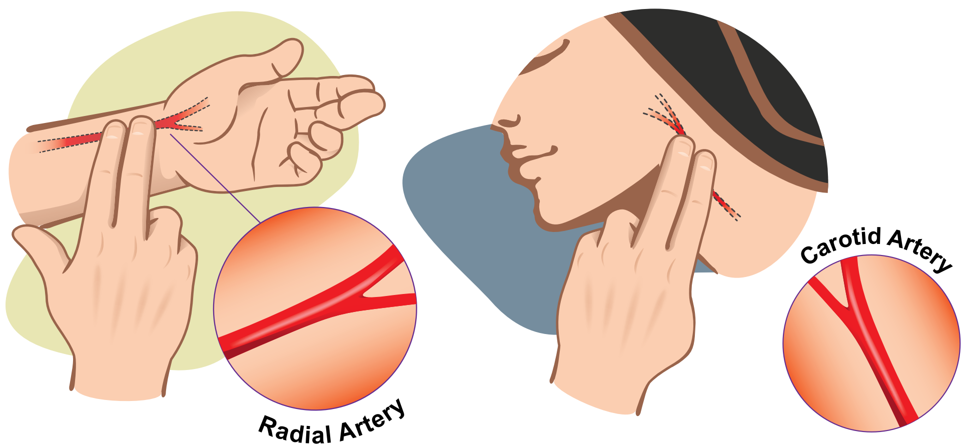


Figure 4.8 Radial and Carotid Artery Pulse

SYSTOLIC:
The pressure in blood vessels when the heart beats (ventricular contraction).

DIASTOLIC:
The pressure in blood vessels when the heart rests (ventricular filling).

HYPOTENSION:
Low blood pressure measuring 90/60 mm Hg or lower.

HYPERTENSION:
High blood pressure measuring more than 140/90 mm Hg.

According to the American Heart Association, normal blood pressure is anything less than 120/80 mm Hg. Blood pressure is written as **systolic** pressure (the pressure during the contraction phase of the heartbeat) over **diastolic** pressure (the pressure during the relaxation phase of the heartbeat). **Hypotension** is the condition of low blood pressure measuring 90/60 mm Hg or less. During hypotension, the brain does not receive enough oxygen, which can cause dizziness or fainting. **Hypertension** is the term for blood pressure measured at or above 140/90 mm Hg. Chronic hypertension can cause health issues like heart disease. Symptoms of hypertension include headaches, vision problems, chest pain, and an irregular heartbeat.

TEST TIP!

To remember which number is where in a blood pressure measurement, remember that the heart has to contract before it relaxes. Systolic pressure is pressure on artery walls during contraction, while diastolic pressure is the pressure when the heart is at rest.

Therefore, systolic/diastolic.

The reading *with* pressure (systolic) will always be bigger than the reading at *rest* (diastolic).

Table 4.1 Blood Pressure Categories

CATEGORY	SYSTOLIC MM HG	DIASTOLIC MM HG
Normal	<120	<80
Elevated	120–129	<80
Pre-Hypertensive (Stage 1)	130–139	80–89
Hypertension (Stage 2)	140+	90+
Hypertensive Crisis	>180	>120

There are four factors affecting blood pressure measurements. When these factors increase, so does blood pressure.

1. **Cardiac output:** how much blood the heart is pumping per minute.
2. **Blood volume:** the total volume of blood contained in the circulatory system.
3. **Peripheral resistance** of arteries: the elasticity (or lack thereof) of artery walls.
4. **Blood viscosity:** the thickness of blood moving through circulation.

CARDIAC OUTPUT: The amount of blood pumped through the heart per minute.

BLOOD VOLUME: The total volume of blood within the circulatory system of an individual.

PERIPHERAL RESISTANCE: The vascular resistance of the arteries to blood flow.

BLOOD VISCOSITY: The thickness and "stickiness" of blood and how it affects its flow through the blood vessels.

Blood

Blood is a specialized type of connective tissue. It is found in all areas of the body, except epithelial tissue, and is approximately 55–60 percent plasma, 40 percent red blood cells, and 2 percent white blood cells and platelets.

Red blood cells are also known as erythrocytes and are, by volume, the most numerous type of blood cells in the body. Their primary function is carrying oxygen from the lungs to the body's tissues. Platelets are irregularly shaped cells found in the blood and the spleen. Their primary function is to help form blood clots to stop bleeding and promote wound healing.

The white blood cells are integral in the body's immune response. There are several types of white blood cells, each with unique functions:

- Basophil—a large white blood cell that locates and destroys cancerous cells and is responsible for the histamine response during an allergic reaction.
- Neutrophil—the most numerous white blood cells (40–70 percent in humans) responsible for the primary immune response of the ingestion or enzymatic digestion of foreign microorganisms.

- Eosinophil—white blood cells that play a role in allergic reactions and immune defense against multicellular parasites.
- Monocyte—an immune cell that helps remove dead or damaged tissues and provides support to the other types of white blood cells.
- Lymphocyte—white blood cells that include natural killer cells, B cells, and T cells, which kill tumor cells, produce **antibodies**, and kill infected or cancerous cells, respectively.

ANTIBODIES:
Blood proteins that combine with other substances in the body to recognize foreign bodies as part of the immune response.

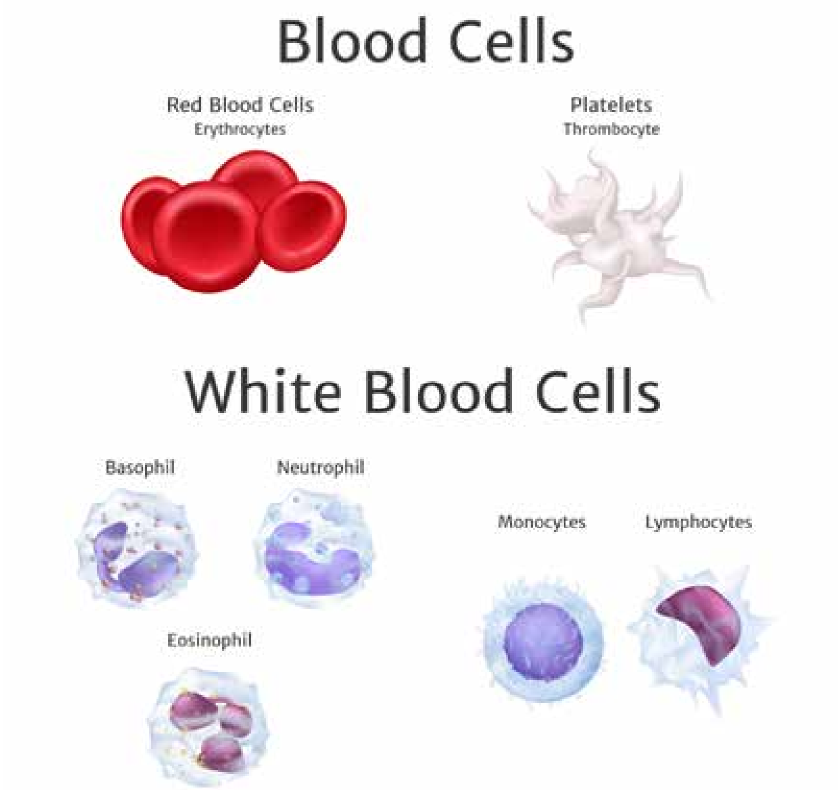


Figure 4.9 Types of Blood Cells

THE LYMPHATIC SYSTEM

The lymphatic system is considered a part of the circulatory system. During exercise, the lymphatic system regulates fluid volume and pressure within the tissues. The major structures of the lymphatic system include the lymph nodes, tonsils, spleen, and thymus. This system contains **lymph**, a colorless fluid surrounding tissues that carries white blood cells. Lymph is created when blood plasma flows through the capillary walls and into the **interstitial fluid** between cells. Approximately 90 percent of the fluid leaving the capillaries is returned via the lymphatic system.

LYMPH:
The colorless fluid of the lymphatic system.

INTERSTITIAL FLUID:
The fluid found between cells.

The key functions of this system include:

- Balancing interstitial fluids
- Absorbing fats and fat-soluble vitamins
- Defending against illness and disease

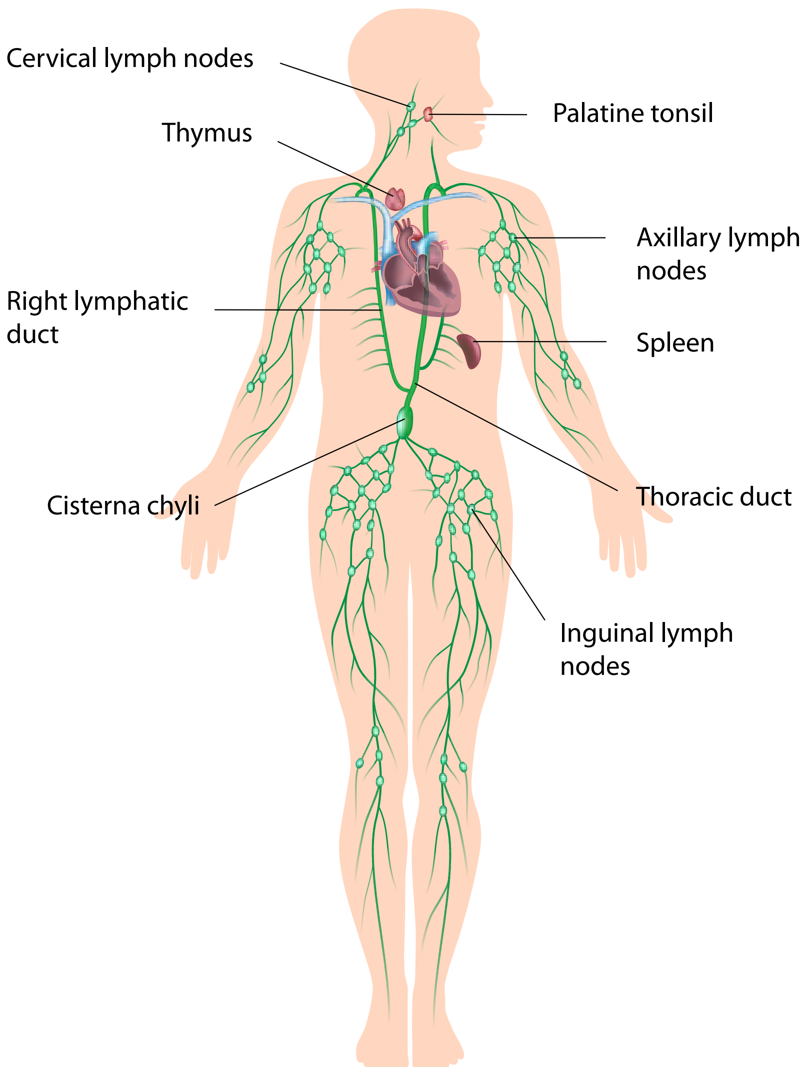


Figure 4.10 The Lymphatic System

Lymph nodes are found throughout the body and help to filter lymph before it is returned to the blood for circulation. The lymph nodes remove diseases (pathogens), create antibodies, generate lymphocytes and store other white blood cells. Antibodies are blood proteins that combine with other substances in the body to recognize foreign bodies such as viruses and bacteria as part of the immune response. The tonsils are clusters of lymphatic tissue found on either side of the back of the throat. They serve to protect the body from any foreign pathogens that may be introduced to the body through the nose or mouth.

The spleen is the largest lymphatic structure in the human body. It filters and serves as a reservoir for blood. In the case of severe blood loss, the spleen contracts to release more blood into circulation. Finally, the thymus serves to manage the immune T cells (lymphocytes that target foreign particles in the body), which travel from the bone marrow to the thymus gland to mature.

THE RESPIRATORY SYSTEM

The respiratory system consists of the following structures:

Nose and nasal cavities: The nose is made of bone and cartilage. Air and particles enter the body through the nose.

Pharynx: The pharynx is commonly called the throat and is a passageway for both air and food.

Larynx: This passageway is between the pharynx and trachea.

Trachea: This is the main passageway of air into the lungs.

Bronchi: This is the passageway of air into the functional tissues of the lungs.

Lungs: The right lung has three lobes, while the left lung has two lobes. The lungs are separated by a membrane partition called the mediastinum, which is where the heart sits.

The primary function of the respiratory system is to bring fresh air into the body while removing waste gases like carbon dioxide. Other functions of this system include:

- Providing oxygen for metabolic processes
- Removing waste products of metabolism
- Regulating the pH of blood

RESPIRATION:
The intake of oxygen and subsequent release of carbon dioxide in an organism.

PULMONARY VENTILATION:
The process of exchange of air between the lungs and the ambient air.

Respiration is the act of breathing and is the process through which the respiratory system completes these necessary tasks. Every few seconds, autonomic nerve impulses initiate inhalation and exhalation—a task that requires no effort or thought in healthy individuals.

Pulmonary ventilation is also known as breathing. When we breathe in, air from the external environment travels through the nose or mouth, down through the pharynx, and past the larynx. The trachea is the main airway to the lungs. From here, the air passageway divides into the left and right bronchi, which supply the left and right lungs with air. Inside the lungs, the bronchi branch into smaller vessels known as bronchioles and eventually to alveoli, the smallest functional pulmonary tissues.

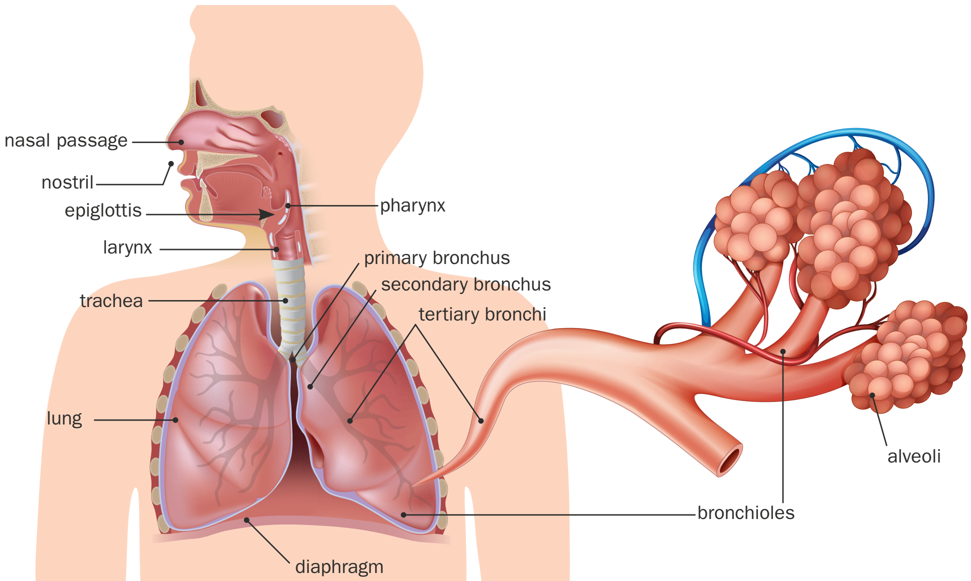


Figure 4.11 Pulmonary Anatomy

PULMONARY VENTILATION

Air moves into the lungs during **inspiration** and out during **expiration**. Inspiration is breathing air into the lungs, while expiration is the exhale of air out of the lungs during a single breath. The movement of air into and out of the lungs is controlled by changes in atmospheric pressure caused by the contraction and relaxation of the **diaphragm**. The diaphragm is the dome-shaped muscle that separates the lungs and pleural cavity from the abdomen and, upon contraction, increases the volume of the lungs to draw air in.

Gases move from areas of high pressure to areas of low pressure in a process called **diffusion**. During inspiration, the diaphragm muscles contract. This pulls the rib cage out and up, increasing the space (volume) inside the **thoracic cavity**. The thoracic cavity is also known as the chest cavity, and it is enclosed by the ribs, sternum, and spinal column. As the volume of the thoracic cavity increases, the pressure within the alveoli—known as **intra-alveolar pressure**—decreases so that air is pulled into the lungs. The opposite is true for expiration as the diaphragm relaxes. The pressure in the alveoli is slightly above atmospheric pressure, and the lungs are slightly elastic, which drives air out of the lungs. Therefore, inhalation is an active process, as muscle contraction is required, while expiration is passive, as the diaphragm relaxes to push air out of the lungs.

INSPIRATION:
Breathing air into the lungs.

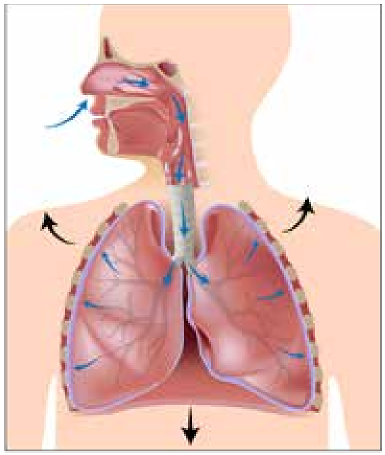
EXPIRATION:
Breathing air out of the lungs.

DIAPHRAGM:
The dome-shaped muscle that separates the lungs and pleural cavity from the abdomen.

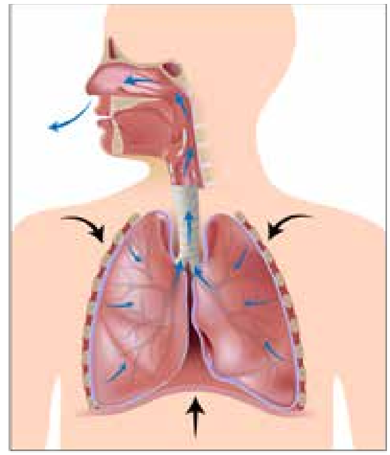
DIFFUSION:
The passive movement of molecules or particles along a concentration gradient or from regions of higher concentration to regions of lower concentration.

THORACIC CAVITY:
The chest cavity enclosed by the ribs, sternum, and spinal column.

INTRA-ALVEOLAR PRESSURE:
The pressure within the alveoli that changes throughout respiration.



Inhalation



Expiration

Figure 4.12 Respiration

External Respiration

EXTERNAL RESPIRATION: The exchange of gases between the lungs and the blood.

The exchange of gases between the lungs and blood is known as **external respiration**, and this exchange occurs at the alveoli. Alveoli are encapsulated by capillaries, which facilitate the exchange of gases between the lungs and the blood. Deoxygenated blood returning to the lungs is high in carbon dioxide and low in oxygen. During inspiration, oxygen from the lungs (high-level concentration) diffuses into the blood, and during expiration, carbon dioxide moves from the blood to the lungs to be excreted. The oxygenated blood following diffusion continues through the circulatory system to deliver oxygen to the necessary organs and tissues.

Internal Respiration

INTERNAL RESPIRATION: The process of diffusing oxygen from the blood into the interstitial fluid and into the cells.

Internal respiration occurs at the cellular level. Following external respiration, oxygen binds to hemoglobin, a protein found in the red blood cells, which carries the oxygen to the cells. As oxygen is delivered to the necessary cells, biomolecular waste products, such as carbon dioxide, are released. Carbon dioxide then binds to the hemoglobin, which carries it back to the lungs to be removed.

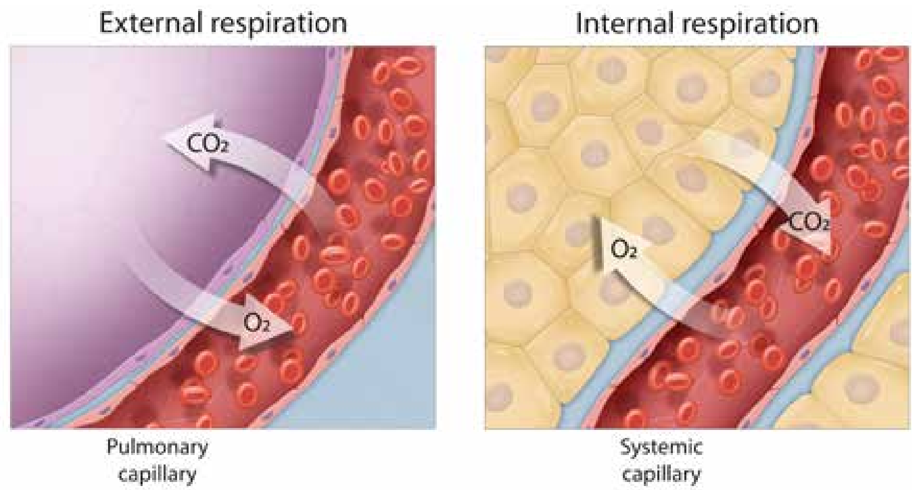


Figure 4.13 External vs. Internal Respiration

THE ENDOCRINE SYSTEM

The endocrine system regulates growth, development, homeostasis, reproduction, and metabolic activities through chemical messengers known as **hormones**. Hormones are stored, created, and released by **endocrine glands** and regulate most bodily functions. The endocrine system is also composed of **exocrine glands**, which produce substances that are released through a duct or opening on the body's surface.

Hormones regulate nearly all our bodily functions. They regulate growth and development, help us cope with both physical and mental stress, and regulate all forms of training responses, including protein metabolism, fat mobilization, and energy production. Resistance training is a natural stimulus that can cause an increase in tissue mass. These adaptations are influenced by the changes in circulating hormonal concentrations as a result of exercise.

HORMONES

Hormones are made of **amino acids**, lipids, or peptides (chains of amino acids). The sex hormones estrogen and testosterone and those secreted by the adrenal cortex (aldosterone and cortisol) are lipid hormones, also known as **steroids**.

Lipid hormones can diffuse across the plasma membrane of cells, while other hormones cannot. Amino acid and peptide hormones must attach to cells with surface receptors that will, once bound, trigger a desired reaction within a cell.

A negative feedback loop is one method of hormone regulation in the body. When a hormone

HORMONES:
Chemical messengers stored, created, and released by endocrine glands.

ENDOCRINE GLANDS:
Ductless glands releasing hormones that remain within the body.

EXOCRINE GLANDS:
Glands that produce and release substances through ducts or openings on the body's surface.

AMINO ACIDS:
Simple organic compounds known as the building blocks of proteins.

STEROIDS:
A class of chemicals characterized by their carbon structure, working to reduce inflammation and the activity of the immune system.

is secreted and received by another cell, that cell sends information back to the endocrine system to stop or reverse the production of that hormone.

Some hormones are controlled by the release of other hormones. For example, the pituitary gland releases corticotropin, which begins the production of cortisol (from the adrenal glands) during stress. Thyrotropin, or thyroid-stimulating hormone (TSH), stimulates the production of hormones from the thyroid.

Other hormones are released after direct neural stimulation. For example, antidiuretic hormone (ADH) is released into the bloodstream from nerve cells in the hypothalamus.

Table 4.2 Endocrine Glands and Their Hormones

HOST	HORMONE	HORMONE FUNCTION	CONTROL OF HORMONE SECRETION	EFFECTS OF EXERCISE ON HORMONE SECRETION
Anterior pituitary	Growth hormone (GH)	Stimulates tissue growth; mobilizes fatty acids for energy; inhibits carbohydrate metabolism	Hypothalamic-releasing factor	↑ with increasing exercise
	Thyrotropin (TSH)	Stimulates production and release of thyroxine from thyroid gland	Hypothalamic TSH-releasing factor; thyroxine	↑ with increasing exercise
	Corticotropin (ACTH)	Stimulates production and release of cortisol, aldosterone, and other adrenal hormones	Hypothalamic ACTH-releasing factor; cortisol	Effects unknown
	Gonadotropin (FSH & LH)	FSH works with LH to stimulate production of estrogens and progesterone by ovaries and testosterone by male testes	Hypothalamic FSH- and LH-releasing factor; female: estrogen and progesterone; male: testosterone	No change
	Prolactin (PRL)	Inhibits testosterone; mobilizes fatty acids	Hypothalamic PRL-inhibiting factor	↑ with increasing exercise
	Endorphins	Block pain; promote euphoria; affect feeding and female menstrual cycle	Stress: physical/emotional	↑ with long-duration exercise

Table 4.2 Endocrine Glands and Their Hormones (CONT)

HOST	HORMONE	HORMONE FUNCTION	CONTROL OF HORMONE SECRETION	EFFECTS OF EXERCISE ON HORMONE SECRETION
Posterior pituitary	Vasopressin (ADH)	Controls water excretion by kidneys	Hypothalamic secretory neurons	↑ with increasing exercise
	Oxytocin	Stimulates muscles in uterus and breasts; important in birth and lactation	Hypothalamic secretory neurons	Effects unknown
Adrenal cortex	Cortisol Corticosterone	Promotes use of fatty acids and protein catabolism; conserves blood sugar: insulin antagonist; has anti-inflammatory effects with epinephrine	ACTH; stress	↑ in heavy exercise only
	Aldosterone	Promotes retention of sodium, potassium, and water by kidneys	Angiotensin and plasma potassium concentration; renin	↑ with increasing exercise
Adrenal medulla	Epinephrine Norepinephrine	Facilitates sympathetic activity, increases cardiac output, regulates blood vessels, increases glycogen catabolism and fatty acid release	Stress stimulates hypothalamic sympathetic nerves	Epinephrine: ↑ with heavy exercise; Norepinephrine: ↑ with increasing exercise
Thyroid	Thyroxine (T4) Triiodothyronine (T3)	Stimulates metabolic rate; regulates cell growth and activity	TSH; whole-body metabolism	↑ with increasing exercise
Pancreas	Insulin	Promotes CHO transport into cells; increases CHO catabolism and decreases blood glucose; promotes fatty acid and amino acid transport into cells	Plasma glucose levels	↑ with increasing exercise
	Glucagon	Promotes release of glucose from liver to blood; increases fat metabolism	Plasma glucose levels	↑ with increasing exercise

Table 4.2 Endocrine Glands and Their Hormones (CONT)

HOST	HORMONE	HORMONE FUNCTION	CONTROL OF HORMONE SECRETION	EFFECTS OF EXERCISE ON HORMONE SECRETION
Parathyroid	Parathormone	Raises blood calcium; lowers blood phosphate	Plasma calcium concentration	↑ with long-term exercise
Ovaries	Estrogen Progesterone	Controls menstrual cycle; increases fat deposition; promotes female sex characteristics	FSH, LH	↑ with exercise; depends on menstrual phase
Testes	Testosterone	Controls muscle size; increases number of red blood cells; decreases bodyfat; promotes male sex characteristics	LH	↑ with exercise
Kidneys	Renin	Stimulates aldosterone secretion	Plasma sodium concentration	↑ with increasing exercise

ENDOCRINE GLANDS

Endocrine glands secrete hormones directly into the blood to be transported to their target tissues. Since they circulate, hormones come in contact with nearly every cell in the body. However, hormones are specific in that they can only act on target cells that have receptors on the cell surface specifically for that hormone.

The major glands of the endocrine system include:

Hypothalamus: The main role of this gland is to maintain homeostasis. It either stimulates or inhibits heart rate, blood pressure, body temperature, fluid and **electrolyte** balance, thirst, appetite, body weight, glandular secretions of the stomach and intestines, the release of substances influencing the pituitary gland, and sleep cycles.

ELECTROLYTE:
Minerals in the body that have an electric charge.

Pineal gland: The only hormone this gland is known to secrete is melatonin.

Pituitary gland: Pituitary hormones control other parts of the endocrine system, including the thyroid gland, adrenal glands, ovaries, and testes.

Thyroid: The main function of the thyroid is to regulate metabolism.

Parathyroid: There are four parathyroid glands that help regulate calcium levels in the body.

Thymus: The thymus is only active until puberty. Before puberty, it stimulates the development of T lymphocytes, which play a role in the lymphatic system's defense against illness and infection.

Adrenal: The adrenal glands are attached to the kidneys and are made up of the adrenal cortex and adrenal medulla. Hormones secreted by the adrenal cortex are essential to life. Those secreted by the adrenal medulla are not.

Pancreas: The main role of the pancreas is to maintain blood **glucose** balance.

GLUCOSE:
A simple sugar the body uses for energy production on the cellular level.

Ovaries: The ovaries secrete hormones essential for female reproductive development and fertility.

Testes: The testes are responsible for maintaining male reproductive health.

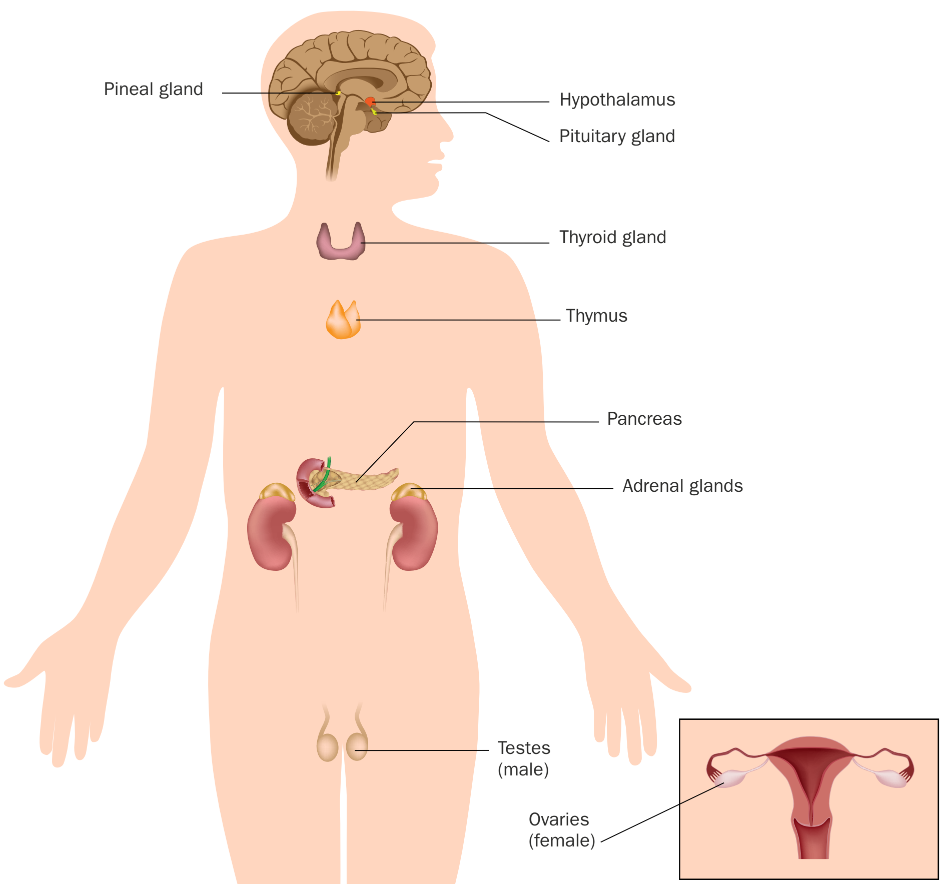


Figure 4.14 Endocrine Glands

HORMONAL RESPONSES TO EXERCISE

Many hormones are sensitive to exercise. These hormones can increase blood glucose (blood sugar) levels, affect the heart rate, and alter muscular force production, contraction rate, and cellular energy production. Some hormones can affect how the muscles repair and grow as well. The primary hormones a fitness professional should be familiar with as they relate to physical activity and exercise include:

- Testosterone
- Growth hormone (GH)
- Insulin-like growth factor
- **Insulin**
- Cortisol
- Catecholamines

INSULIN:
A hormone produced in the pancreas to regulate blood sugar.

TESTOSTERONE:
A steroid hormone found in both males and females.

OSTEOPOROSIS:
A skeletal condition that results in weak or brittle bones.

CATABOLIC:
Metabolic activity involving the breakdown of molecules such as proteins or lipids.

PROTEIN SYNTHESIS:
The process of arranging amino acids into protein structures.

ANABOLIC:
The process of creating larger molecules from smaller units.

GROWTH HORMONE (GH):
A hormone released by the pituitary gland that stimulates growth in animal cells.

INSULIN-LIKE GROWTH FACTORS (IGF):
A protein similar to insulin that stimulates growth of cells.

Testosterone

In mammals, **testosterone** is primarily secreted in the testes of males and the ovaries of females, although small amounts are also secreted by the adrenal glands. It is the principal male sex hormone and is classified as a steroid. In men, testosterone plays a key role in health and well-being as well as in the prevention of **osteoporosis**. On average, an adult human male body produces about 40 to 60 times more testosterone than an adult human female body. However, females are more sensitive to the hormone behaviorally.

Not all exercise protocols elicit increases in the circulating concentrations of hormones in the body. A significant amount of force is required to activate high-threshold motor units not typically stimulated by endurance exercise. Keep in mind, however, high-intensity endurance exercise can have a very dramatic **catabolic** effect. An increase in testosterone may occur to maintain **protein synthesis** to keep up with this protein breakdown. Following an exercise session, remodeling of the muscle tissue begins in the presence of hormonal secretions to stimulate **anabolic** action.

The primary anabolic hormones involved in muscle tissue growth and repair aside from testosterone are **growth hormone (GH)** and **insulin-like growth factors (IGF)**.

Training experience and age of participants also affect testosterone. Research suggests that males under 30 have higher increases in free testosterone as a result of long-term high-intensity training than do females of any age or males over 30.

Growth Hormone (GH)

Secreted from the pituitary gland and made from more than 190 amino acids, growth hormone may:

- Increase protein synthesis
- Increase fat breakdown
- Increase collagen synthesis
- Decrease glucose utilization

Growth hormone secretion is at its peak during adolescence. With good nutrition, sleep, and training, levels of GH can be kept higher later in life. Research suggests that people who maintain higher levels of GH because of exercise in their younger years are more likely to have a healthier body composition later in life.

Many of these hormone actions may be helped by insulin-like growth factor (IGF). Growth hormone stimulates both the release of IGFs and the availability of amino acids for protein synthesis. Without growth hormone, IGF cannot be released by the liver.

The time of day affects the blood secretion levels of GH, with the highest levels observed at night. Like with testosterone, the intensity of training matters regarding the hormonal response of GH in the body. Heavy loads with shorter rest periods are shown to elicit a stronger GH response post-exercise. Growth hormone may have an anti-insulin effect, and research suggests it suppresses the ability of insulin to stimulate the uptake of glucose in tissues and enhances glucose synthesis in the liver.

Insulin-Like Growth Factors

Many of the effects of growth hormone are mediated by insulin-like growth factors from the liver. IGFs travel in the blood attached to binding proteins, then are released as free hormones to interact with receptors on target cells. Fat cells have relatively high levels of IGF in comparison to skeletal muscle, which has very little of its own. With high-intensity training, research suggests that the amount of IGF in the bloodstream and the number of IGF receptors found in the body increase as a prominent training adaptation.

Insulin

Released by the pancreas, insulin increases cellular uptake of glucose-synthesizing muscle glycogen, which in turn decreases blood glucose. Small increases in blood insulin levels will slow or stop the breakdown of fat (adipose tissue) for energy with glucose becoming the primary source. During prolonged workouts, blood glucose reduction along with decreased insulin production can greatly increase the mobilization of fatty tissue for energy production.

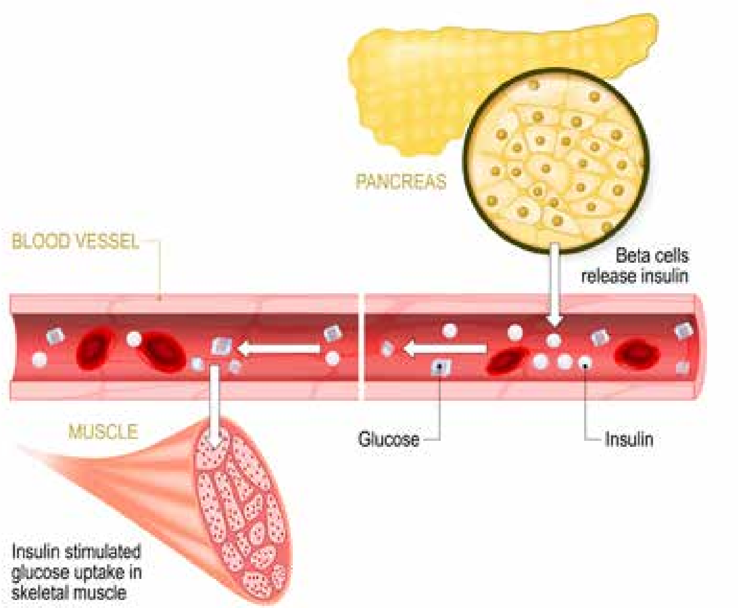


Figure 4.15 How Insulin Works

> **TEST TIP!**
>
> Insulin helps move glucose into the cells. Insulin = IN the cells.

Cortisol

CORTISOL: A catabolic hormone released in response to physical and emotional stress.

Secreted by the adrenal gland, **cortisol** is catabolic and causes a breakdown of protein in the muscles. Cortisol is an antagonist that inhibits glucose uptake and utilization. It has been found to be released during high-intensity exercise and as a stress response (emotional and physical). It has a greater catabolic effect in fast-twitch muscle fibers than in slow-twitch muscle fibers.

KETONE BODIES: Molecules released by the liver in starvation states for an alternate energy source.

KETOSIS: A metabolic process that occurs when the body does not have enough carbohydrates for energy; the liver metabolizes fatty acids to produce ketones as a replacement energy source.

Some research on cortisol and sleep cycles suggests that moderate to low-intensity exercise can reduce blood cortisol levels instead of increasing them. This is largely attributed to the differing levels of physical stress the body undergoes in low intensity versus high-intensity exercise. Also, excess cortisol may cause the body to release **ketone bodies** and bring on a state of **ketosis**. Ketone bodies are typically produced during times of low food intake or starvation to provide an alternate source of cellular energy. However, too many ketone bodies in the blood can cause ketoacidosis, making the blood fatally acidic.

TEST TIP!

Remember that cortisol can be good or bad based on how long it remains elevated.

Short-term cortisol elevation:

- Increases blood sugar (glucose) levels
- Enhances the brain's use of glucose
- Reduces inflammation
- Reduces unnecessary bodily functions during the fight-or-flight response

Extended-duration cortisol elevation:

- Increases appetite
- Increases blood pressure
- Promotes weight gain
- Contributes to type 2 diabetes

Catecholamines

The "fight-or-flight" hormones epinephrine, norepinephrine, and dopamine are released by the adrenal glands in response to stress and are referred to as **catecholamines**. Like with cortisol, epinephrine will increase with heavy resistance training as heavy resistance training is very stressful on the body. Since epinephrine is involved in metabolism, force production, and the rate of response of other hormones such as testosterone and IGFs, the stimulation of catecholamines is likely one of the first hormonal changes in response to resistance exercise.

CATECHOLAMINES: Hormones released by the adrenal glands into the blood as a result of stress.

EXOCRINE GLANDS

Exocrine glands release secretions that are carried to an epithelial or skin surface and secreted via ducts. They allow the body to expel substances that contain mucus, proteins, water, enzymes, and ions. Examples of exocrine glands include the sweat glands, sebaceous glands (secrete oils), mammary glands (secrete milk), and digestive glands producing enzymes and other substances in the digestive tract. Substances secreted from the exocrine glands are non-hormonal in nature, but the production of the secretions is controlled by the release of hormones within the body.

TEST TIP!

Remember that EXOcrine glands secrete substances that EXIT the body, while ENDOcrine glands produce substances that remain within the body.

THE DIGESTIVE SYSTEM

The digestive system collectively breaks down food into smaller molecules for use in energy production at the cellular level. There are six functions the digestive system is responsible for regarding the breakdown of food for energy:

1. **Ingestion:** taking food in through the mouth.
2. **Mechanical digestion:** the process of chewing (mastication) and the churning and mixing actions of the stomach that further break down food.
3. **Chemical digestion:** enzymes released throughout the digestive tract are released to break food into smaller molecules.
4. **Movements:** food moves through the digestive system by the rhythmic contractions of the smooth muscle of the digestive tract—a process known as **peristalsis**.
5. **Absorption:** simple molecules get absorbed by the cell membranes in the lining of the small intestine into blood or lymph capillaries.
6. **Elimination:** the removal of waste products and indigestible particles.

PERISTALSIS:
The muscular contractions of the smooth muscle of the digestive tract, which moves food through the digestive tract.

The digestive tract—beginning at the mouth and ending at the anus—is between four and six meters long in the average adult. Unlike the circulatory system, it is an open system with openings at both ends. Important digestive system components include the:

- Mouth
- Esophagus
- Stomach
- Small intestine
- Large intestine and rectum
- Liver
- Gallbladder
- Pancreas

MOUTH

Food enters the digestive system through the mouth. The mouth has four functions in the digestive process. First, the mouth physically breaks apart food via mastication (chewing) to reduce the size of ingested food pieces. Second, it mixes food with saliva to create a moist mass called a "bolus." Once a bolus is formed, food is ready to be swallowed. Saliva contains digestive enzymes that begin the chemical breakdown of the components of food and provide lubrication as the bolus moves into the esophagus.

Third, the mouth helps to regulate the temperature of food by either cooling it or warming it. This is an important function, as many digestive enzymes function best at certain temperatures. For humans, this range is close to normal body temperature. Finally, the mouth initiates the swallowing of food to move it along the digestive tract.

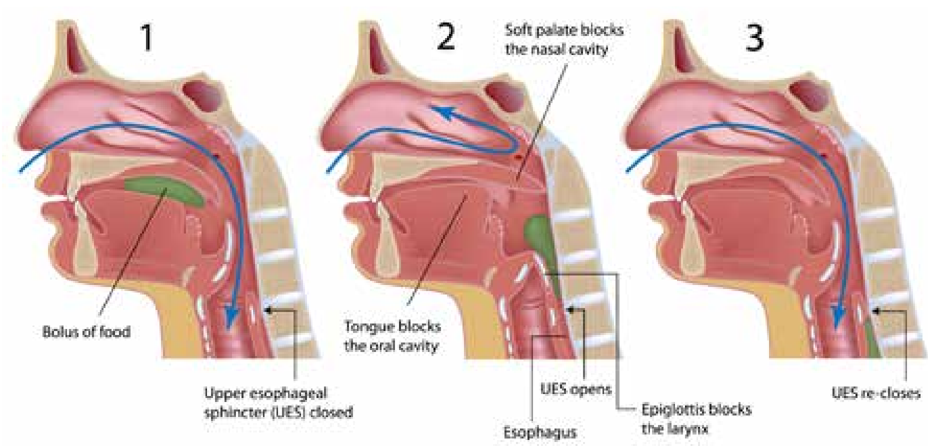


Figure 4.16 Swallowing

ESOPHAGUS

The esophagus extends between the pharynx and stomach and is the transport conduit for food and water traveling to the stomach. When the bolus enters the esophagus, an involuntary wave of muscle contractions is triggered, propelling the food mass down into the stomach. This muscle contraction action is known as "peristalsis." This peristaltic wave travels down the esophagus at the rate of about three inches per second. Once at the base of the esophagus, a ringlike muscle (the esophageal sphincter) is reached, which relaxes to allow the food into the stomach.

STOMACH

The stomach is a muscular sac about two quarts in volume. It is responsible for the storage and gradual release of food into the small intestine, digestion through chemical secretions and the physical activity of churning the digesting food, and transport of ingested food down the gut.

The stomach secretes several types of substances to aid in the breakdown of food. Mucus acts as a protective layer to lubricate the stomach wall and a buffer against acidic secretions. Hydrochloric acid is also secreted in the stomach and helps to keep the stomach relatively free of microorganisms (bacteria) while maintaining the low pH (more acidic) inside the stomach. Hydrochloric acid also acts to catalyze the action of pepsins, which begin the digestion of proteins.

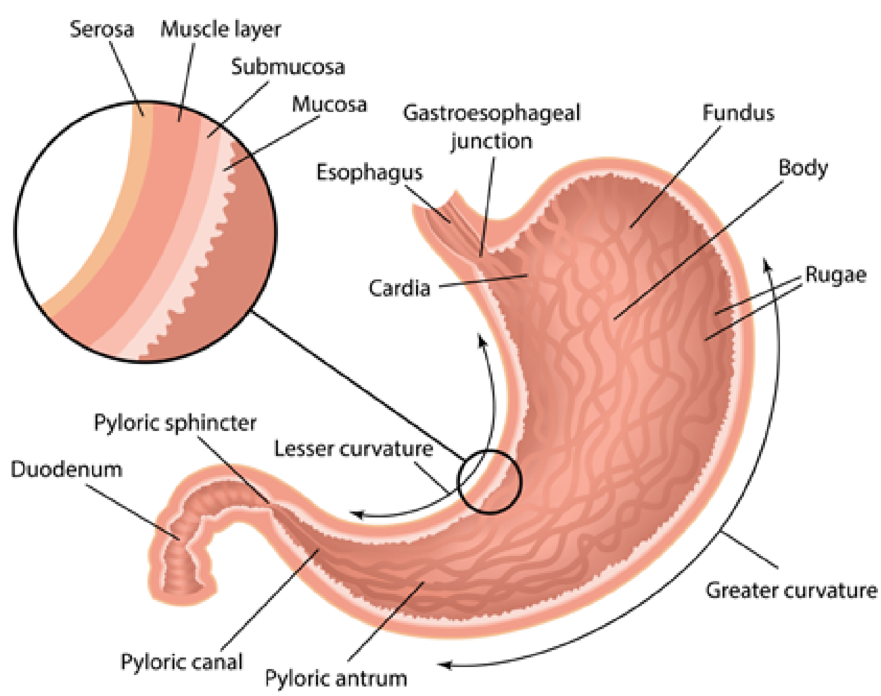


Figure 4.17 The Stomach Anatomy

While the intestines are known as the primary location for absorption, the stomach can absorb some nutrients as well. The stomach can absorb water, glucose, alcohol, aspirin, some other drugs, and certain vitamins such as niacin. The fact that water and glucose can be partially absorbed through the stomach is a benefit for quick replenishment of these nutrients during exercise. Some popular sports drinks take advantage of this fact by including glucose as a main ingredient.

The stomach only begins the process of breaking down complex molecules. Complete digestion of these substances occurs farther along in the digestive tract. Complex molecules are broken down into their smaller components (e.g., proteins into amino acids). This breakdown process, also called “hydrolysis,” continues in the intestines when the partially digested material in the stomach enters the small intestine through the pyloric sphincter muscle. At this stage, it is called **chyme**.

CHYME:
A pulpy, acidic fluid that moves from the stomach to the small intestines containing partially digested food and gastric juices.

SMALL INTESTINE

The small intestine stretches about 12 feet long and is divided into three main regions: duodenum, jejunum, and ileum. The duodenum is connected to the stomach and makes up the first part of the small intestine. Some absorption takes place here, but it is primarily a location for the storage and continued breakdown of food. The next regions of the small intestine, the jejunum and ileum, are responsible for most of the nutrient absorption.

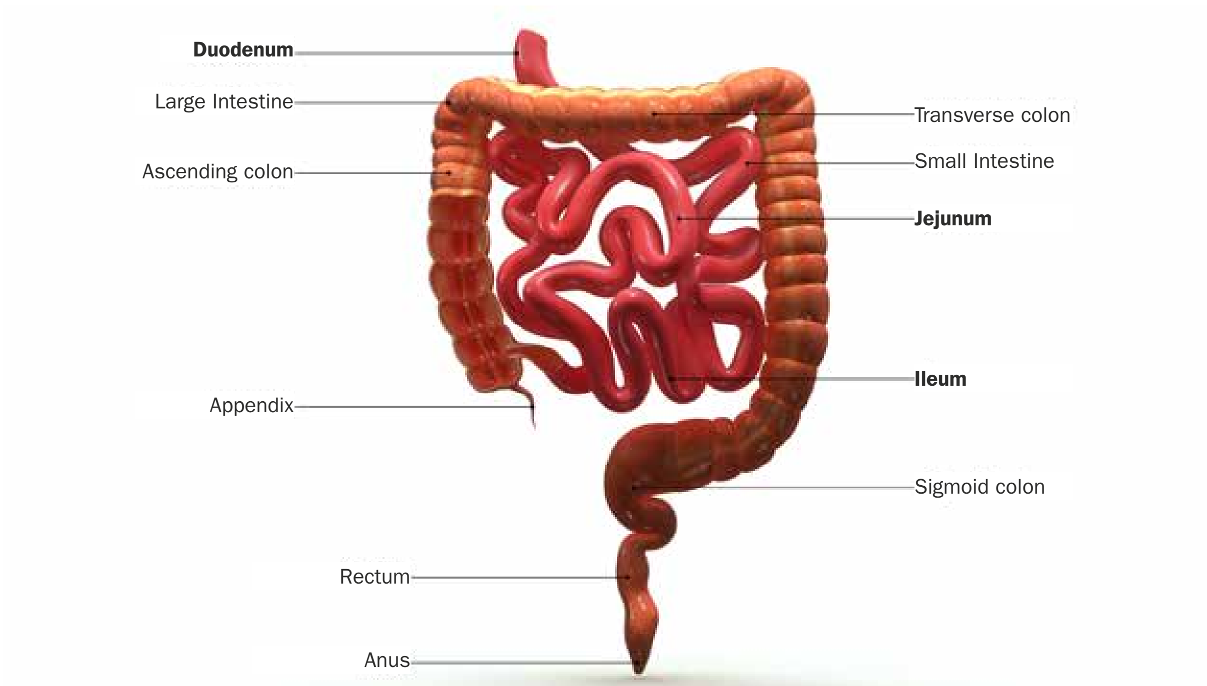


Figure 4.18 Anatomy of the Intestines

To accomplish complete absorption, the inside surface of the small intestine has a unique anatomy. Instead of being a flat surface, like that of the skin, the small intestine is lined with special cells called villi. These villi are very small fingerlike projections that line the entire inner surface of the intestine. The surface area of the intestine is greatly increased by the villi. Each villus is served by blood vessels. When nutrients pass through the cells of the villi, they are transported into the blood vessels and then to the liver.

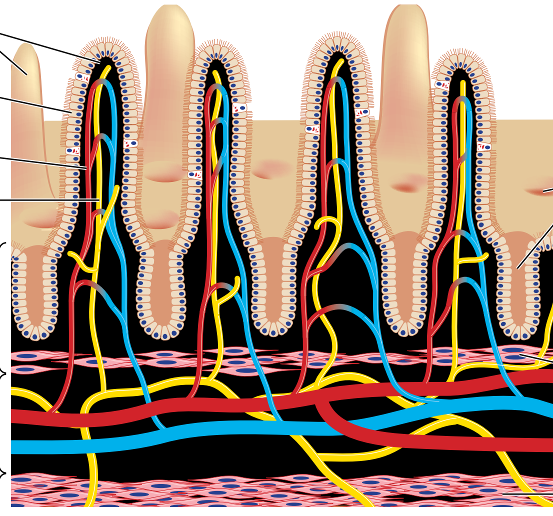


Figure 4.19 Small Intestine Villi

The lymphatic system is also present within the villi and works to transport ingested fats. A small projection called a lacteal extends into the villus and is responsible for about 60 to 70 percent of ingested fat being transported to the liver.

LARGE INTESTINE AND RECTUM

The large intestine is about three feet long. The area where the ileum and large intestine join is called the cecum. The appendix is found at the end of the cecum as well. In the large intestines, some final absorption of water, minerals, and vitamins occurs. Bacteria are present in the large intestine, and through their metabolism, they produce vitamins that are absorbed, such as vitamin K. The large intestine (also called the colon) stores the waste products of digestion.

The further decomposition of fecal matter by bacterial action produces gas. The amount of gas produced varies depending on the nutrient substrate that makes it down to the colon. When the proper stimulus occurs, the colon empties its contents into the rectum, triggering defecation. Normally, the rectum remains empty and rectal filling occurs due to peristalsis. The more fiber in the diet, the softer the feces and the easier it is to eventually defecate.

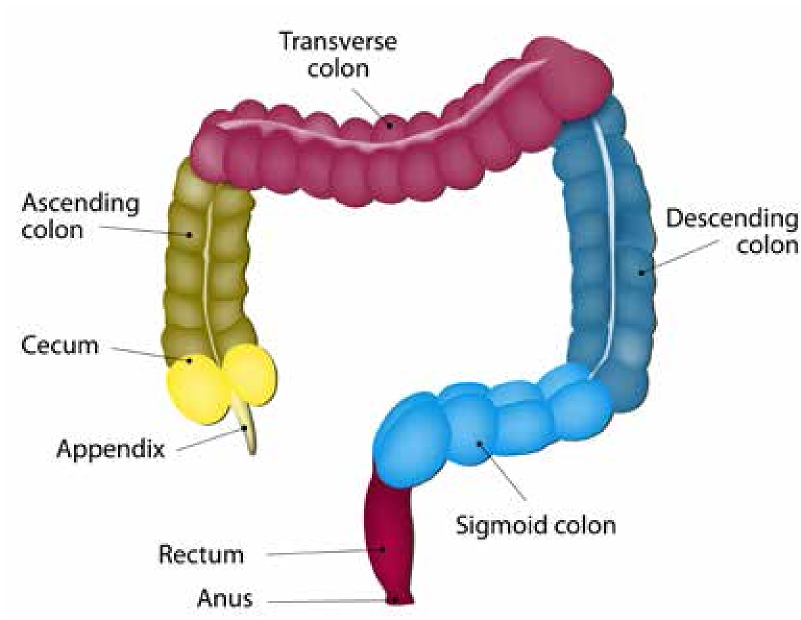


Figure 4.20 Large Intestine Anatomy

LIVER

The liver is the largest gland in the body. It gets oxygenated blood from the hepatic artery (the major blood vessel that carries blood from the liver) and nutrient-rich blood from the digestive tract through the hepatic portal vein (the vein carrying blood to the liver from the stomach, spleen, pancreas, and intestines).

The liver serves many important functions, including:

- Secretion of plasma proteins, carrier proteins, hormones, prohormones, and apolipoprotein
- Making and excreting bile salts
- Storage of fat-soluble vitamins
- Detoxification and filtration
- Carbohydrate, protein, and lipid metabolism

GALLBLADDER

Attached to the liver is the gallbladder. Its primary role is to store **bile** for use in digestion. Bile is made of water, bile salts, bile pigments, and cholesterol, and it helps in the digestion and absorption of fats.

BILE:
A bitter greenish-brown alkaline fluid aiding digestion, secreted by the liver and stored in the gallbladder.

SALIVARY AMYLASE:
An enzyme found in saliva that converts starches and glycogen to more simple sugars.

PANCREAS

The pancreas is located behind the stomach. It has both endocrine and exocrine functions in the body and plays a major role in digestion by secreting the digestive enzymes amylase, trypsin, peptidase (protease), and lipase. **Salivary amylase** is an enzyme found in saliva that converts starches and glycogen to more simple sugars, while trypsin acts in the small intestine to break down protein. Peptidase also breaks down proteins, and lipase helps to digest dietary fat. Specialized cells on the pancreas called the islets of Langerhans secrete the endocrine hormones insulin, glucagon, and somatostatin to control blood sugar and regulate the activity of the gastrointestinal tract.

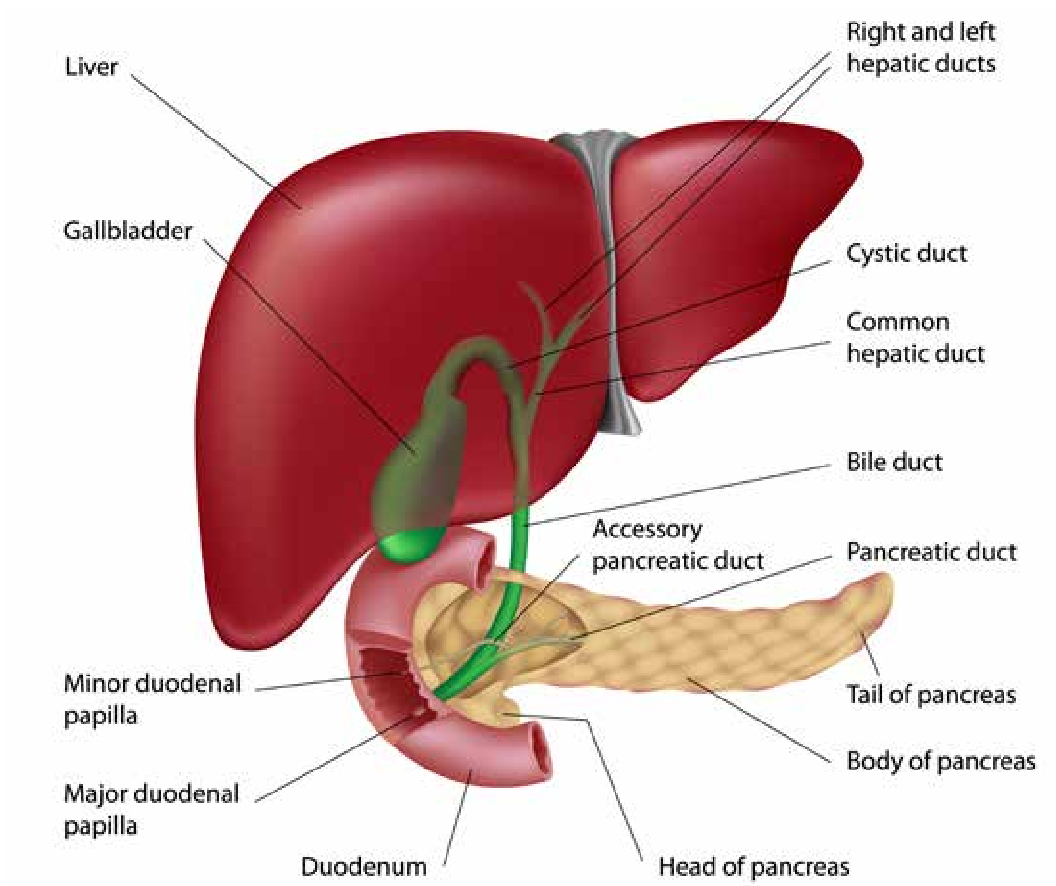


Figure 4.21 Liver, Gallbladder, and Pancreas

THE INTEGUMENTARY SYSTEM

The **integumentary system** is the largest human organ system. It covers the entire human body and is made up of skin, hair, and nails. This system protects the internal organ systems from damage and disease, prevents water and fluid loss, and helps to regulate body temperature. The layers of the skin also include the exocrine glands and sensory nerves.The skin has three layers:

The **epidermis** is the outermost layer of the skin that makes the skin taut and creates a waterproof barrier.

The **dermis** lies beneath the epidermis and is the layer holding blood cells, sweat glands, hair roots (follicles), and connective tissues.

The **hypodermis** is the deepest layer of skin that holds **subcutaneous fat** and connective tissues.

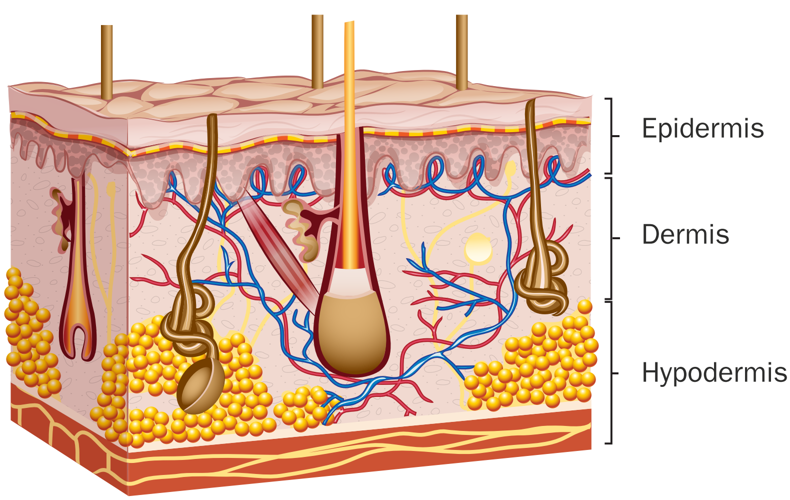


Figure 4.22 Human Skin

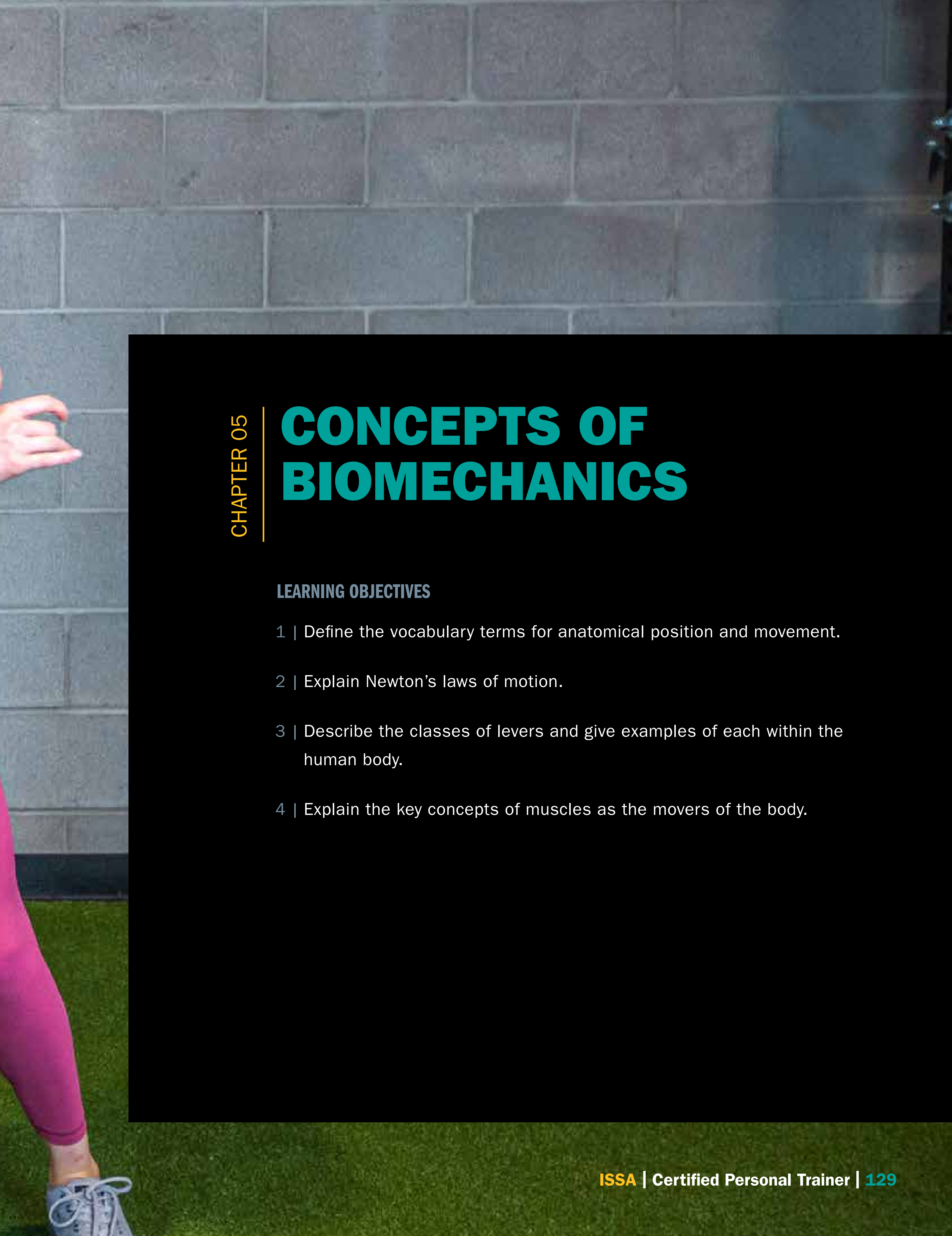
INTEGUMENTARY SYSTEM:
Organ system protecting the body; composed of skin, hair, and nails.

EPIDERMIS:
The outermost layer of the skin.

DERMIS:
Deep to the epidermis; holds blood vessels, sweat glands, and hair follicles.

HYPODERMIS:
The deepest layer of skin housing fat cells and connective tissues.

SUBCUTANEOUS FAT:
Generally harmless fat cells located just beneath the skin.



CHAPTER 05

CONCEPTS OF BIOMECHANICS

LEARNING OBJECTIVES

1 | Define the vocabulary terms for anatomical position and movement.

2 | Explain Newton's laws of motion.

3 | Describe the classes of levers and give examples of each within the human body.

4 | Explain the key concepts of muscles as the movers of the body.

BIOMECHANICS:
The study of the mechanical laws governing movement of living organisms.

KINESIOLOGY:
The study of the mechanics of human movement.

Bones, muscles, connective tissues, and the nervous system work together to produce movement. A personal trainer must have a firm grasp of healthy human movement to effectively assess a client's movement patterns to build safe and effective training programs. Two fields of study specifically help fitness professionals understand and classify human movement: **biomechanics** and **kinesiology**.

Kinesiology explores the human movement in exercise, everyday life, and sport while biomechanics looks at a biological system (e.g., the human body), applying scientific concepts from physics and mechanics to describe how the system moves. Both biomechanics and kinesiology play a major role in exercise selection and training execution to produce desired fitness adaptations while avoiding injury.

ANATOMICAL REFERENCE TERMS

ANATOMICAL POSITION:
The anatomically neutral body position facing forward with the arms at the sides of the body and palms and toes pointing straight ahead.

The terms used to reference an anatomical position or location are used extensively in biomechanics and fitness training. Each term is valuable in helping fitness professionals understand and articulate different movements and locations on the body and refers to the body when in **anatomical position**—facing forward with the arms at the sides of the body and palms and toes pointing straight ahead.

Figure 5.1 Anatomical Position

Table 5.1 Anatomical Terms

ANATOMICAL LOCATION TERM	DEFINITION
Anterior or ventral	Front of the body or toward the front relative to another reference point
Posterior or dorsal	Back of the body or toward the back relative to another reference point
Superior	Above a reference point
Inferior	Below a reference point
Proximal	Position closer to the center of the body relative to a reference point
Distal	Position farther from the reference point
Medial	Position relatively closer to the midline of the body
Lateral	Position relatively farther from the midline of the body
Prone	Lying facedown
Supine	Lying on one's backside
Deep	Further beneath the surface relative to another reference point
Superficial	Closer to the surface relative to another reference point
Unilateral	Refers to only one side
Bilateral	Refers to both sides
Ipsilateral	On the same side
Contralateral	On the opposite side
Caudal	Toward the bottom
Cephalic	Toward the head
Volar	Relating to the palm of the hand or sole of the foot

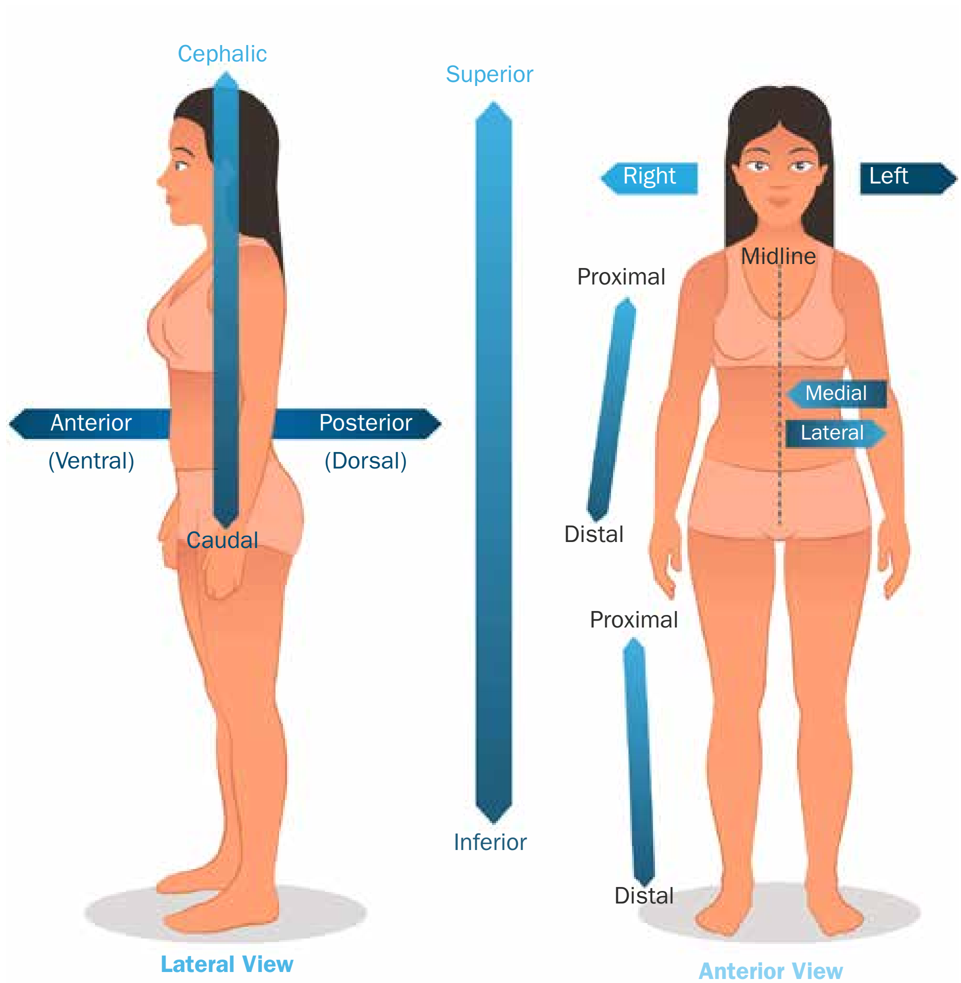


Figure 5.2 Anatomical Locations or Positions

ANATOMICAL MOVEMENT

The terms for anatomical movement are also critical to understanding the biomechanics of the body. These terms are widely universal within the health and fitness field and describe how the muscles of the body act on the skeleton and generate movement.

Table 5.2 Terms for Anatomical Movement

TERM	DEFINITION/ACTION
Abduction	Movement away from the midline
Adduction	Movement toward the midline
Flexion	Movement decreasing the angle between two body parts
Extension	Movement increasing the angle between two body parts
Lateral flexion	Flexion in the frontal plane
Protraction	Abduction of the scapula
Retraction	Adduction of the scapula
Elevation	Movement in a superior direction
Depression	Movement in an inferior direction
Plantar flexion	Extension of the foot downward (inferiorly)
Dorsiflexion	Flexion of the foot upward (superiorly)
External rotation	Rotational movement away from the midline
Internal rotation	Rotational movement toward the midline
Circumduction	Circular movement of a limb extending from the joint where the movement is controlled
Inversion	Movement of the sole of the foot toward the median plane
Eversion	Movement of the sole of the foot away from the median plane
Pronation	Turning the palm or arch of the foot down
Supination	Turning the palm or arch of the foot up
Hyperextension	Position that extends beyond anatomical neutral
Ipsilateral	Same-side movement
Contralateral	Opposite-side movement
Lateral	Situated away from the midline
Medial	Situated toward or closer to the midline

PLANES OF MOTION

FRONTAL PLANE:
An imaginary line that divides the body into anterior and posterior halves.

SAGITTAL PLANE:
An imaginary line that divides the body into left and right halves.

TRANSVERSE PLANE:
An imaginary line that divides the body into inferior and superior halves.

The anatomical planes of motion are used to describe the direction of movement. The **frontal plane**, sometimes called the coronal plane, divides the body into anterior and posterior halves. Lateral movements such as hip and shoulder abduction occur in this plane. The **sagittal plane** divides the body into left and right halves. Flexion and extension occur in this plane. There are few movements that are performed exclusively in the sagittal plane—most movements are a combination of two or more planes of motion. However, a movement such as the squat is largely in the sagittal plane.

The **transverse plane** divides the body into inferior and superior halves, and it runs perpendicular to the frontal and sagittal planes. Anything requiring rotation, such as a golf swing or throwing a ball, occurs in this plane. The contralateral (opposite) motions of the shoulders and hip while walking are in the transverse plane, though the body from afar seems to be moving forward with sagittal plane arm and leg swings.

RANGE OF MOTION (ROM):
The measurement of movement around a specific joint or body part.

Everyday activity involves movement in all three planes. Therefore, designing fitness programs that incorporate movement in all three planes is critical. Though clients move in all three planes, humans may have reduced **range of motion (ROM)** in the frontal and transverse planes and may lack extension of the spine (in the sagittal plane) from excessive sitting and moving predominantly in a single plane. Joints are healthiest when able to move through a normal ROM without restriction and ROM for a joint is specific to each individual.

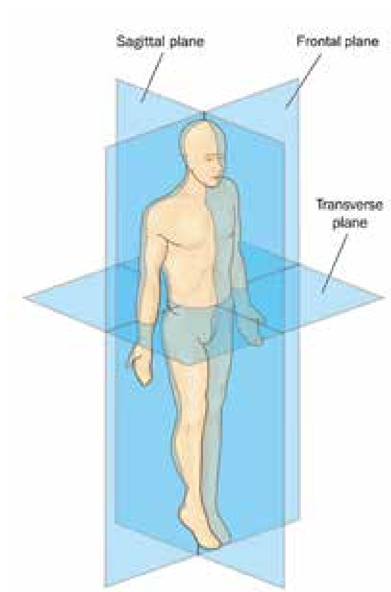
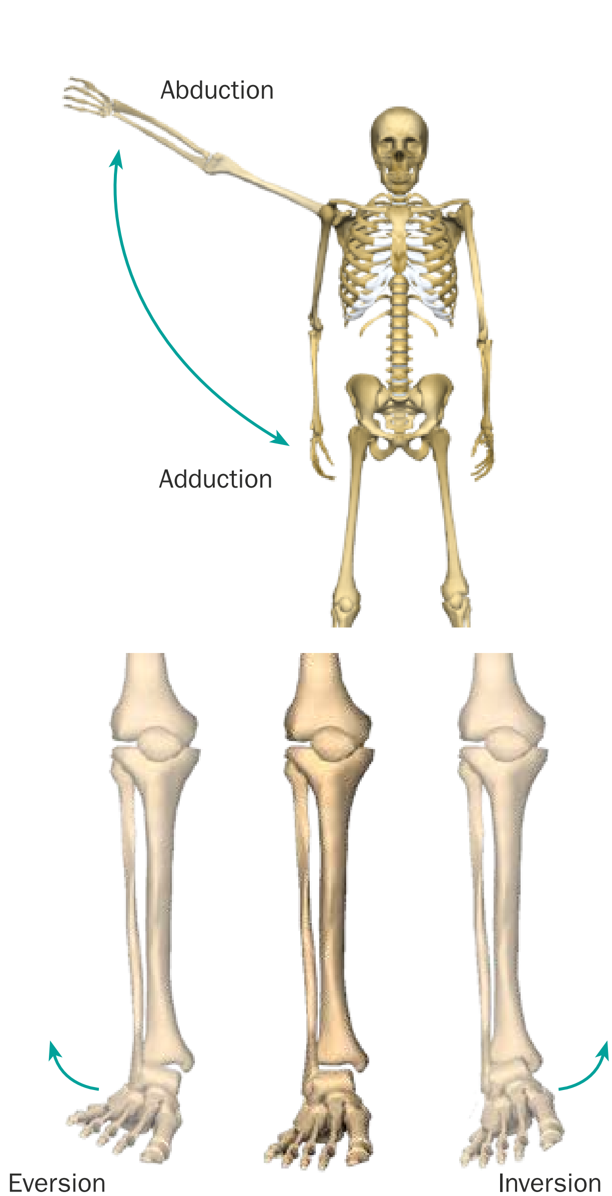
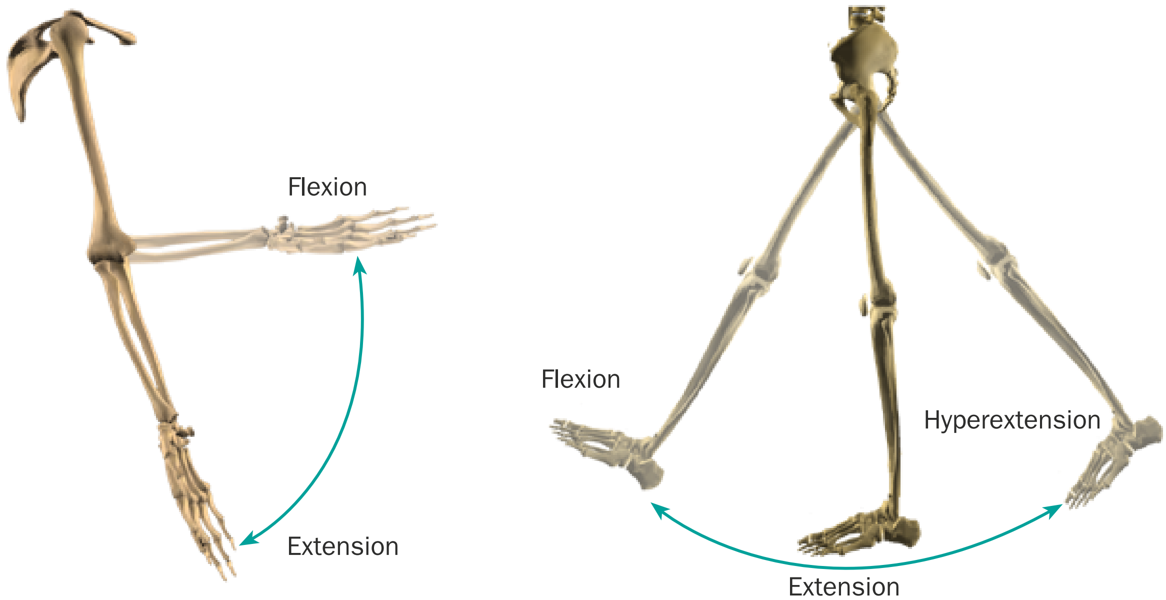


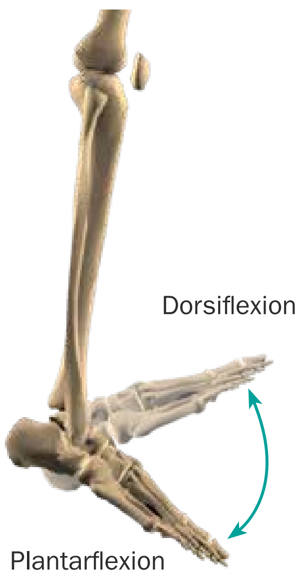
Figure 5.3 Anatomical Planes



OTHER MOVEMENTS IN THE FRONTAL PLANE INCLUDE:
Trunk lateral flexion and extension
Scapula depression
Scapula elevation
Scapula upward rotation
Scapula downward rotation

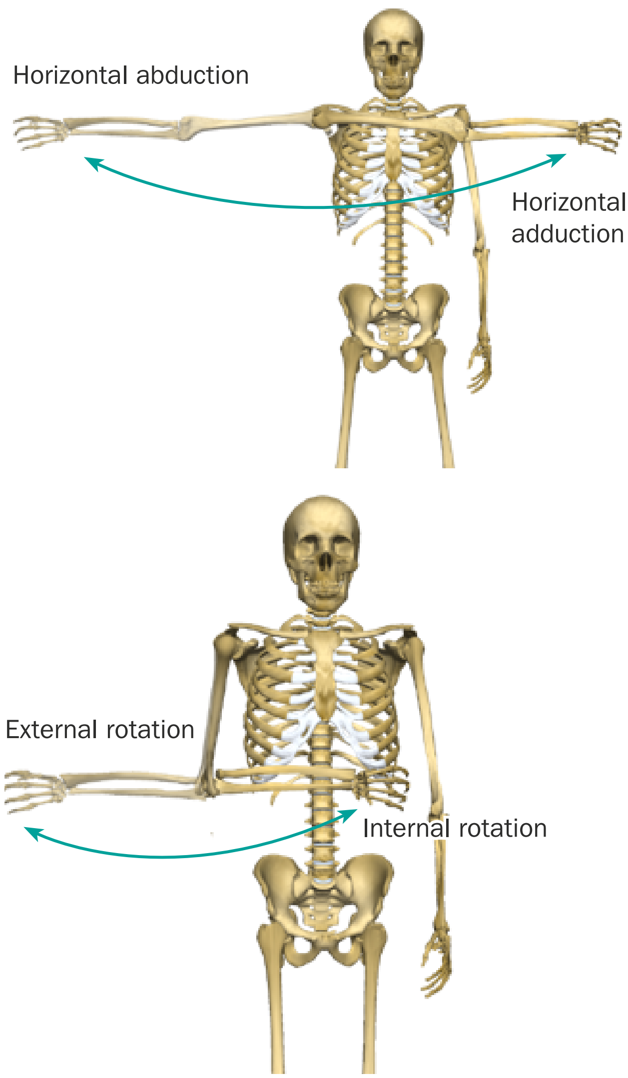
Figure 5.4 Movements in the Frontal Plane

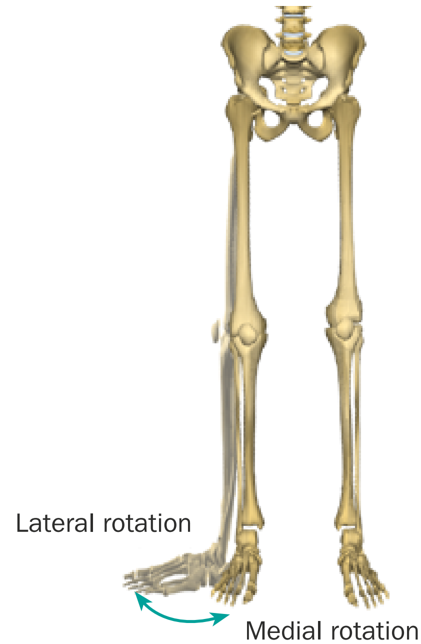




OTHER MOVEMENTS IN THE SAGITTAL PLANE INCLUDE:
Knee flexion and extension
Trunk flexion and extension
Shoulder flexion and extension

Figure 5.5 Movements in the Sagittal Plane





OTHER MOVEMENTS IN THE TRANSVERSE PLANE INCLUDE:
Torso rotation
Head and neck rotation
Scapular retraction
Scapular protraction

Figure 5.6 Movements in the Transverse Plane

BALANCE:
An even distribution of weight enabling someone or something to maintain its center of gravity within a base of support.

EQUILIBRIUM:
A state in which opposing forces or influences are balanced.

STABILITY:
The ability to control and maintain control of joint movement or body position.

CENTER OF GRAVITY:
The hypothetical position in the body where the combined mass appears to be concentrated and the point around which gravity appears to act.

BASE OF SUPPORT:
The area beneath an object or person that includes every point of contact that the object or person makes with the supporting surface.

GRAVITY:
The attraction between objects and the Earth.

MUSCULAR FORCE:
Involves the contraction of a muscle while exerting a force and performing work. It can be concentric (shortening), eccentric (lengthening), or isometric (tension without joint movement).

DYNAMIC BALANCE:
The ability to remain upright and balanced when the body and/or arms and legs are in motion.

BALANCE, EQUILIBRIUM, AND STABILITY

In human movement, **balance**, **equilibrium**, and **stability** are constantly challenged. Maintaining optimal position is critical to reduce the effort to hold position and produce or accept force. Balance describes the ability of an individual to maintain their **center of gravity** within a **base of support** while stability describes the body's resistance to change in joint or body position. **Gravity** is the attraction between objects and the earth. It is an attraction that exists between all objects, everywhere in the universe. All objects on earth are subject to the forces of gravity. **Muscular force** is generated to move the skeleton, and therefore, creating movement innately creates an imbalance or instability within the body. This is known as **dynamic balance**—when the body can remain upright over a moving base of support. This ability allows humans to move while executing the tasks of daily living as well as exercise and sport performance. Helping clients improve this ability can be life-changing, enhancing their lives in both work and play. **Static balance**, on the other hand, is the ability to remain upright and balanced when the body is at rest.

TEST TIP!

There are different types of movement:

- Sustained force movement is where continuous muscle contractions occur to keep moving a weight.
- Dynamic balance movement is where constant agonist-antagonist muscle contractions occur to maintain a certain position or posture.
- Ballistic movement is where inertial movement exists after an explosive or quick, maximum-force contraction; here is pre-tensing of the muscle in the eccentric contraction so the muscle can contract concentrically with maximum speed and quickness.
- Guided movement occurs when both the agonist and the antagonist contract to control the movement.

Receptors in the joints, muscles, and tendons help you know where your body is in space. This is called kinesthesis.

STATIC BALANCE:
The ability to remain upright and balanced when the body is at rest.

Stability and balance are maximized when the center of gravity can be determined and, if necessary, shifted. The center of gravity is the point at which both body **mass** and **weight** are equally distributed. Although somewhat similar terms, this simple example can help clarify the difference between weight and mass. A rocket and astronaut launched from earth into space both weigh increasingly less the farther they travel away from earth (gravity). Their mass, however, stays the same.

MASS:
The amount of matter in an object.

WEIGHT:
The gravitational force of attraction on an object.

Stability and balance are affected by numerous factors such as changes in the center of gravity—some controllable (such as the choice of stance width) and some uncontrollable (rocky ground). When an individual's center of gravity falls within a base of support, the individual will be balanced. In general, when the base of support is larger, the individual will find balance easier (e.g., squatting on two legs vs. squatting on one leg). When a line is drawn straight down from the center of gravity, it is known as the **line of gravity**. To remain balanced, this line of gravity should fall within the base of support—the feet. When the line of gravity is within the base of support, an individual is stable. When outside of the base of support, a reaction needs to take place to remain balanced.

LINE OF GRAVITY:
A vertical line straight through the center of gravity.

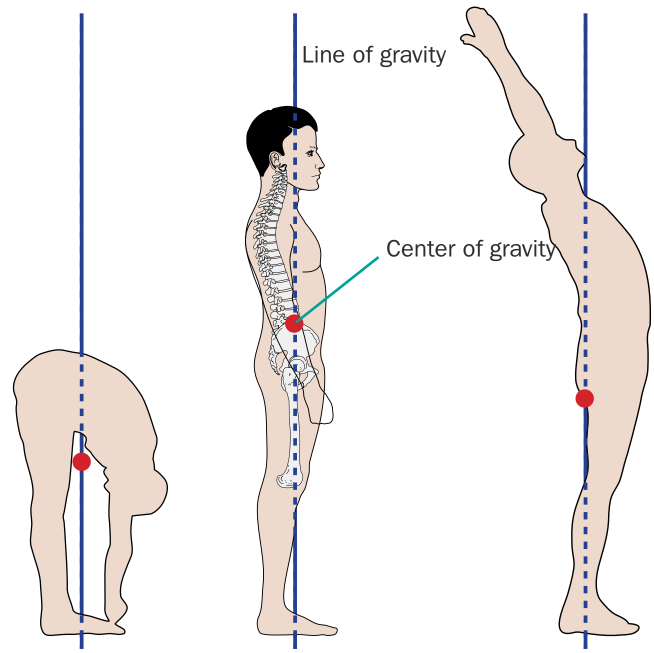


Figure 5.7 Center and Line of Gravity

The height of the center of gravity will affect an individual's balance, and a small change can make a large difference. A personal trainer may adjust someone's center of gravity by adjusting their foot position and stance. For example, executing a dumbbell overhead press with the knees locked and the feet side by side does not provide a lot of balance or stability while moving the weight overhead. To improve balance, the feet can be moved to hip width, and the knees can be held in a soft bend. The change in height is small but has a significant impact. The lower and wider base of support prevents the exerciser from tipping over and increases both balance and stability. Splitting the legs front and back, while maintaining the hip width, would make the overhead movement even more stable. Which plane of motion a base is widened in is a critical factor for improving balance and stability and is dependent on the intended movement or exercise.

Training for balance has been shown to be beneficial in improving dynamic joint stabilization. This type of training focuses on reflexive (without conscious thought) joint alignments while moving to prevent falling and optimize movement. Training for balance requires placing a demand on a client's ability to maintain balance, which is how far outside the base of support the client can move without losing control of their center of gravity. Standing on one leg may be an appropriate challenge for most. Reaching to catch a ball while standing on one leg may benefit others, such as athletes. The outcome of balance training is to enhance a client's awareness of their limit of stability (their kinesthetic awareness). Kinesthetic sense is based on proprioception, which is awareness of the position of the joints. Altered joint motions due to tight muscles (muscle imbalance) can cause faulty alignment both in static and dynamic postures. For example, tight chest muscles can pull the shoulders forward.

JOINT MOBILITY AND STABILITY

Human movement requires joints to be both mobile and stable. Ultimately, healthy joints should have the ability to move through the proper range of motion but with control. This is a collaboration between the nervous system's desire to move and send signals to muscles to produce force, and the muscles' efficiency at controlling joint motion. Muscular efficiency is producing the right amount of force with the right muscles at the right time. **Joint mobility** is defined as the degree of movement around a joint before movement is restricted by surrounding tissues (tendons, ligaments, body fat, or muscles). Therefore, **joint stability** is the ability of the muscles around a joint to control movement or hold the joint in a fixed (stable) position.

JOINT MOBILITY:
The degree of movement around a joint before movement is restricted by surrounding tissues.

JOINT STABILITY:
The ability of the muscles around a joint to control movement or hold the joint in a fixed (stable) position.

TEST TIP!

Joints typically needing greater mobility: foot/ankle, hip, thoracic spine, shoulder, and wrist

Joints typically needing greater stability: knee, lumbar spine, cervical spine, and elbow

The mobility and stability allowed by joints are important for maintaining proper posture and function. Movement dysfunctions are derived from overactive (tight) and underactive (weak) musculature, which affects the movement at a joint. A single joint with dysfunction may then cause dysfunction with other joints inferiorly and superiorly as well.

Keep in mind, joint mobility can be limited by many factors including the uncontrollable factors of age, sex, genetics, body type, and joint shape which can vary in humans. Joint mobility can be affected by someone's level of fitness which is controllable.

Though there are many uncontrollable factors, training will play the most significant role in improving joint mobility. Improvements in mobility may be limited by exercise program design and program adherence by the client.

LAWS OF MOTION: The laws of physics describing movement.

FORCE: The interaction that creates work or physical change. Its components are magnitude, direction, point of application, and line of action.

INERTIA: The resistance to action or change and describes the acceleration and deceleration of the human body.

ACCELERATION: The rate of change of velocity.

DECELERATION: A special type of acceleration where a person or object is slowing down.

THE LAWS OF MOTION

Sir Isaac Newton's **laws of motion** explain what is observed in fitness and human movement. These laws of physics relate an object's motion (such as a dumbbell's) to the forces acting on it (muscle actions) and gravity. Newton's laws of motion help fitness professionals understand how objects behave when standing still, while moving, and when forces act on them.

NEWTON'S FIRST LAW: INERTIA

Newton's first law states that a body in motion tends to stay in motion while a body at rest tends to stay at rest unless acted on by an outside **force**. Muscular contraction produces force and can change the status of movement such as going from a static standing posture to taking a step forward.

Inertia is defined as the resistance to action or change and describes the **acceleration** and **deceleration** of the human body. Running on inclines or declines and tools such as parachutes add resistance to the object in motion—the body—and thus will increase the intensity of the activity.

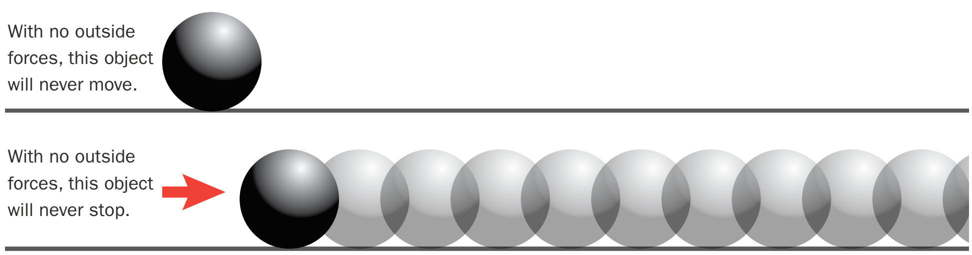


Figure 5.8 Inertia

NEWTON'S SECOND LAW: ACCELERATION

Newton's second law of motion has two parts. First, a change in acceleration of mass occurs in the same direction of the force causing it. Throwing a medicine ball in a specific direction makes the medicine ball accelerate in the direction it was thrown. Second, the change of acceleration is directly proportional to the force causing it and inversely proportional to the mass of the body. How hard an individual throws the medicine ball will determine how much acceleration there will be, though the medicine ball's mass will also determine its acceleration. Mass is the amount of matter in an object, so assuming that gravity is constant, mass and weight can be directly related to each other.

$$a = \textbf{change in } v \textbf{ / change in } t$$

In this equation, a is acceleration, v is **velocity**, and t is time. So acceleration is the change in velocity (final velocity minus starting velocity) divided by the change in time (elapsed time), and the outcome is measured in meters per second squared (m/s^2). In the common example of cars accelerating from 0 to 60 miles per hour, the car that can achieve 60 miles per hour in the shorter time has the higher rate of acceleration.

VELOCITY:
The speed of an object and the direction it takes while moving.

In this law of motion, force is equal to an object's mass multiplied by its acceleration: using the medicine ball example, the amount of force a medicine ball would impact something with would be determined by its mass (how much of it there is) multiplied by its acceleration (how fast it is traveling).

$$F = m \times a$$

This law is essential to exercise. In tandem with the law of inertia, a dumbbell lying on the floor is in a state of resting inertia. It will not move unless someone picks it up or moves it. However, for it to move, a force greater than the weight of the dumbbell must be applied. It is therefore relatively simple to pick up a 5-pound dumbbell. However, a heavier dumbbell, such as a 50-pound weight, will be harder to move.

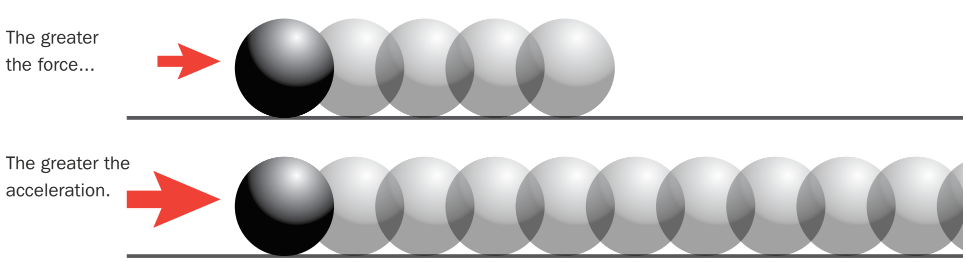


Figure 5.9 Acceleration

There is an inverse relationship between force and velocity known as the **force-velocity curve**. As it relates to muscle contraction, the speed of muscle contraction (or more specifically changes in the muscle length) changes the amount of force of the contraction and, as a result, affects the amount of power that can be produced. Consider the equation:

FORCE-VELOCITY CURVE:
A representation of the inverse relationship between force and velocity in muscle contraction.

$$F \times \text{velocity} = P$$

Where F is force and P is power.

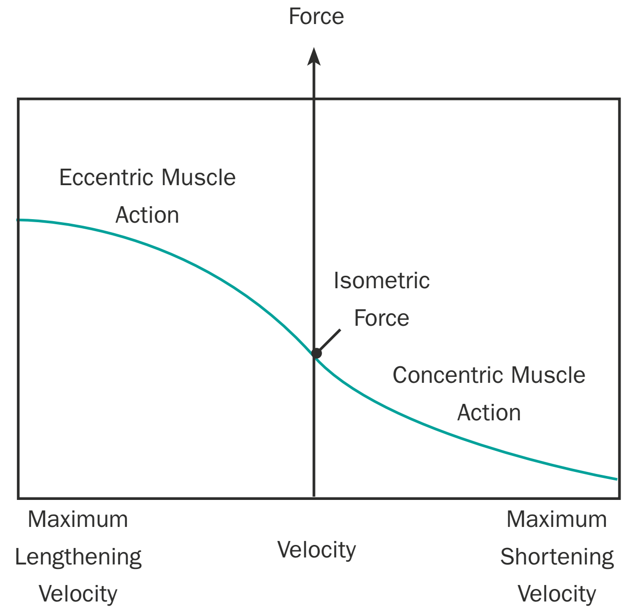


Figure 5.10 The Relationship Between Force and Velocity

MOMENTUM:
The quantity of motion of a moving body, measured as a product of its mass and velocity.

In the example of a dumbbell biceps curl, the force on the dumbbell is applied to begin the movement. The dumbbell begins to move upward against gravity and generates **momentum**—measured as mass times velocity. If enough momentum is developed, the muscle will no longer need to provide force on the weight to temporarily maintain its current state of movement before gravity pulls it back down again. This is what allows a person performing a barbell clean to stop pulling upward and get under the bar to catch it.

If an increase in mass increases the amount of force needed to move the object, then the same is true if the acceleration is greater. Maximum-force effort can quickly accelerate an object, for example, when kicking a ball. The effort required to decelerate the body in the movement of a maximum-effort kick must be large enough to overcome the force of the acceleration used to perform the skill. This is one of the reasons strength training is useful in avoiding sport-related injuries. Being stronger helps a person slow down their own movements when necessary.

It is also true that a muscle cannot stop an object in motion if it cannot generate enough force to do so. Take, for example, the seated lat pull-down exercise. If the weight of the weight stack is too heavy for the latissimus dorsi to control concentrically, the exerciser will "cheat" and recruit the musculature of the core to create a swing, and thus momentum, to bring the bar down. Since the latissimus dorsi cannot handle the load, during the eccentric action of releasing the bar back to the starting position, the weight stack will gain momentum that overpowers the muscles in the body. As a result, the weight will come crashing back down to the stack instead of being controlled back to the start.

NEWTON'S THIRD LAW: ACTION AND REACTION

Newton's third law states that for every action, there is an opposite and equal reaction. Put simply, the human body provides the force to move, and the surface on which it moves provides a reactionary force.

Every action has an equal and opposite reaction

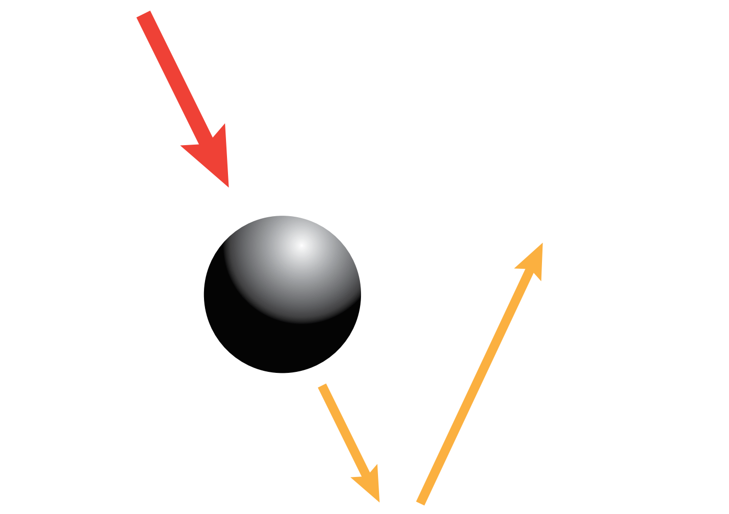


Figure 5.11 Action and Reaction

Changing the training environment is an easy way to apply this law of motion. When running, for example, the ground is acting on the runner as they stride. It is relatively easy to run on a smooth, flat surface such as a track or blacktop. However, when the surface is changed to the beach, the runner will have to overcome the resistance of shifting sand under their feet to generate more forward motion. Sand creates a different reaction because it lessons the runner's force on contact. Using Newton's laws shows that the sand's inertia is overcome (first law), causing it to move in the direction of the applied force or foot strike (second law), and that the opposite force (third law) is not equal due to the effect of the second law on the sand. Whereas on a hard surface, the force would be equal and opposite. The result is a loss of **speed** and force as the sand shifts. **Ground reaction force (GRF)** describes this phenomenon. GRF is the force the ground exerts on a body it is in contact with. For every stride the runner makes, their contact with the ground will be met with an equal and opposite force.

SPEED:
The ability to move the body in one direction as fast as possible.

GROUND REACTION FORCE (GRF):
The force the ground exerts on a body it is in contact with.

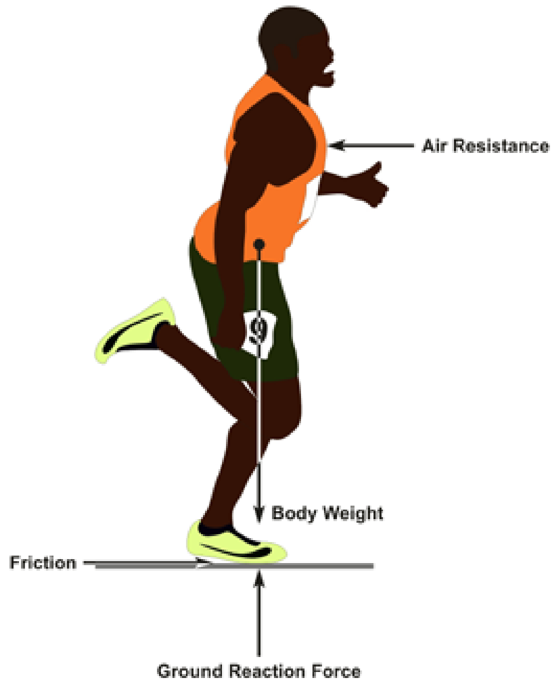


Figure 5.12 Ground Reaction Force (GRF)

FRICTION:
The resistance of relative motion that one surface or object encounters when moving over another.

COMPRESSION FORCE:
The force of two surfaces pressing toward one another.

TENSILE FORCE:
The force when two surfaces pull apart from one another.

SHEAR FORCE:
The force of two surfaces moving across one another.

The interaction between two objects that results in a change to the motion of those objects is known as force. This interaction can be a push or a pull coming from an external source (gravity and **friction**) or an internal source (muscles pulling on bones) and is the foundation for the creation of movement (both acceleration and deceleration).

There are three types of force that can occur between two objects: compression, tensile, and shear. **Compression force** occurs when two surfaces press toward one another, causing them to be compacted. An example of compression is the vertebrae of the spine. While in an upright position, gravity acts as a force that causes a level of compression among the vertebrae. **Tensile force** is the opposite—pulling two contact surfaces apart. An example of tensile force could be hanging from a pull-up bar. In this example, the bones of the shoulder joint are being pulled apart. **Shear force** is created when two surfaces move or glide across one another. Shear force can occur in the knee when the bone of the lower leg is relatively stable and the bone of the upper leg moves across (over the top of) it. Another example is a deadlift or the position of the hip in a hinge and resultant shear on the spine. Forces are not good or bad. They exist all around people, to people, and in people. What matters most is how someone helps create, diminish, or enhance these forces through movement training. An exerciser manipulates these forces, often unconsciously. Aspects of forces such as direction, location, magnitude, frequency, duration, variability, and rate all play a role in creating the right challenge the body needs to adapt.

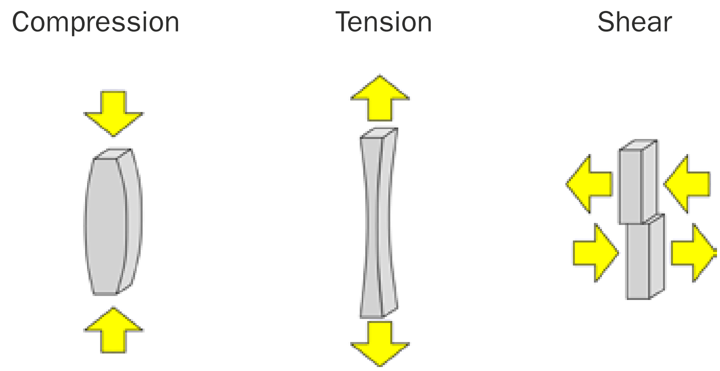


Figure 5.13 Types of Force

Muscles of the human body can only pull to create movement. Therefore, voluntary motion of the human body is always initiated by a **muscular contraction**. These contractions initiate and propagate movement and are the source of force within the body. There are two types of motion for human movement: **linear motion** and **angular motion**. Movement can occur in either a straight or curved line (linear motion) or rotate around an **axis** (angular motion).

Joint movement is almost always angular motion. In the musculoskeletal system, linear and angular motions are related. For example, the angular motion of a joint can produce the linear motion of walking forward. This also applies to movements occurring beyond the body but resulting from the motion of the body. For example, the angular motion of the joints to produce a baseball bat swing creates linear motion in the object struck—the baseball.

Displacement describes the distance an object is moved from its starting point or location. For example, in baseball, the displacement from home base to first base is 90 feet. The displacement from home base to first base, and back to home base is 0 feet since the batter would be back to the same location. **Distance** refers to the total or sum of the length of travel. The distance from home base to first base is 90 feet. In the same example, if someone went from home base to first base and then back home they would travel a total distance of 180 feet. The concepts of linear and angular movement can be applied to both displacement and distance. **Angular displacement** refers to the change in location, measured in degrees of rotation, of an object that is rotating about an axis while **linear displacement** is the distance an object moves in a straight line. The velocity of an object refers to the direction and rate of its displacement. Speed is more simply the measure of the distance traveled by a body in a unit of time or, in other words, how fast the object is moving.

MUSCULAR CONTRACTION: The shortening or resistance to lengthening of a muscle fiber.

LINEAR MOTION: Movement along a line, straight or curved.

ANGULAR MOTION: Rotation around an axis.

AXIS: Point of rotation around which a lever moves.

DISPLACEMENT: The distance an object is displaced from a starting point.

DISTANCE: The total or sum of the length an object travels.

ANGULAR DISPLACEMENT: The change of location of an object that is rotating about an axis.

LINEAR DISPLACEMENT: The distance an object moves in a straight line.

FRICTION

Friction is a physical force affecting the body's ability to create force, accelerate, and decelerate. Friction is the force created by the resistance between two surfaces of two objects moving across one another. It is the force that allows the body to walk forward. The planted foot grips the ground due to friction and can push downward and backward, which causes the ground to push forward (equal and opposite, Newton's third law) on the foot. This equal and opposite force in this case is known as the GRF.

Friction can be

- static,
- sliding, or
- rolling.

Static friction is the friction of an object that does not move. The forces against the object are equal to the forces being placed on it. Sliding friction is the friction between two surfaces where one or both are moving against one another. It is sometimes referred to as kinetic friction. Finally, rolling friction is the force that resists a surface rolling across another such as a ball bearing or a wheel on a road surface.

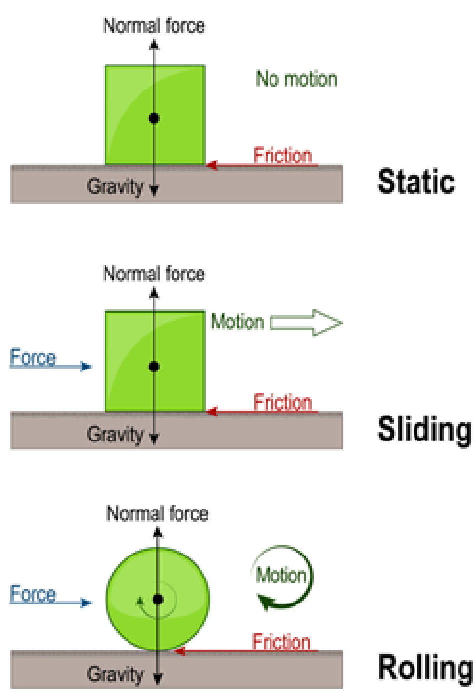


Figure 5.14 Types of Friction

Depending on the movement, friction may or may not be desired. When walking or running on a solid surface, the participant relies on the friction between the feet and the ground to exert force against each other and propel the body forward. Loose gravel will lower friction and cause the exerciser to lose their footing. However, a figure skater would prefer less friction because it keeps their skates moving smoothly across the ice.

PRINCIPLES OF BIOMECHANICS

There are seven principles of biomechanics—grouped into four distinct categories—explained by the laws of motion and **kinetics**. In physics and as it relates to physical exercise, kinetics is the study of the forces that act on (energy that pushes or pulls) a mechanism. The categories of biomechanics include the following:

KINETICS: The study of forces acting on a mechanism.

1. Stability
2. Maximum effort (maximum amount of force or velocity)
3. Linear motion
4. Angular motion

Table 5.3 Principles of Biomechanics: Overview

CATEGORY	PRINCIPLE(S)	DESCRIPTION	EXAMPLE
Stability	Stability	The ability to maintain control (i.e., resist change) of a joint or position.	Maintaining the positioning of the trunk, hips, and legs during a push-up.
Maximum effort	Production of maximum force	The maximum amount of force produced by a muscle or group of muscles.	Performing a one-rep maximum (1RM) for a barbell bench press.
	Production of maximum velocity	The maximum movement velocity, or muscular contraction speed, for a muscle or group of muscles.	Vertical jump. Throwing a baseball.

Table 5.3 Principles of Biomechanics: Overview (CONT)

CATEGORY	PRINCIPLE(S)	DESCRIPTION	EXAMPLE
Linear	Force-velocity relationship	The greater the applied force on the same object, the greater the velocity.	A larger arc of a golf swing will produce greater force and therefore move the golf ball farther.
	Direction of movement	Movement occurs in the direction opposite the applied force.	The body moves forward as the stroke applies force backward while swimming.
	Ground Reaction Forces (GRFs)	The force exerted by the ground to a body in contact with it. Because the ground does not move when applying force against a movable object, the object will move in the same direction of the force applied by the person.	In a barbell squat, the bar goes up when an exerciser applies force against it because the ground won't move. In a bench press, the bar goes in the same direction of the force the exerciser applies because the bench is solidly held by the ground. The exerciser is applying force down onto the bench rather than into the bar.
Angular motion	Angular motion	The motion of an object around a fixed point or axis. All lever actions are angular, and therefore most joint movements are angular.	A figure skater spinning. Elbow motion in a biceps curl because the ulna spins on the humerus.
	Conservation of angular momentum	Angular momentum is constant until an external force acts on it.	A figure skater during a triple-axel jump. In the air, there is very little acting against the skater's rotation. When gravity pulls the skater back down, the friction of the blade on the ice will stop the spin.

ANGLE OF MUSCLE PULL

When doing strength exercises, the strength at the various points throughout a ROM will vary based on the angle the muscle is pulling. For example, when executing a biceps curl, it is more difficult to begin the curl with the elbow fully extended than if the elbow is in slight flexion. When the muscle contracts, much of the force is exerted on the joint to stabilize the elbow rather than the forearm to lift the weight. Most of the force moves to the biceps muscle only as the elbow approaches a 90-degree angle. This advantage near the right angle is known as a **mechanical advantage**, and it means the body is stronger at the established angle. Positions of least mechanical advantage are often called "sticking points."

MECHANICAL ADVANTAGE:
The ratio of force that creates meaningful movement compared to the force applied to generate the movement.

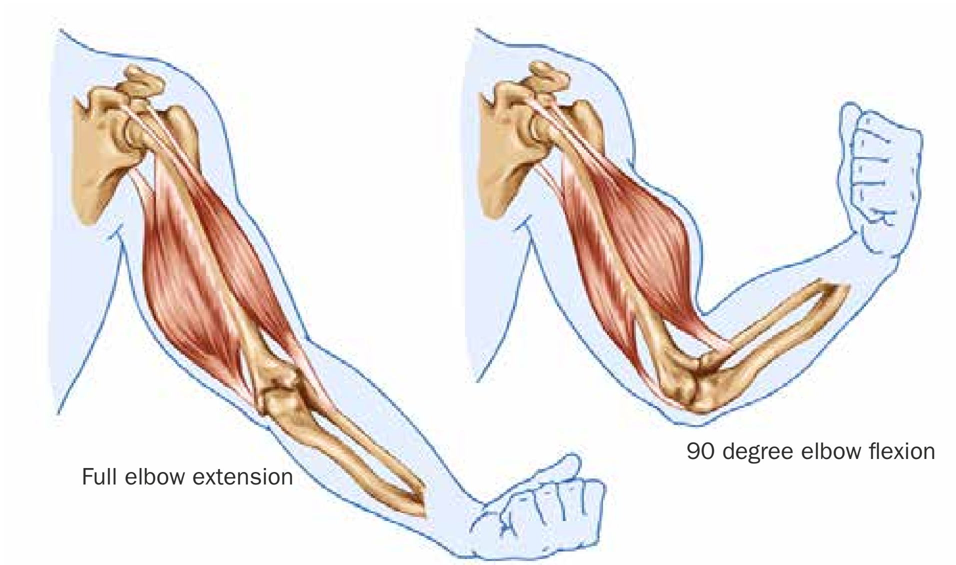


Figure 5.15 Angle of Biceps Pull in Elbow Flexion

WORK

Moving the body and exercising are examples of measurable **work**. Work is the energy transferred when force is applied to an object and is represented by the following formula:

WORK:
Force times distance measured in foot-pounds.

$$W = F \times D$$

where W is work, F is force, and D is distance or displacement. The greater the force and the farther the distance moved, the greater the work being done.

POWER:
The combination of strength and speed—the ability for a muscle to generate maximal tension as quickly as possible.

POWER

Power is defined as the amount of work done in a unit of time. The key is the amount of time needed for execution. Power refers to the rate at which work can be done. Walking up a flight of stairs requires work and walking up a flight of stairs faster requires more power. It's a measurable quantity. Work and power differ in the amount and rate of energy used. For example, if a lifter executing a squat with a 300-pound loaded barbell has to move a distance of 3 feet from the bottom position to the top position, the work done is calculated as follows:

W = 300 pounds x 3 feet

W = 900 feet/pound

This calculation assumes that bodyweight and external factors are omitted. To calculate the amount of power, the time taken to execute the movement must be considered as well. Assume it took 3 seconds to move the barbell.

900 feet/pound divided by 3 seconds = 300 feet/pound of work per second.

However, if it only took 2 seconds to move the load, the result is quite different.

900 feet/pound divided by 2 seconds = 450 feet/pound of work per second

The shorter-duration lift was done with more power (450 feet/pound vs. 300 feet/pound). This simply shows that the faster **mechanical work** is done by the body, the greater the power, and the slower mechanical work is done, the lesser the power.

MECHANICAL WORK:
The amount of energy transferred by a force, the product of force and distance.

LEVERS

Levers are the most common mechanical machines within the human body. They cannot be altered, but the body can use them to be more efficient. A lever consists of a rigid bar and an axis or point of rotation the lever moves around. Levers rotate around an axis (or **fulcrum**) as a result of force (also referred to as load or effort) applied to move weight or applied against resistance.

LEVERS:
A rigid or semirigid bar rotating around a fixed point when force is applied to one end.

FULCRUM:
The point on which a lever rests or is supported and on which it pivots.

Within the body, the bones are the levers, the joints are the axis (fulcrum), and the muscles contract to apply force. There are three classes of levers within the human body, and the location of the fulcrum, resistance, and effort (force) differentiate the first-, second-, and third-class levers.

The location of the applied force and effort will vary based on the type of lever being used. However, the arms of the lever remain consistent. The **effort arm** is the length of the **lever arm** between the applied effort and the axis while the **resistance arm** is the lever length between the load and the axis. The **moment arm** represents the perpendicular distance between the axis or joint in the body and the line of the force being applied.

EFFORT ARM:
The portion of the lever arm between the applied effort and the axis.

LEVER ARM:
The rigid bar portion of a lever that rotates around the fulcrum.

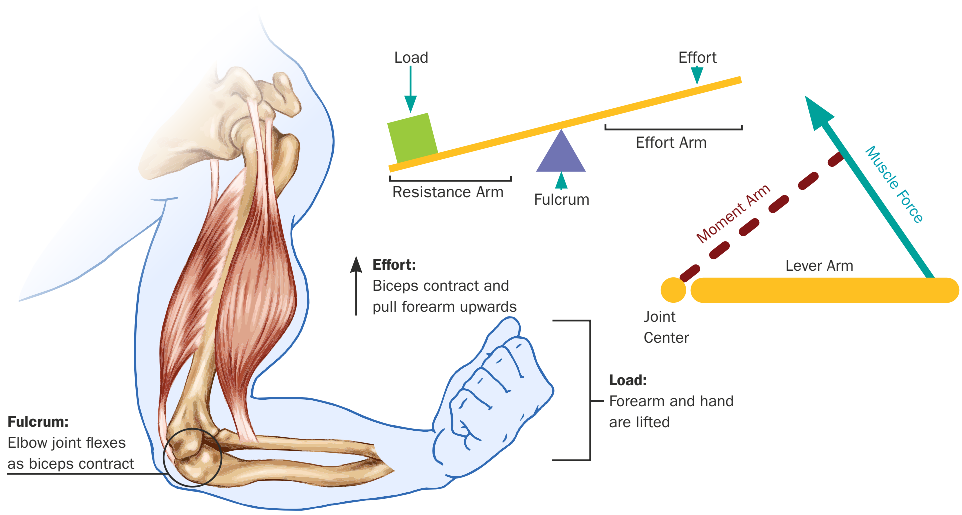


Figure 5.16 The Lever Arms

RESISTANCE ARM:
The portion of the lever arm between the load and the axis.

MOMENT ARM:
The perpendicular distance between the fulcrum and the line of the force being applied.

FIRST-CLASS LEVER

For a first-class lever, the fulcrum (axis) is located between the effort and the load (resistance). This type of lever creates balanced movements when the fulcrum is centrally located between the effort and load—as seen with a seesaw. The fulcrum, however, can be offset to one side or the other as with the triceps in elbow extension or the action of the point on which a lever rests or is supported and on which it pivots.

In the human body, an example of a first-class lever is the extension and flexion of the neck, with the fulcrum at the base of the skull.

SECOND-CLASS LEVER

For a second-class lever, the load (resistance) is located between the fulcrum (axis) and the effort. Force movements are easily created by second-class levers because the load can be moved with relatively small effort with the fulcrum at the extreme end of the lever. A wheelbarrow and a nutcracker are examples of second-class levers.

In the human body, an example of a second-class lever is the plantar flexion of the foot used to raise up to the toes, with the ball of the foot acting as the fulcrum. Few instances of this type of lever can be found in the body.

THIRD-CLASS LEVER

For a third-class lever, the effort is between the fulcrum (axis) and the load (resistance). These levers are adept at producing speed and ROM and are the most common type of lever in the body. Like shoveling dirt or paddling a boat, this lever requires a decent amount of effort (force) to move a small load.

Most levers in the human body are of the third class. An example of a third-class lever is the elbow flexion driven by the biceps brachii, with the elbow joint acting as the fulcrum.

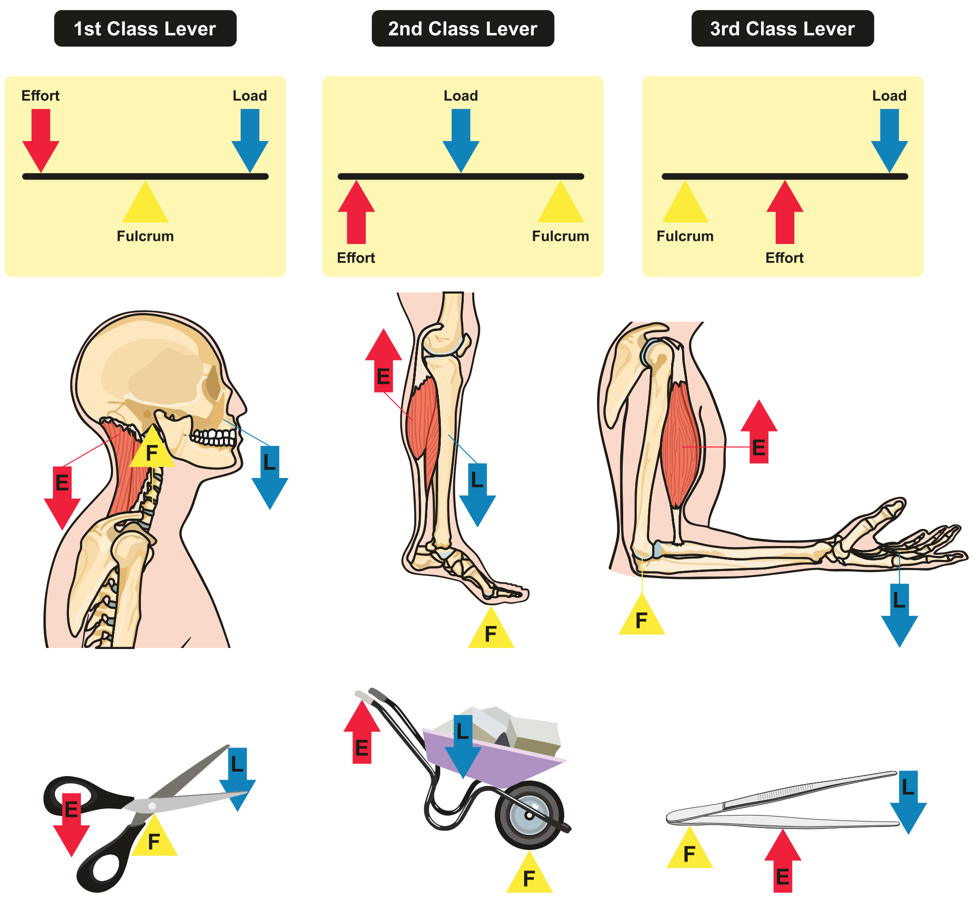


Figure 5.17 Classifications of Levers

TORQUE

Torque is force applied rotationally. Because most joint movements happen through the use of levers that apply force rotationally, most joint movements are a result of torque rather than linear force. Just as a linear force is a push or a pull, a torque can be thought of as a twist to an object around a specific axis. The **rotary motion** thus describes the movement around a fixed axis moving in a curved path.

Torque is determined by multiplying the force (effort) by the length of the **force arm**, which is the distance between the fulcrum and the force or load. This is sometimes called a lever arm. It is crucial to understand, however, that the torque can be increased by lengthening the force arm and increasing the leverage to move the load.

TORQUE:
Force applied that results in rotation about an axis.

ROTARY MOTION:
The movement around a fixed axis moving in a curved path.

FORCE ARM:
The distance between the fulcrum and the force or load application in a lever.

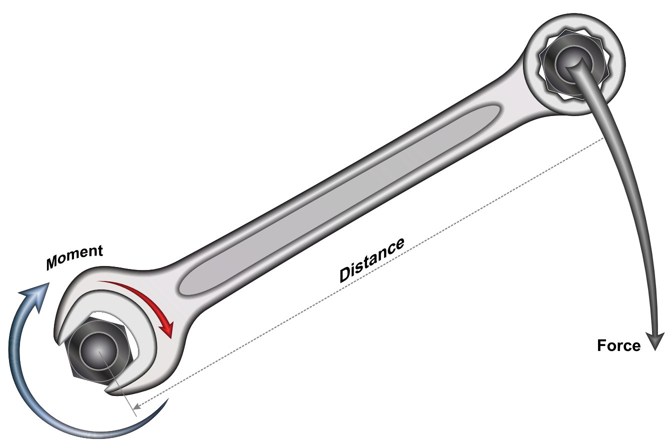


Figure 5.18 Torque and the Length of the Force Arm

Levers and torque are important to understand because some human movement requires levers in multiple places working simultaneously, such as when throwing a tennis ball. Most of the joints and levers in the body will be used as an individual steps, rotates, and swings their arm to throw the ball. The combination of these joints is a factor of the principle of maximum velocity—the more joints involved, the more force that can be produced.

Torque affects human movement because the length of the lever determines velocity. For example, a tennis player can strike a tennis ball harder and with more velocity with a straight arm than with a bent elbow because the lever (their arm and the racket together) is longer and can move faster. This is also evident in sports such as baseball, hockey, and golf, where lengthy implements are used. The increase in speed occurs at the end of the lever where force is applied to the load. The speed of movement at the fulcrum does not have to increase for the velocity to increase at the end of the lever when the lever arm is lengthened.

ORIGIN:
The proximal muscular attachment point to a bone.

INSERTION:
The distal muscular attachment point to a bone.

MUSCLES AS MOVERS

Muscles create movement by generating force and transferring that force to the attached bones via the connective tissue (tendons). The **origin** of a muscle is where it attaches to a bone, closest to the midline of the body (proximal). The **insertion** point is the opposite end of the muscle, the distal end (farther from the midline). Some muscles, like the biceps brachii have multiple bundles of muscles referred to as the different heads of the muscle. They have separate origins but share the same insertion.

INSERTIONS AND ORIGINS

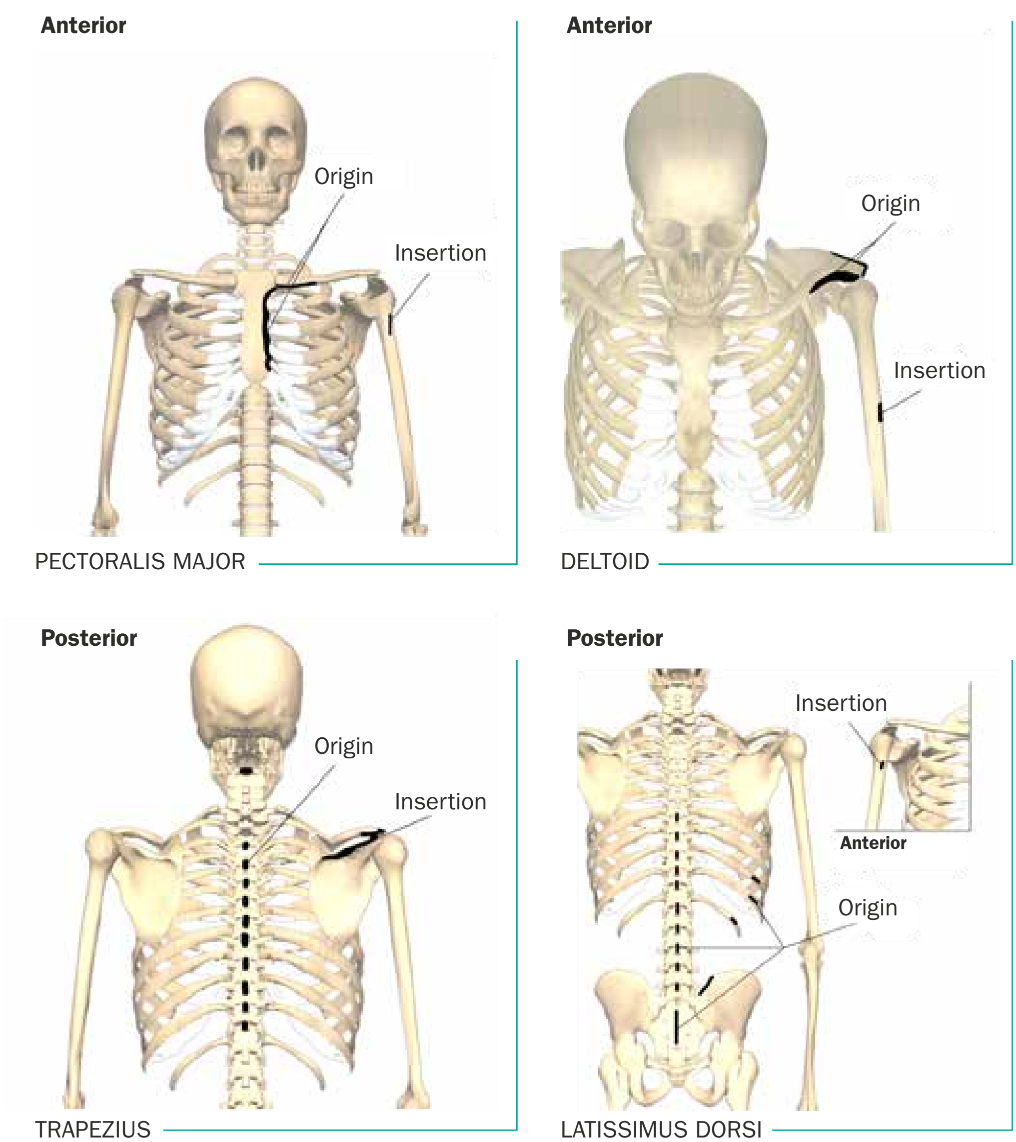


Figure 5.19 Upper Body

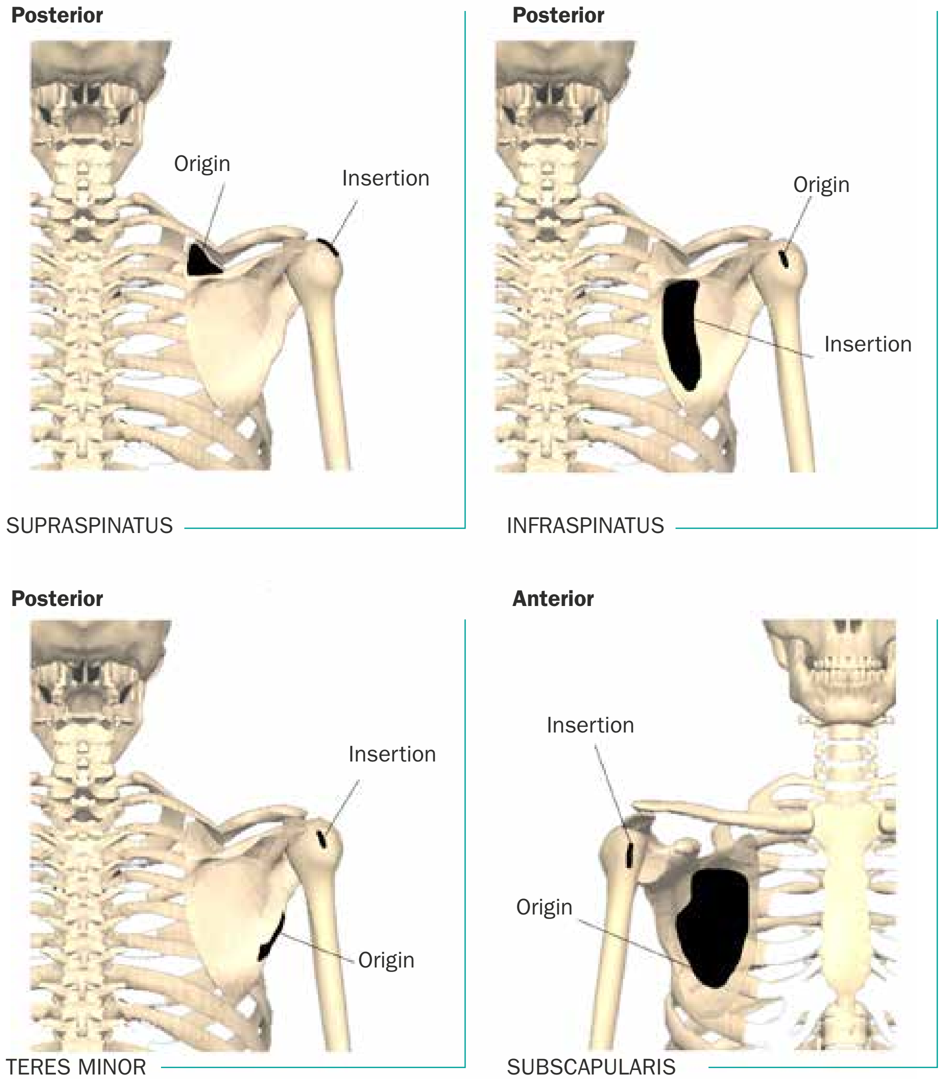


Figure 5.20 Rotator Cuff

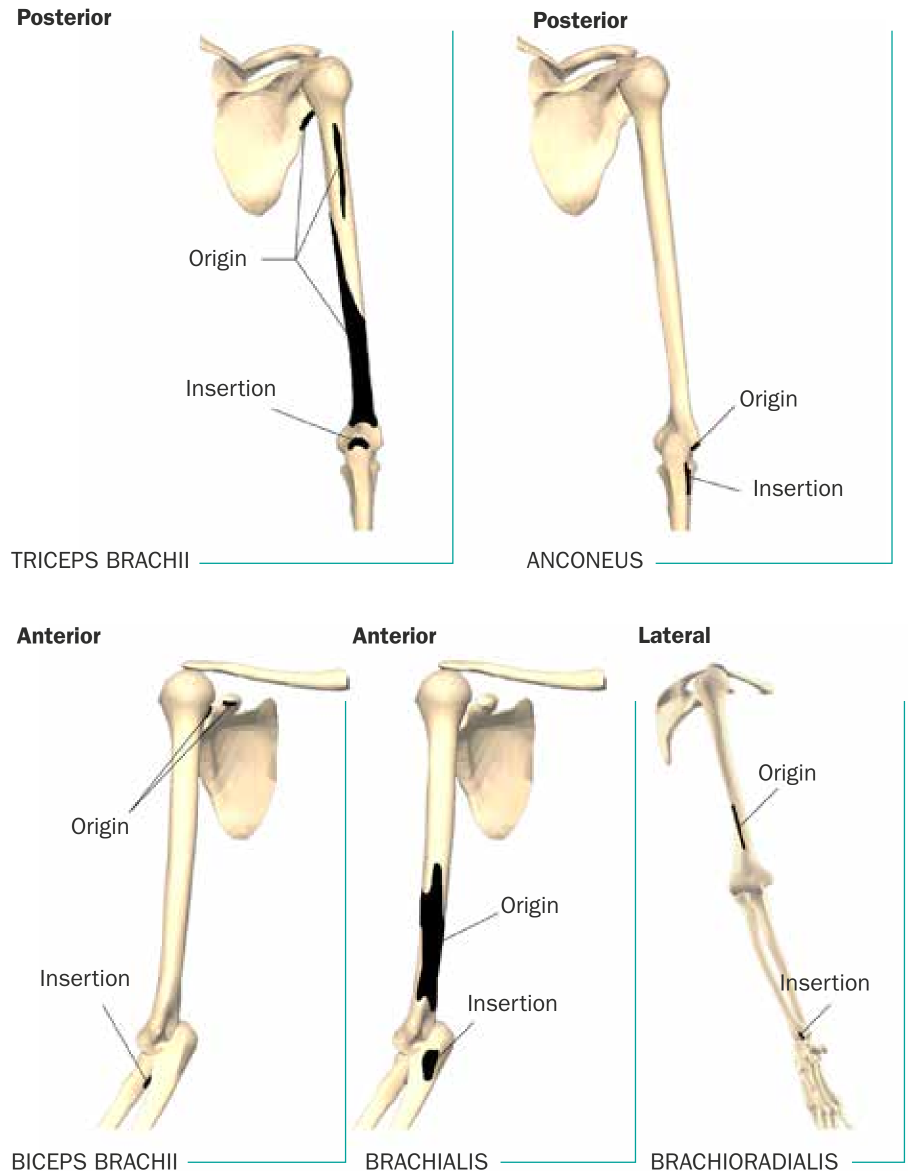


Figure 5.21 Upper Arm

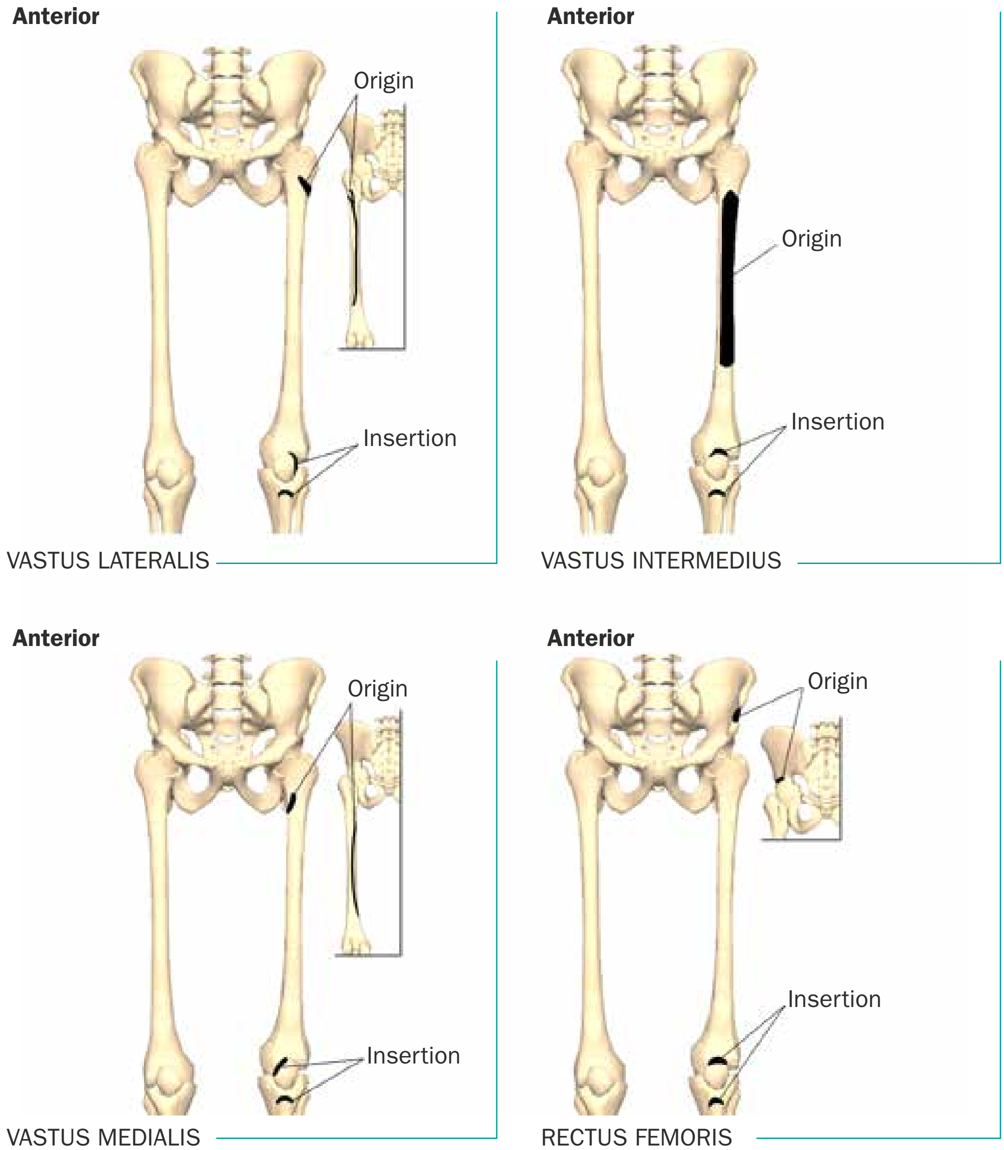


Figure 5.22 Quadriceps Group

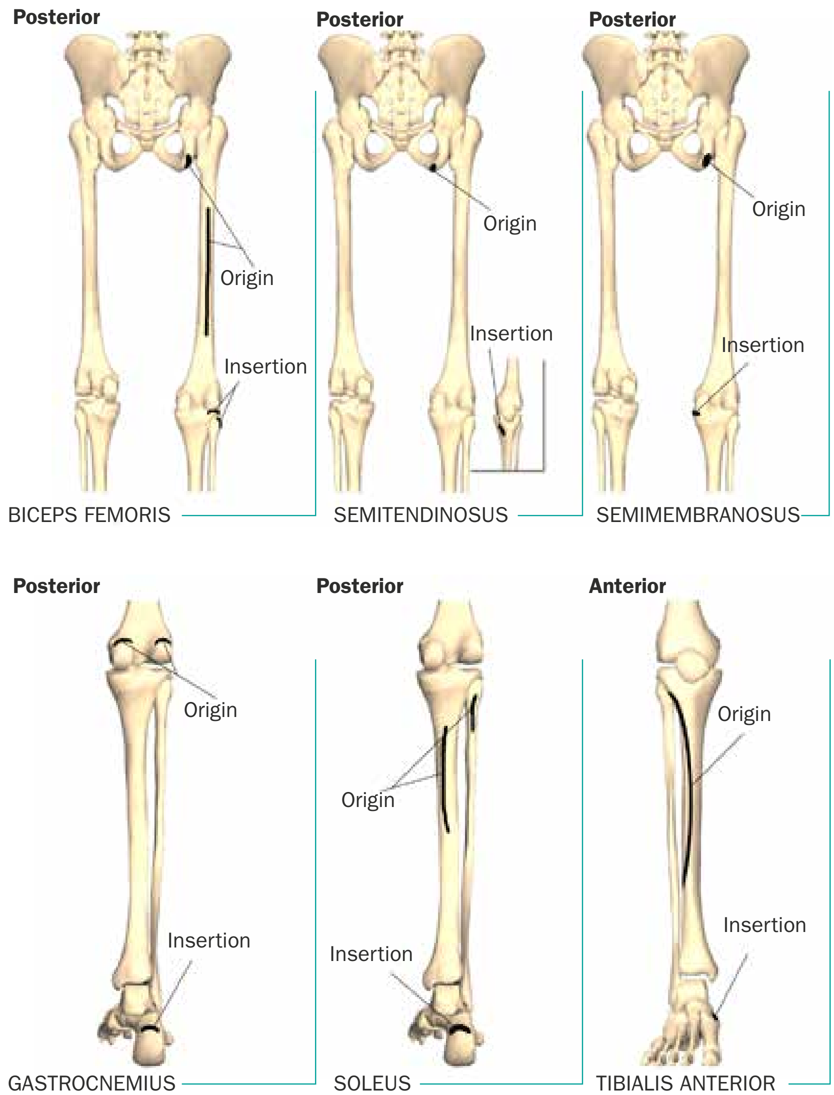


Figure 5.23 Hamstring Group and Lower Leg

AGONIST:
The primary muscle used for a mechanical movement.

SYNERGISTS:
Muscle(s) supporting the mechanical movement of a prime mover.

ANTAGONIST:
Muscle(s) opposing the mechanical movement of a prime mover.

SHERRINGTON'S LAW OF RECIPROCAL INHIBITION:
A law that states that for every muscle activation, there is a corresponding inhibition of the opposing muscle.

The muscles of the human body are often arranged in groups or pairs based on their actions and the joints on which they exert force. An **agonist**, or prime mover, is the primary muscle involved in a joint movement while **synergists** are secondary muscles supporting the action of the prime mover.

An **antagonist** muscle opposes the action of a prime mover for a given movement. Muscle antagonism is explained through **Sherrington's law of reciprocal inhibition**, stating that for every neural muscle activation, there is a corresponding inhibition of the opposing muscle. A single muscle may become a prime mover, a synergist, or an antagonist depending on the direction and angle of a movement pattern. **Stabilizer muscles** work to stabilize joints and support joint movement, but they themselves do not contribute greatly to the joint motion. A personal trainer must understand these relationships for assessments and program design for optimal muscle targeting regardless of the training type.

STABILIZER MUSCLES: The muscles playing the role of stabilizing or minimizing joint movement.

An example of a group of muscles working together in this fashion is a dumbbell curl. The biceps brachii is the agonist, the brachioradialis is a synergist and the triceps are the antagonist.

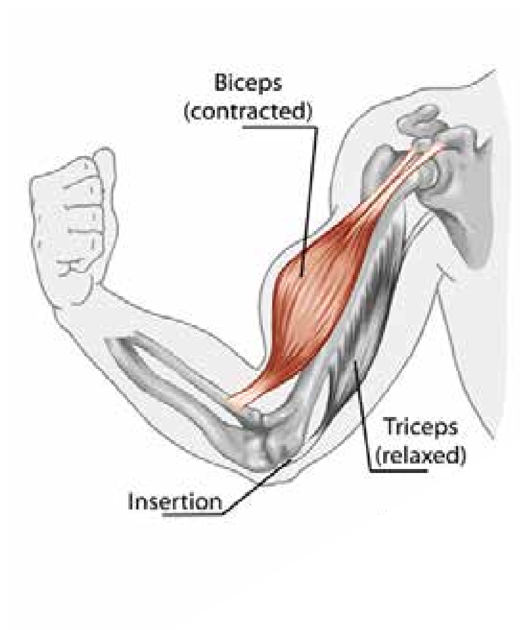


Figure 5.24 The Agonist and Antagonist for a Biceps Curl

Table 5.4 Biceps Curl: Agonist, Synergist, and Antagonist Muscles

CLASSIFICATION	EXAMPLE
Agonist	Biceps
Synergist	Brachioradialis
Antagonist	Triceps

Knowledge of muscle location and their relationship to joints is an important part of understanding the movement muscles create. The muscular and skeletal systems work together and use neural input to create movement around a joint. When a muscle contracts, typically one attachment point will move toward the other. And although the muscle always contracts from both ends toward the center, muscle contraction brings those two points (origin and insertion) closer together, thus creating a movement. A basic understanding of muscle origins and insertions is critical in understanding why individual muscles pull bones in specific directions and how muscles help to create the major joint actions.

LENGTH-TENSION RELATIONSHIP: The amount of tension a muscle can produce with respect to its length.

FORCE-COUPLE RELATIONSHIP: Two or more muscles acting in different directions that influence the rotation of a joint in a specific direction.

MUSCLE SYNERGIES: The activation of a group of muscles to generate movement around a particular joint.

There are a few additional components of human physiology that affect muscles and movement. First, the **length-tension relationship** is the force a muscle can produce at specific muscle lengths. As an individual moves a joint, the overlap of the contractile proteins (actin and myosin) changes, and this affects the potential for the development of cross-bridges and therefore muscle-force production. Muscles have an optimal length that they can produce force from.

Second, the **force-couple relationship** describes a situation where two or more muscles acting in different directions influence the rotation of a joint in a specific direction. The biceps and triceps provide a simple example of this, just as a force couple at the knee would be the quadriceps and the hamstrings. Lastly, there are also **muscle synergies** that occur when a pair of muscle forces act together on a joint to produce movement. An example of this is the synergy between the internal and external obliques. They work together to create movements like trunk rotation and lateral flexion.

For certified personal trainers, understanding the forces and physiology affecting human movement makes it easier to create safe and effective training programs. Continued education on the concepts of biomechanics can also help trainers put together more personalized plans for their clients.

INNERVATION: The distribution or supply of nerves.

Correct anatomical knowledge of muscle connection function is invaluable in helping certified personal trainers make safe and effective programming decisions. The following figures and tables will assist in the understanding of muscle origin and insertion, and therefore muscle action, the specific movements that each muscle is responsible for, and **innervation**, the nerves that control the muscles.

MUSCLES OF THE UPPER ARM

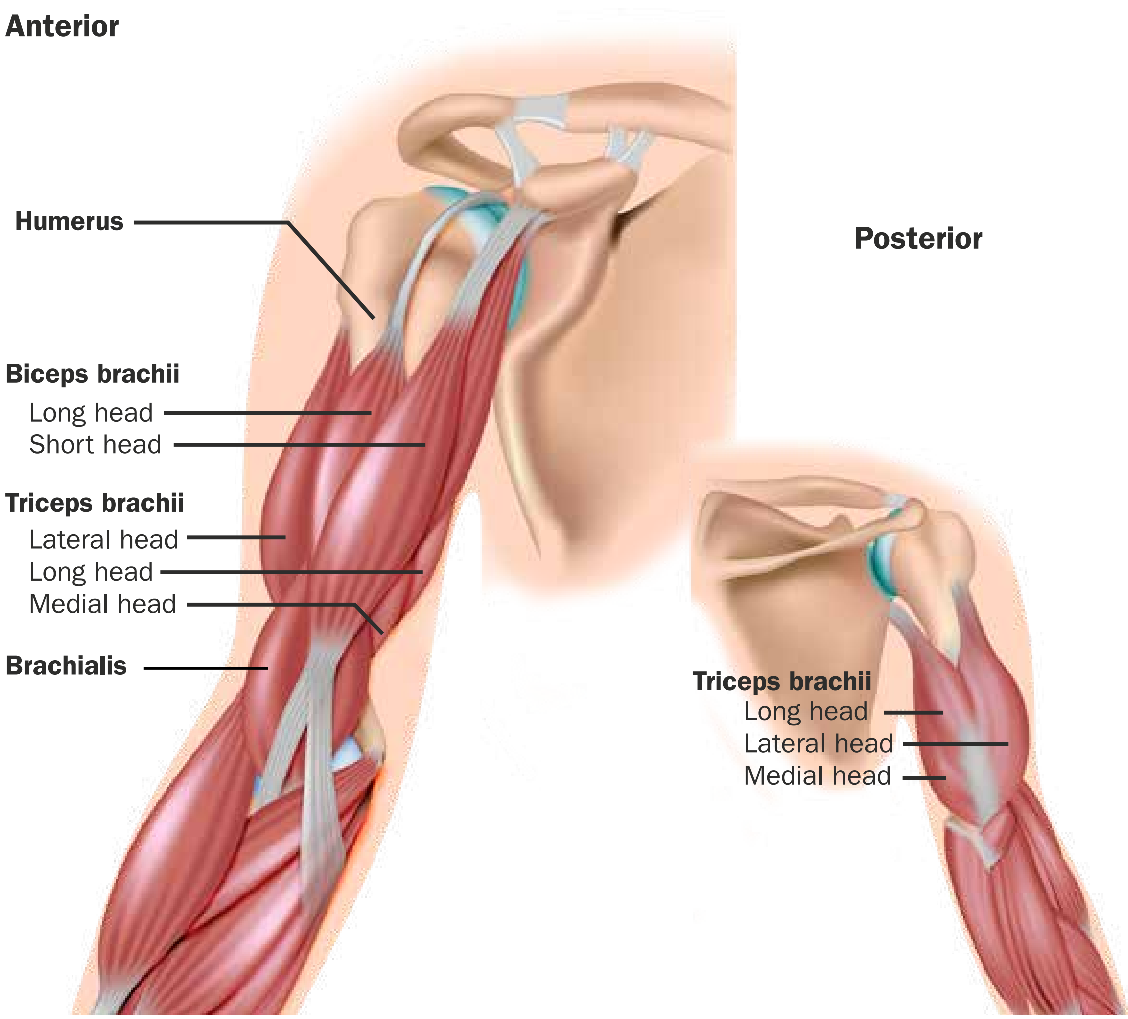


Figure 5.25 Upper Arm

1. Humerus (bone)
2. Biceps brachii (long head)
3. Biceps brachii (short head)
4. Triceps brachii (lateral head)
5. Triceps brachii (long head)
6. Triceps brachii (medial head)
7. Brachialis

MUSCLES OF THE FOREARM

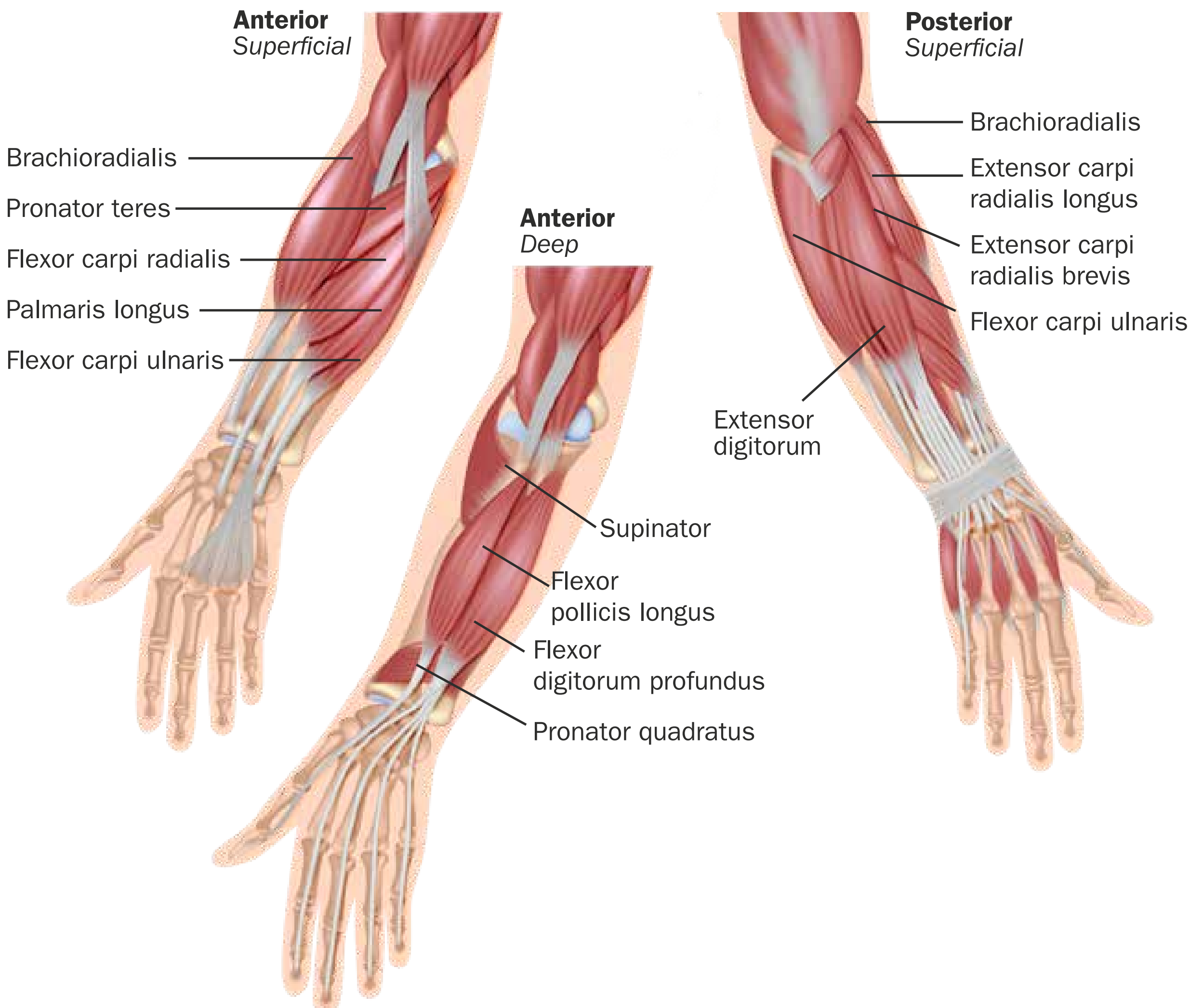


Figure 5.26 Forearm

1. Brachioradialis
2. Pronator teres
3. Flexor carpi radialis
4. Palmaris longus
5. Flexor carpi ulnaris
6. Supinator
7. Flexor pollicis longus
8. Flexor digitorum profundus
9. Pronator quadratus
10. Extensor carpi radialis longus
11. Extensor carpi radialis brevis
12. Extensor digitorum

Table 5.5 Elbow and Radioulnar Joint

Elbow and Radioulnar Joint				
MUSCLE	**ORIGIN**	**INSERTION**	**ACTION**	**INNERVATION**
Biceps brachii	Long head: supraglenoid tubercle above the superior lip of glenoid fossa Short head: coracoid process of scapula and upper lip of glenoid fossa	Tuberosity of radius and bicipital aponeurosis	Flexion of elbow, supination of forearm, weak flexion shoulder joint	Musculocutaneous nerve (C5, C6)
Brachialis	Distal half of anterior portion of humerus	Coronoid process of the ulna	Flexion of elbow	Musculocutaneous nerve (C5, C6)
Brachioradialis	Distal two-thirds of lateral condyloid ridge of humerus	Lateral surface, distal end of the radius at styloid process	Flexion of elbow, pronation from supinated to neutral position, supination from pronation to neutral position	Radial nerve (C5, C6)
Triceps brachii	Long head: infraglenoid tubercle below inferior lip of glenoid fossa of scapula Lateral head: upper half of posterior surface of humerus Medial head: distal two-thirds of posterior surface of humerus	Olecranon process of the ulna	Long head: adduction of the shoulder joint, extension of elbow All heads are involved in the extension of the elbow	Radial nerve (C7, C8)
Anconeus	Posterior surface of lateral condyle of the humerus	Posterior surface of the olecranon process of the ulna	Extension of the elbow	Radial nerve (C7, C8)

MUSCLES OF THE SHOULDER

Shoulder

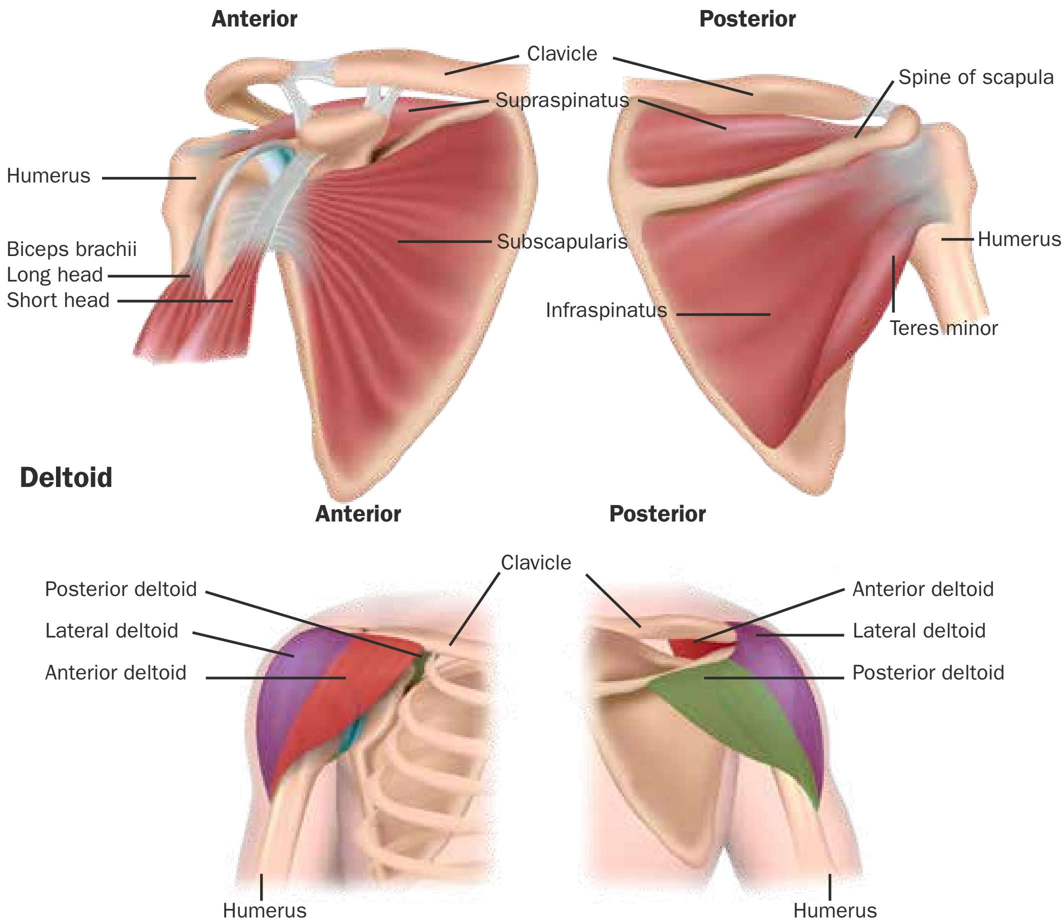


Figure 5.27 Shoulder and Deltoid

1. Humerus (bone)
2. Clavicle (bone)
3. Anterior deltoid
4. Lateral deltoid
5. Posterior deltoid
6. Supraspinatus
7. Infraspinatus
8. Subscapularis
9. Teres minor

Table 5.6 Shoulder Joint

SHOULDER JOINT				
MUSCLE	**ORIGIN**	**INSERTION**	**ACTION**	**INNERVATION**
Deltoid	Anterior: anterior lateral third of clavicle	Anterior: deltoid tuberosity on lateral humerus	Anterior: abduction, flexion, horizontal adduction, and internal rotation of glenohumeral joint	Anterior: axillary nerve (C5, C6)
	Middle: lateral aspects of acromion	Middle: deltoid tuberosity on lateral humerus	Middle: abduction of the glenohumeral joint	Middle: axillary nerve (C5, C6)
	Posterior: inferior edge of spine scapula	Posterior: deltoid tuberosity on lateral humerus	Posterior: abduction, extension, horizontal abduction, and external rotation of glenohumeral joint	Posterior: axillary nerve (C5, C6)
Coracobrachialis	Coracoid process of scapula	Medial border of middle humeral shaft	Flexion, adduction, and horizontal adduction of glenohumeral joint	Musculocutaneous (C5–C7)
Supraspinatus	Medial two-thirds of supraspinatus fossa	Superiorly on greater tubercle of humerus	Weak abduction and stabilization of humeral head in glenoid fossa	Suprascapular nerve (C5)

Table 5.6 Shoulder Joint (CONT)

SHOULDER JOINT				
Infraspinatus	Medial aspect of infraspinatus fossa just below spine of scapula	Posteriorly on greater tubercle of humerus	External rotation, horizontal abduction, and extension of the glenohumeral joint; stabilization of humeral head in glenoid fossa	Suprascapular nerve (C5, C6)
Teres minor	Posteriorly on middle, upper aspect of lateral border of scapula	Posteriorly on greater tubercle of humerus	External rotation, horizontal abduction, and extension of glenohumeral joint; stabilization of humeral head in glenoid fossa	Axillary nerve (C5, C6)
Subscapularis	Entire anterior surface of subscapular fossa	Lesser tubercle of humerus	Internal rotation, adduction, and extension of glenohumeral joint; stabilization of humeral head in glenoid fossa	Upper and lower subscapular nerve (C5, C6)
Teres major	Posteriorly on inferior third of lateral border of scapula and slightly superior to inferior angle	Medial lip of intertubercular groove of the humerus	Extension, internal rotation, and adduction of glenohumeral joint	Lower subscapular nerve (C5, C6)

MUSCLES OF THE BACK

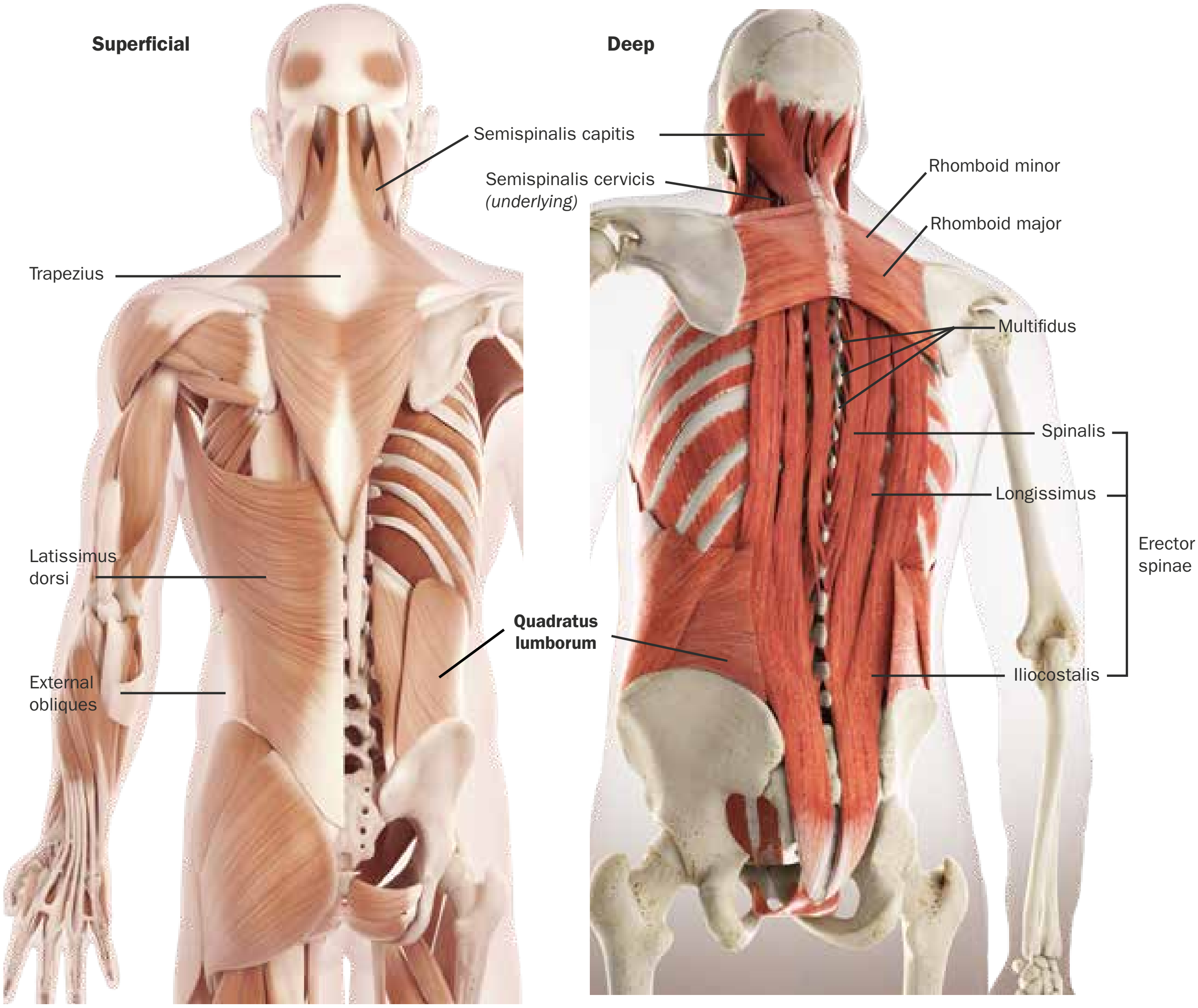


Figure 5.28 Back

1. Trapezius
2. Latissimus dorsi
3. External obliques
4. Semispinalis capitis
5. Semispinalis cervicis
6. Quadratus lumborum
7. Rhomboid minor
8. Rhomboid major
9. Multifidus
10. Spinalis (erector spinae group)
11. Longissimus (erector spinae group)
12. Iliocostalis (erector spinae group)

Table 5.7 Back

BACK				
Latissimus dorsi	Posterior crest of ilium, back of sacrum, and spinous process of lumbar and lower T6–T12, slips from lower three ribs	Medial side of intertubercular groove of humerus	Adduction, extension, and internal rotation of glenohumeral joint; horizontal abduction of glenohumeral joint	Thoracodorsal nerve (C6–C8)
Rhomboid	Spinous process of C7 and T1–T5	Medial border of scapula below spine	(Retraction) draw scapula toward spinal column (downward rotation; elevation)	Dorsal scapula nerve (C5)
Trapezius	Upper: base of skull, occipital protuberance, and posterior ligaments of neck	Upper: posterior aspect of the lateral clavicle	Upper: scapula elevation and extension of the head at neck	Upper: accessory nerve (cranial nerve XI and branches of C3, C4)
	Middle: spinous process of 7C and T1–T3	Middle: medial border of the acromion process and upper border of acromion	Middle: elevation, upward rotation, and adduction of scapula	Middle: accessory nerve (cranial nerve XI and branches of C3, C4)
	Lower: spinous process of T4–T12	Lower: base of scapular spine (triangular shape)	Lower: depression adduction and upward rotation of the scapula	Lower: accessory nerve (cranial nerve XI and branches of C3, C4)
Levator scapulae	Transverse process of C1–C4	Above base of scapular spine on medial border	Elevates medial margin of scapulae	Dorsal scapular nerve C5 and branches of C3 and C4

MUSCLES OF THE MIDSECTION

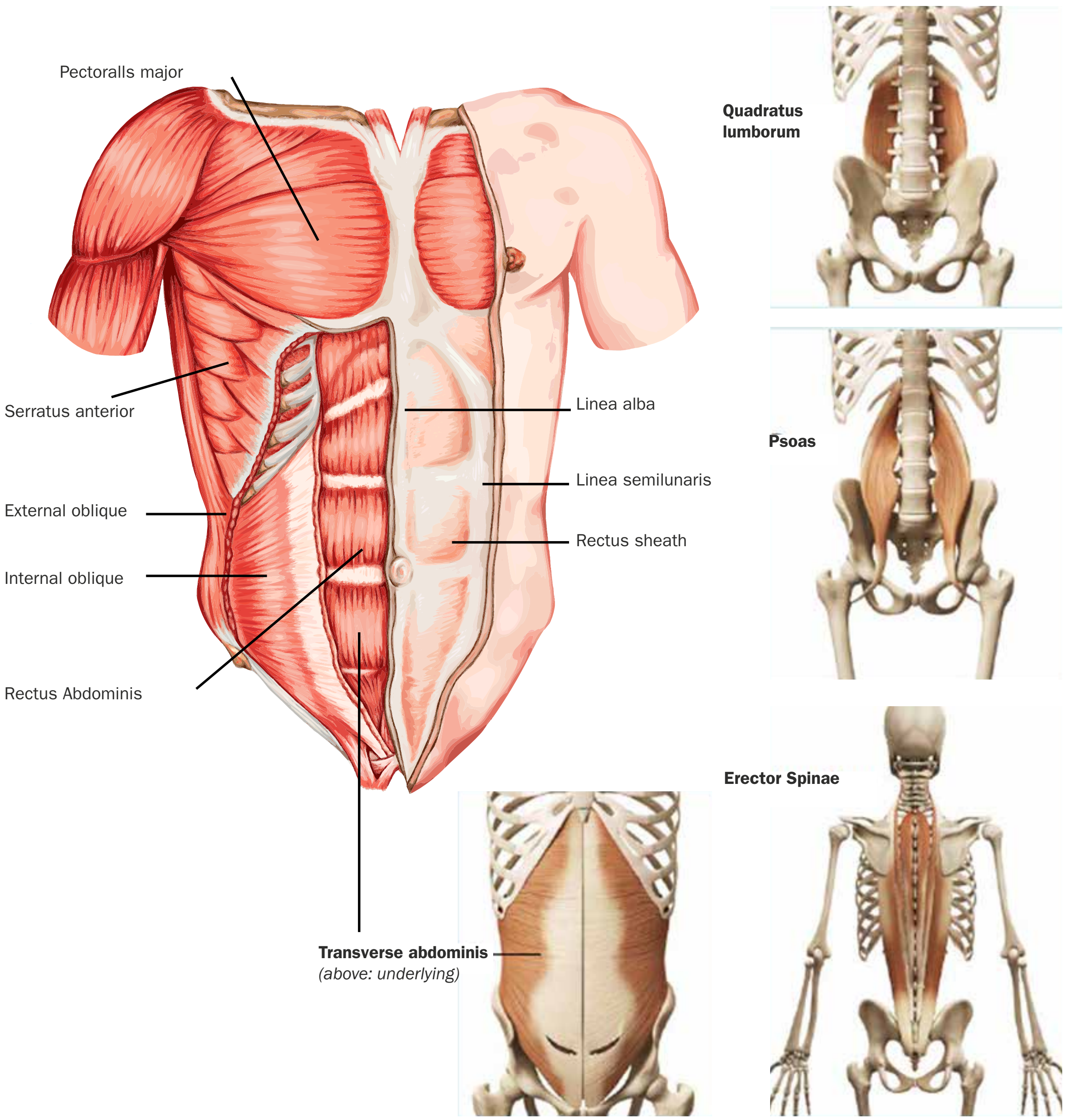


Figure 5.29 Midsection

1. Pectoralis major
2. Serratus anterior
3. External oblique
4. Internal oblique
5. Rectus abdominis
6. Transverse abdominis
7. Linea alba
8. Linea semilunaris
9. Rectus sheath
10. Quadratus lumborum
11. Psoas
12. Erector spinae

Table 5.8 Trunk and Spinal Column

Trunk and Spinal Column				
MUSCLE	**ORIGIN**	**INSERTION**	**ACTION**	**INNERVATION**
Rectus abdominis	Superior surface of pubis around symphysis	Inferior surfaces of costal cartilages (ribs 5–7) and xiphoid process of sternum	Depresses ribs and flexes vertebral column	Thoracic spinal nerves (T7–T12)
Transversus abdominis	Cartilages of the lower ribs, iliac crest, and lumbodorsal fascia	Linea alba and pubis	Compresses abdomen	Intercostal iliohypogastric and ilioinguinal nerves
External oblique	External and inferior borders of ribs 5–12	Linea alba and iliac crest	Compresses abdomen; depresses ribs; flexes, bends to side; or rotates spine	Intercostal iliohypogastric and ilioinguinal nerves
Internal oblique	Lumbodorsal fascia and iliac crest	Inferior surfaces of ribs 9–12, costal cartilages 8–10, linea alba, and pubis	Compresses abdomen; depresses ribs; flexes, bends to side; or rotates spine	Intercostal iliohypogastric and ilioinguinal nerves
Serratus anterior	Surface of upper nine ribs at side of chest	Anterior aspect along entire length of medial border of scapula	(Protraction) draws medial border of scapulae away from vertebrae (upward rotation)	Long thoracic nerve (C5–C7)

MUSCLES OF THE CHEST

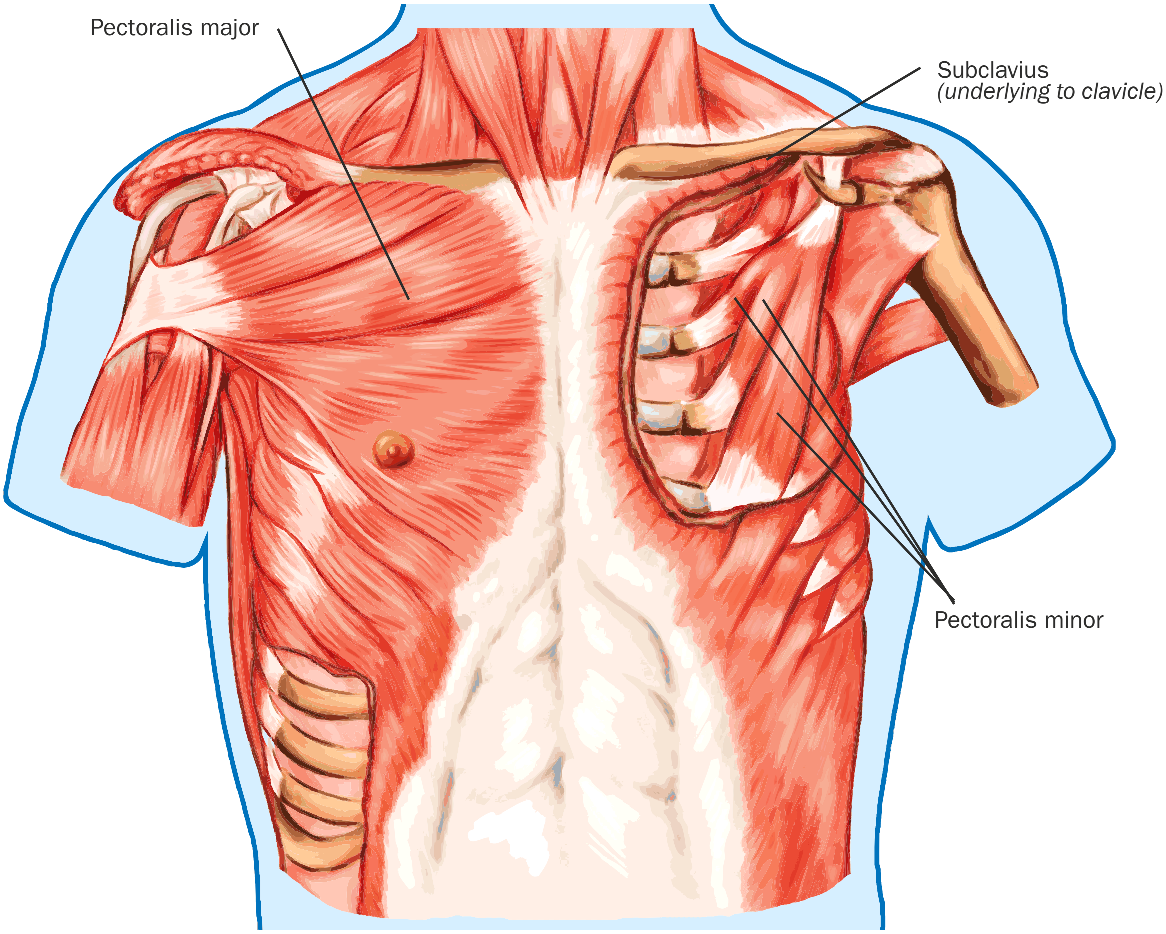


Figure 5.30 Chest

1. Pectoralis major
2. Subclavius
3. Pectoralis minor

Table 5.9 Chest

CHEST				
MUSCLE	**ORIGIN**	**INSERTION**	**ACTION**	**INNERVATION**
Pectoralis major	Clavicular: medial half of anterior surface of clavicle	Clavicular: flat tendon 2 or 3 inches wide to the outer lip of intertubercular groove of the humerus	Clavicular: internal rotation, horizontal adduction, flexion abduction, and adduction (when the arm is 90˚ of abduction of the glenohumeral joint)	Clavicular: lateral pectoral nerve (C5–C7)
	Sternal: anterior surfaces of costal cartilage of first six ribs and adjacent portion of sternum	Sternal: groove of humerus	Sternal: internal rotation, horizontal adduction, extension, and adduction of the glenohumeral joint	Sternal: medial pectoral nerve (C8, T1)
Pectoralis minor	Anterior surfaces of ribs 3–5	Coracoid process of scapula	(Protraction) draws scapula forward (downward rotation; depression)	Medial pectoral nerve (C8, T1)
Subclavius	Sternal end of first rib	Underside of the middle third of the clavicle	Depresses the clavicle and elevates first rib	Subclavian nerve (C5, C6)

MUSCLES OF THE UPPER LEG AND HIPS

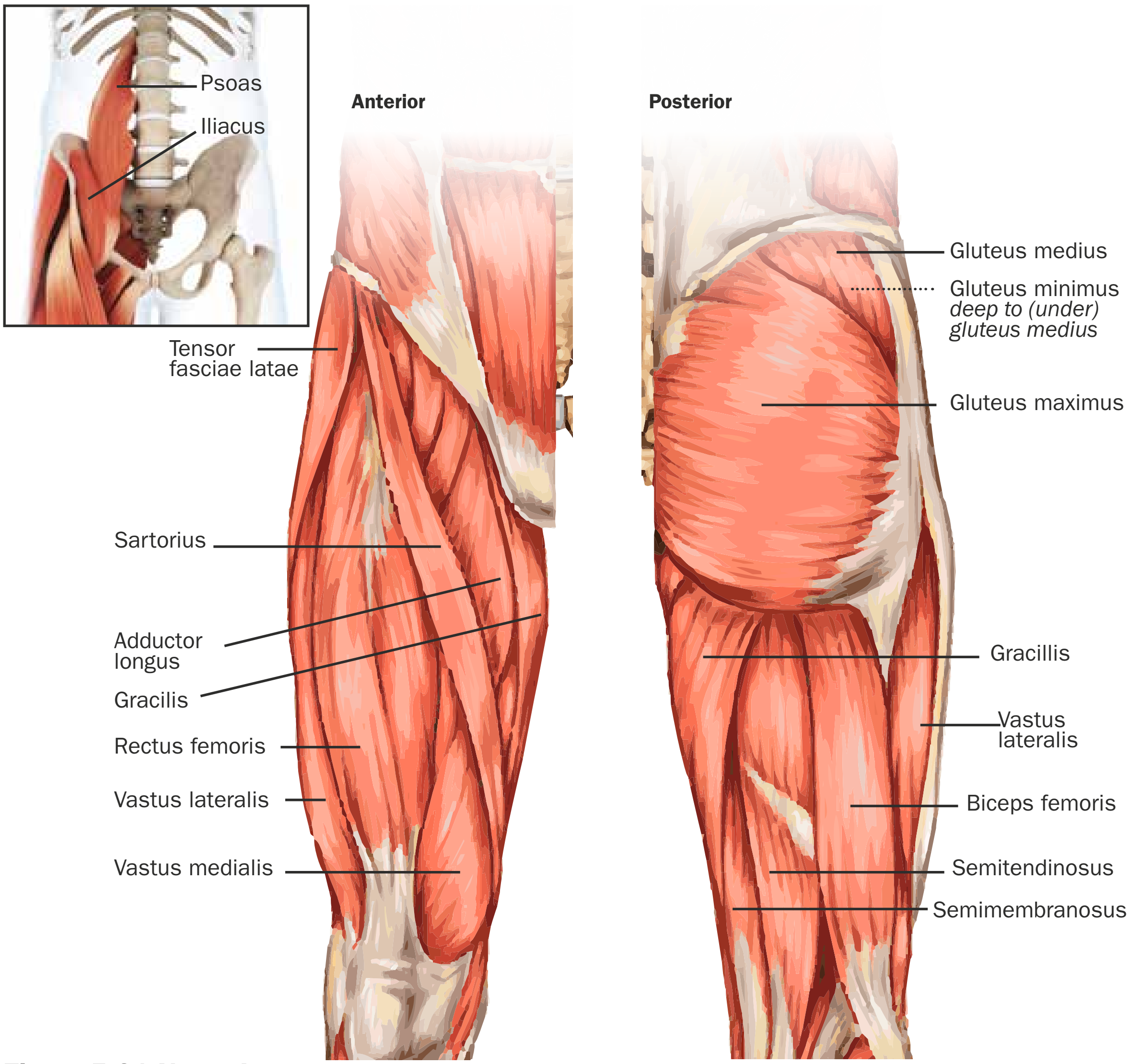


Figure 5.31 Upper Leg

1. Psoas
2. Iliacus
3. Gluteus medius
4. Gluteus minimus
5. Tensor fasciae latae
6. Sartorius
7. Adductor longus
8. Gracilis
9. Rectus femoris
10. Vastus lateralis
11. Vastus medialis
12. Gluteus maximus
13. Biceps femoris
14. Semitendinosus
15. Semimembranosus

Table 5.10 Hip and Pelvis

Hip Joint and Pelvic Girdle				
MUSCLE	**ORIGIN**	**INSERTION**	**ACTION**	**INNERVATION**
Rectus femoris	Anterior iliac spine of the ilium and groove (posterior) above the acetabulum	Superior aspect of patella and patellar tendon to tibial tuberosity	Flexion of hip, extension of knee	Femoral nerve (L2–L4)
Gluteus maximus	Posterior quarter of the crest of ilium, posterior surface of sacrum and coccyx near the ilium, and fascia of lumbar area	Oblique ridge on lateral surface of greater trochanter and iliotibial band of fasciae	Extension of hip and external rotation of hip, lower fibers assist in adduction	Inferior gluteal nerve (L5, S1–S2)
Semitendinosus	Ischial tuberosity	Upper anterior medial surface of tibia	Extension of hip, flexion of knee, and internal rotation of hip and knee	Sciatic nerve-tibial division (L5, S1–S2)
Semimembranosus	Ischial tuberosity	Posteromedial surface of medial tibial condyle	Extension of hip, flexion of knee, and internal rotation of hip and knee	Sciatic nerve-tibial division (L5, S1–S2)
Biceps femoris	Long head: ischial tuberosity	Lateral condyle of tibia and head of fibula	Extension of hip, flexion of knee, and internal rotation of hip and knee	Long head: sciatic nerve-tibial division (S1–S3)
	Short head: lower half of linea aspera and lateral condyloid ridge			Short head: sciatic nerve-peroneal division (L5, S1–S2)

Table 5.11 Knee Joint

Knee Joint				
MUSCLE	**ORIGIN**	**INSERTION**	**ACTION**	**INNERVATION**
Vastus lateralis	Intertrochanteric line, anterior and inferior borders of greater trochanter gluteal tuberosity, upper half of the linea aspera, and entire lateral intermuscular septum	Lateral border of patella and patellar tendon to tibial tuberosity	Knee extension	Femoral nerve (L2–L4)
Vastus intermedius	Upper two-thirds of anterior surface of the femur	Upper border of patella and patellar tendon to tibial tuberosity	Knee extension	Femoral nerve (L2–L4)
Vastus medialis	Entire length of linea aspera and the medial condyloid ridge	Medial half of upper border of patella and patellar tendon to tibial tuberosity	Knee extension	Femoral nerve (L2–L4)

MUSCLES OF THE LOWER LEG

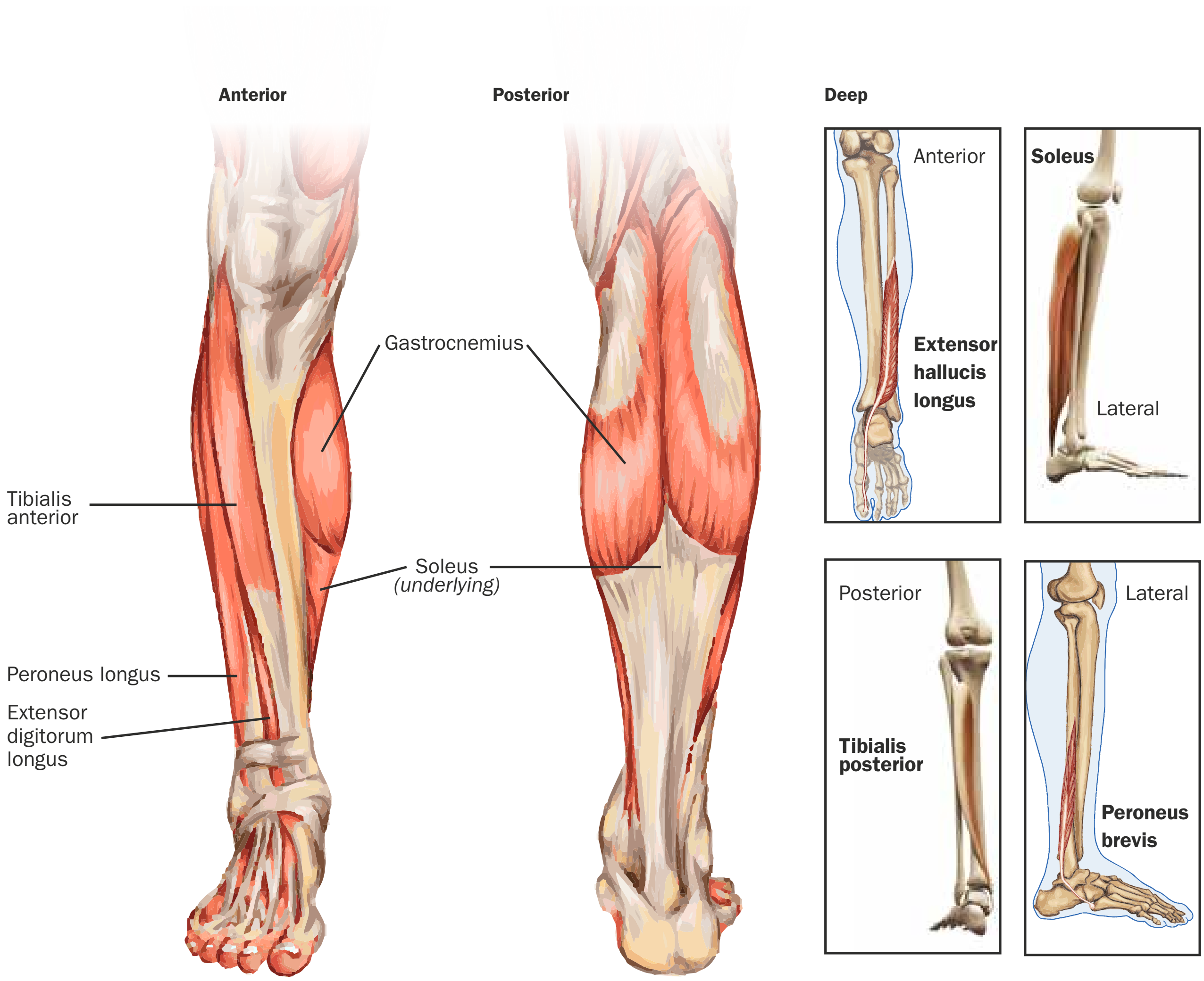


Figure 5.32 Lower Leg

1. Tibialis anterior
2. Peroneus longus
3. Extensor digitorum longus
4. Extensor hallucis longus
5. Gastrocnemius
6. Soleus
7. Peroneus brevis
8. Tibialis posterior

Table 5.12 Foot and Ankle

Ankle and Foot				
MUSCLE	**ORIGIN**	**INSERTION**	**ACTION**	**INNERVATION**
Gastrocnemius	Medial head: posterior surface of the medial femoral condyle Lateral head: posterior surface of the lateral femoral condyle	Posterior surface of the calcaneus (Achilles tendon)	Plantar flexion of the ankle and flexion of the knee	Tibial nerves (S1, S2)
Soleus	Posterior surface of the proximal fibula and proximal two-thirds of the posterior tibial surface	Posterior surface of the calcaneus (Achilles tendon)	Plantar flexion of the ankle	Tibial nerves (S1, S2)
Tibialis anterior	Upper two-thirds of the lateral surface of tibia	Inner surface of medial cuneiform and the first metatarsal bone	Dorsal flexion of ankle and inversion of foot	Deep peroneal nerve (L4–L5, S1)


METABOLISM

CHAPTER 06

ENERGY AND METABOLISM

LEARNING OBJECTIVES

1 | Identify the organelles of the human cell.

2 | Define and explain the three primary energy systems in the human body.

3 | Describe how the energy systems overlap.

4 | Define metabolism and energy balance and the factors that affect each.

The human body requires a constant supply of energy to move and function properly. Energy comes from the sun and is transferred to humans and animals through the ingestion and digestion of **macronutrients** as plant and animal foods. Once consumed, the body goes through a series of intricate processes to break down the food and turn it into usable energy - this is know as **metabolism**. The study of this (how energy is transformed in living organisms) is called **bioenergetics**.

CELLS

Cells perform all functions of life. They carry out specialized functions, convert nutrients into energy, and create structure for the body. There are many types of cells with different locations and functions within the body, but they all have the same basic components a fitness professional must generally understand to better grasp energy and metabolism. Cells consist of a membrane that encompasses multiple **organelles** and genetic material. Organelles are tiny structures within the cell, each with a unique function.

PLASMA MEMBRANE

The **plasma membrane** surrounds all organelles and the **cytoplasm** of a cell. The membrane has two layers made up of lipids (fats) and proteins. Referred to as the **phospholipid bilayer**, it is made up of glycerol, two **fatty acids**, and a phosphate group. Proteins on or within the phospholipid bilayer assist in cellular reactions and the transport of macronutrients into and out of the cell.

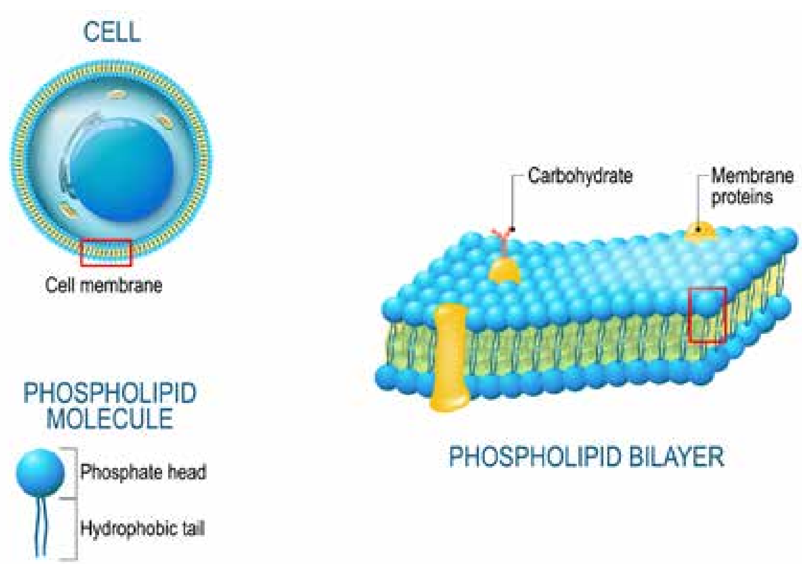


Figure 6.1 The Cell Membrane

MACRONUTRIENTS: A type of food necessary in large quantities in the diet to support function and energy production (i.e., carbohydrate, protein, and fat.)

METABOLISM: All of the chemical processes that occur in the body to support life including converting food into energy.

BIOENERGETICS: The study of how energy is transformed in living organisms.

CELLS: The building blocks of all living organisms.

ORGANELLES: Tiny structures within cells, each with a unique function.

PLASMA MEMBRANE: The cellular membrane made of lipids and proteins that forms the external boundary of the cytoplasm and regulates the passage of molecules in and out of the cytoplasm.

CYTOPLASM: The viscous fluid inside a living cell excluding the nucleus.

PHOSPHOLIPID BILAYER: The dual layer of lipids that make up the cell membrane of most human cells.

FATTY ACIDS: The smaller, absorbable building blocks of the fat that is found in the body.

The membrane is semipermeable—meaning some molecules can pass through it. Some require a transport protein while others do not. The presence of cholesterols within the membrane allow cells to maintain their fluidity and structure at varying temperatures.

NUCLEUS

The nucleus has its own membrane and holds **deoxyribonucleic acid (DNA)**. DNA forms strands called chromosomes, which contain the genetic blueprints for each unique cell in the human body. Eye color, height, skin tone, and hair texture are some of the many features influenced by the strands of DNA carried in the nucleus.

Cytoplasm or cytosol is the viscous fluid inside the plasma membrane excluding the nucleus. The cytoplasm is the site of many cellular reactions such as the following:

- **Gluconeogenesis** (the creation of glucose from non-carbohydrate substrates)
- Fatty acid synthesis
- The activation of amino acids
- **Glycolysis** (the breakdown of glucose)

The nucleus of the cell also initiates cell division, known as (**mitosis**). In this process, the cell divides itself to produce two cells from one.

RIBOSOMES

Ribosomes are small, spherical organelles made of protein and ribonucleic acid (RNA). They can be free-floating in the cytoplasm or attached to another organelle—the **endoplasmic reticulum (ER)**. Proteins made by free-floating ribosomes are intended to act inside the cell. Proteins made from attached ribosomes are intended to be transported outside of the cell to act.

ENDOPLASMIC RETICULUM (ER)

The ER is an organelle that forms a network of canals within the cytoplasm and is continuous with the nuclear membrane. An ER with ribosomes attached is a **rough endoplasmic reticulum**. A **smooth endoplasmic reticulum (SER)** has no ribosomes attached. The SER's primary role in the cell is to produce lipids and, in some cases, metabolize them and associated products. The SER in liver cells, for example, enables **glycogen** to be broken down into glucose. An SER is also involved in the production of steroid hormones in the adrenal cortex and endocrine glands. In muscle cells, the SER releases calcium ions to trigger the contraction of muscle cells and is called the sarcoplasmic reticulum.

DEOXYRIBONUCLEIC ACID (DNA): Self-replicating genetic material in human cells.

GLUCONEOGENESIS: The generation of new glucose molecules from non-carbohydrate carbon substrates.

GLYCOLYSIS: The breakdown of glucose by enzymes, releasing energy and pyruvic acid.

MITOSIS: Cell division that results in two cells identical to the original cell.

RIBOSOMES: Small cellular organelles involved in polypeptide and protein synthesis.

ENDOPLASMIC RETICULUM (ER): A network of tubules attached to the nuclear membrane in cells.

ROUGH ENDOPLASMIC RETICULUM: Endoplasmic reticulum with ribosomes attached.

SMOOTH ENDOPLASMIC RETICULUM (SER): Endoplasmic reticulum that lacks ribosomes.

GLYCOGEN: The stored form of glucose found in muscle tissue and the liver.

GOLGI APPARATUS:
An organelle of folded membranes responsible for packaging and transporting membrane-bound proteins.

GLYCOPROTEINS:
A class of proteins with a carbohydrate group(s) attached.

LYSOSOMES:
An organelle filled with digestive enzymes that breaks down materials the cell has absorbed.

MITOCHONDRIA:
An organelle with a double membrane and many folds inside responsible for generating the chemical energy needed for biochemical reactions.

OXIDATIVE PHOSPHORYLATION:
The energy-producing process that occurs in mitochondria in the presence of oxygen.

GOLGI APPARATUS

Located near the nucleus and ER, the **Golgi apparatus** creates vesicles—or transport bubbles—that move proteins from inside the cell to the cell membrane to be released to their final destination in the body. Many of these proteins are called **glycoproteins**, and they have attached carbohydrate groups. Glycoproteins play an important role in cellular communication and interactions and the function of enzymes, hormones, antibodies, and cell structural proteins.

LYSOSOMES

These organelles serve as the digestive system of the cell. **Lysosomes** have about 50 different enzymes that break down materials the cell has absorbed. They can also digest and destroy elements within the cell that are no longer needed. The digested product in a lysosome is either used to create cellular energy or can be used to create a new molecule.

MITOCHONDRIA

Mitochondria are known as the powerhouse of the cell. They are small, complex organelles that contain their own DNA. During a process called **oxidative phosphorylation**, the mitochondria convert macronutrients into chemical energy for the cell.

In cardiac muscle cells, about 40 percent of the space in the cytoplasm is occupied by mitochondria. In liver cells, about 20 to 25 percent of the space is taken up by mitochondria. A higher mitochondrial density equals a higher energy output potential for a cell.

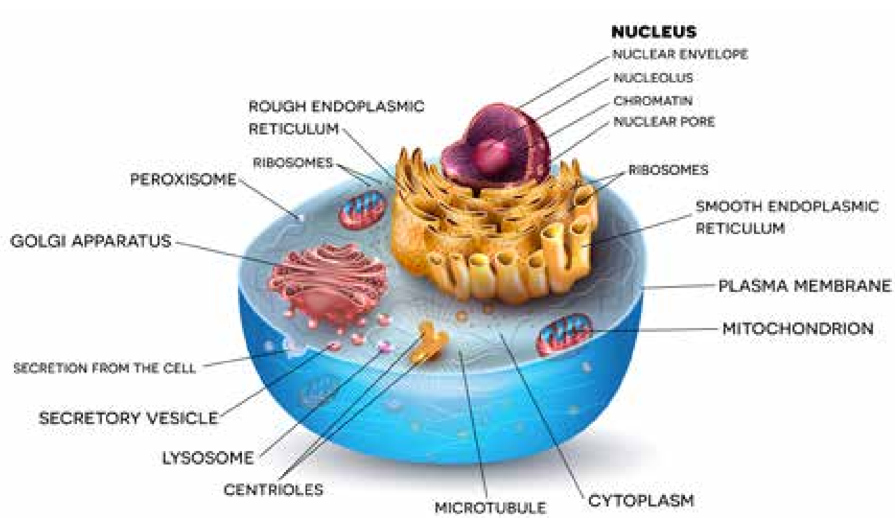


Figure 6.2 Cell Components

FOOD AS ENERGY

The food (i.e., macronutrients) humans ingest must be broken down to be used at the cellular level for energy production. The manual and chemical breakdown of food begins in the digestive system.

There are three macronutrients required by the body: carbohydrate, protein, and fat. They are called macronutrients because they are needed in large quantities daily to support the body's normal function and energy production. Carbohydrates (carbs) are one of the main sources of energy for the body and are broken down into **glucose** or stored as glycogen in the liver and muscles for future use. Whatever is not used or stored as glycogen gets converted to **triglycerides** and stored as fat. Glucose circulates in the blood to be used for energy around the body. Glycogen is made up of many connected glucose molecules. When blood glucose is low, the body breaks down glycogen into glucose to be released into the bloodstream.

GLUCOSE:
A simple sugar the body uses for energy production on the cellular level.

When the body is at rest, it is estimated that approximately 70 percent of the body's energy needs are met by fat sources, and approximately 30 percent of the energy need is met with carbohydrate sources. However, when energy production is sufficient for immediate demands, excess carbohydrates are stored in adipose tissue (body fat) as triglycerides. When dietary fat is digested, it is broken down into fatty acids—the smaller building blocks of fats—for use in energy production or triglycerides for storage in adipose tissue.

TRIGLYCERIDES:
A chemical compund formed when three fatty acids combine with glycerol. The most abundant fat in the body.

Protein is not a primary substrate for energy metabolism unless the body is in a state of severe starvation or when the intake of the other macronutrients is insufficient to support energy demands. Protein has too many important roles in the body, so carbohydrates and fats are preferred sources of energy. Protein plays a significant role in the following:

- Growth and maintenance of tissue (anabolism)
- Protein enzymes aid in biochemical processes
- Protein hormones relay nervous system messages
- Build connective tissues such as tendons, ligaments, and cartilage
- Helps maintain blood pH via hemoglobin
- The proteins albumin and globulin support fluid balance
- Creation of antibodies to fight infection
- Transport and store nutrients

The body will use each macronutrient differently, and, depending on the activity level and energy demand, the mix of which macronutrient is providing most of the energy will vary. The **respiratory quotient (RQ)** is a calculation that estimates which macronutrient is predominantly

RESPIRATORY QUOTIENT (RQ):
A method of determining the fuel mix being used; a way to measure the relative amounts of fats, carbohydrates, and proteins being burned for energy.

INDIRECT CALORIMETRY:
A way to measure energy expenditure by oxygen consumed and carbon dioxide produced.

being used for fuel at a point in time. RQ is the ratio of the volume of carbon dioxide expired (breathed out) to the volume of oxygen being consumed (breathed in), which is known as **indirect calorimetry**. The amounts of oxygen used for the metabolism of fat, carbohydrate, and protein differ. Therefore, differences in the RQ indicate which nutrient source is being predominantly used for energy purposes.

RQ = volume CO_2 exhaled / volume of O_2 inhaled

The RQ for carbohydrates is 1.0, whereas the RQ for fat is 0.7. Fat has a lower RQ value because the fatty acids require more oxygen for the process of oxidation the chemical reaction of combining with oxygen or removing hydrogen.

The RQ for energy production from protein is about 0.8, and the average person at rest will have an RQ of about 0.8. However, the resting RQ is typically from a mixture of using fatty acids and carbohydrates, not protein, for energy production. In a normal diet containing all three macronutrients, about 40 to 45 percent of the energy is derived from fatty acids, 40 to 45 percent from carbohydrates, and 10 to 15 percent from protein. This rate of energy production varies based on diet, physical activity, and the individual's level of physical training.

ADENOSINE TRIPHOSPHATE (ATP)

ADENOSINE TRIPHOSPHATE (ATP):
An energy-carrying molecule used to fuel body processes.

Macronutrients are not directly used as energy, nor are the resulting substrates from digestion. Rather, these substrates (glucose and fatty acids) are converted into **adenosine triphosphate (ATP)**, the energy currency of the cells.

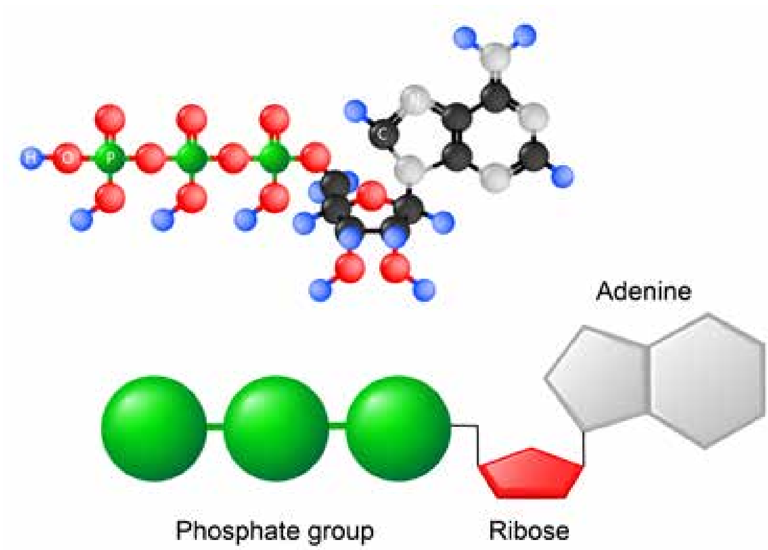


Figure 6.3 Adenosine Triphosphate (ATP)

ATP is a combination of adenine and three phosphate groups. The bonds between the phosphate groups store energy that is released when that bond is broken. When energy is needed in the cell, for muscle contraction for example, the bond of the end phosphate (P) is broken, and energy, heat, and a hydrogen ion (H+) are released. Roughly 40 percent of the energy from ATP is used for cellular work, and the rest is released as heat.

ATP ► ADP + P + energy + heat + H+

During physical exercise, ATP is used in muscle cells to generate muscle contraction. ATP works with myosin in the sarcomere to contract and release the filaments. During contraction, ATP is broken down by the enzyme ATPase. This causes the phosphate group to split from ATP to generate energy and create **adenosine diphosphate (ADP)** and a free phosphate (P). The ADP and P attach to the myosin head and bind to the actin filament.

When movement occurs (when the sarcomere shortens), the ADP and phosphate (P) are released. Another molecule of ATP attaches to the myosin, causing the actin to detach and relax the muscle. Muscle contraction requires two molecules of ATP to complete the contract/relax sequence.

ADENOSINE DIPHOSPHATE (ADP):
An organic compound essential to the flow of energy in living cells.

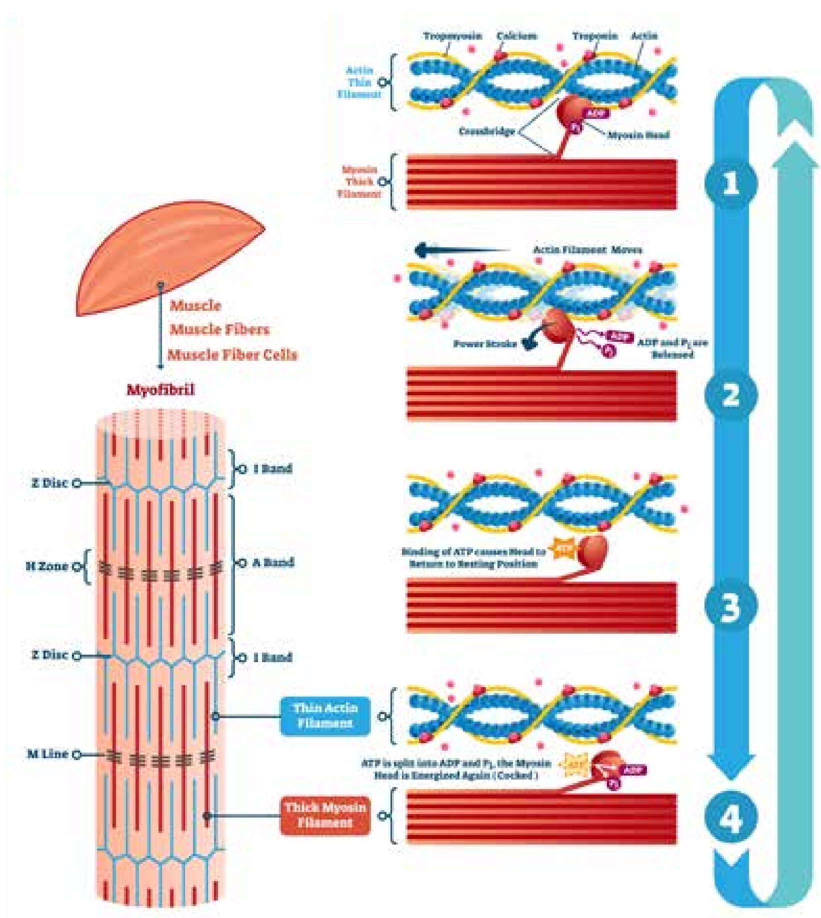


Figure 6.4 ATP and Muscle Contraction

ENERGY PATHWAYS: The chemical-reaction pathways that supply the body with energy on a cellular level.

For the cell to continue work, more ATP must be created. This is done in several ways depending on the intensity and duration of activity. The body metabolizes the food we eat through three distinct **energy pathways**—the ATP/creatine phosphate system (ATP/CP), anaerobic glycolysis, and the oxidative pathway. Each energy pathway is effective at producing energy for various intensities and durations of activity.

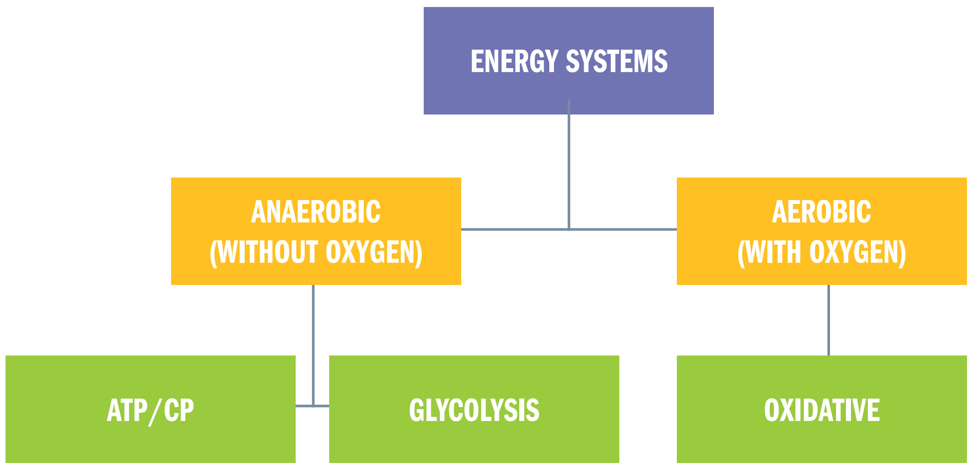


Figure 6.5 Energy Systems

ANAEROBIC ENERGY PRODUCTION

The body stores a limited amount of ATP in the muscle cells, and this ATP is available for immediate energy needs. Stored ATP can only supply energy for up to 10 seconds of work. Examples of activities that use stored ATP include shot put, powerlifting, high jump, a golf swing, a tennis serve, and a pitch or throw.

ANAEROBIC: Without or not requiring oxygen.

After stored ATP is used, the cell creates energy using the immediate energy of the ATP/creatine phosphate (ATP/CP) pathway. This energy pathway is **anaerobic**, meaning it does not require the presence of oxygen.

CREATINE PHOSPHATE (CP): A high energy molecule stored in skeletal muscle, the myocardium, and the brain.

ATP/CREATINE PHOSPHATE (CP) ENERGY PATHWAY

ATP/CP ENERGY PATHWAY: The anaerobic energy system that provides rapid energy using creatine phosphate to generate ATP.

Creatine phosphate (CP), also known as phosphocreatine, is a compound stored in muscle cells. After immediate energy stores of ATP are used, CP is broken down to create more ATP in what is known as the **ATP/CP energy pathway**. ATP becomes ADP when a phosphate bond is broken and the resulting energy is used for work. To create another molecule of ATP, one phosphate group needs to be added back to a molecule of ADP. CP lends this phosphate group to the recycling of ADP back into ATP.

Creatine kinase is the enzyme that breaks CP into creatine and phosphate. Once broken into individual molecules, the phosphate group attaches to ADP to create ATP. Like ATP, CP is only found in small amounts in the muscle cells where it is stored. During maximum-intensity activity, CP stores can be depleted in less than 10 seconds. For these short durations, the ATP/CP energy system supports short, powerful activities such as a high jump, a 100-meter sprint, or lifting a heavy load two to three times.

ANAEROBIC GLYCOLYSIS

For activities that last from 10 to 120 seconds (2 minutes) and when the immediate demand for oxygen is greater than the supply, the body must tap into a second energy pathway. **Anaerobic glycolysis** uses one molecule of ATP to convert glucose to glucose phosphate. Glycogen can also be used in this process.

Anaerobic glycolysis produces a metabolic by-product called **lactic acid** and is sometimes referred to as the lactic acid system. Lactic acid, also called lactate, is used in the body in three ways:

1. To make ATP
2. To make glucose in the liver
3. As a signaling molecule

Recent research on lactic acid shows that the body benefits from producing it. Researchers have found that cells make lactate all the time, not just under maximal exertion and not just anaerobically. Recent findings suggest that lactic acid is a major source of energy used to repair and refuel the energy systems when those systems are taxed to the point that metabolic by-products are generated (metabolic stress).

During intense activity, mitochondria in the cell prefer lactate for energy. Lactate also signals the body to stop the metabolism of fat for energy and switch to the faster metabolism of glucose and glycogen. As more lactic acid is produced, it is released into the blood for use by the heart and brain, which both prefer it (over glucose or glycogen) for energy. However, when excess lactic acid and hydrogen ions build up in the tissues as a by-product of metabolism, they lead to muscular fatigue and muscular soreness. This buildup in the muscle cells causes the burning sensation many people describe during intense activity.

ANAEROBIC GLYCOLYSIS:
The anaerobic energy system converting glucose to lactate when oxygen is limited.

LACTIC ACID:
The chemical by-product of anaerobic glycolysis.

ANAEROBIC THRESHOLD: The point at which the body switches from aerobic metabolism to primarily anaerobic metabolism.

LACTATE THRESHOLD: The maximum effort or intensity an individual can maintain for an extended time with minimal effect on blood lactate levels. This is the point where muscle tissue begins to make large amounts of lactate.

LACTIC ACIDOSIS: The accumulation of excess H+ causing muscle fatigue and soreness.

AEROBIC ENERGY PATHWAYS: Cellular energy pathways that require oxygen for energy production.

AEROBIC GLYCOLYSIS: The breakdown of glucose to ATP in the presence of oxygen.

OXIDATION: The chemical reaction of combining with oxygen or removing hydrogen.

OXIDATIVE ENERGY PATHWAY: An aerobic energy pathway using primarily fat and carbohydrates to produce energy.

The point at which the body switches from metabolism requiring oxygen to primarily anaerobic metabolism is called the **anaerobic threshold** while the point where muscle tissue begins to make large amounts of lactate (exponential increases) is referred to as the **lactate threshold** and can lead to **lactic acidosis**. At this point, the body must stop or slow down until the lactic acid is cleared. Physical training increases the number of mitochondria in the cells, increasing the efficiency of the cells to use lactate for energy production.

AEROBIC ENERGY PRODUCTION

When cells exhaust the immediate ATP energy stores and glucose has been depleted, the **aerobic energy pathways** will begin to dominate energy production. The aerobic energy pathways are dominant in sustained activities lasting more than 120 seconds (2 minutes) and include the process of **aerobic glycolysis**, fatty acid **oxidation**, and, in extreme circumstances, gluconeogenesis.

The **oxidative energy pathway** is a primary source of energy when the body is at rest or during low-intensity activities. Carbohydrates and fats are the primary fuel for this system, with fat providing most of the energy when energy demands are low and the glucose from carbohydrates increasing in comparison as the intensity of activity and immediate energy needs increase.

OXIDATIVE ENERGY PATHWAY

It is not important for a fitness professional to know every step that occurs during aerobic metabolism. However, it is important to understand the general steps and the outcome as it relates to energy production. Aerobic metabolism produces a large amount of ATP, but it does so through a series of steps including glycolysis, the **Krebs cycle**, and the **electron transport chain**. This means the aerobic production of ATP is more efficient but also takes more time to occur.

Glycolysis means, literally, the breakdown of glucose, and this metabolic process occurs both anaerobically and aerobically. In the absence of oxygen, the process is anaerobic glycolysis, and the by-product of this process is lactate. In the presence of oxygen, the process is called aerobic glycolysis, and the by-product of this energy pathway is **pyruvate**, which serves as a transitional molecule in the many stages of aerobic metabolism.

Pyruvate is broken down into acetyl coenzyme A (also known as acetyl-CoA), which then enters the Krebs cycle in the mitochondria during aerobic metabolism. When acetyl-CoA is oxidized, it creates two molecules of ATP, carbon dioxide, and hydrogen ions.

Hydrogen ions released during the Krebs cycle move into the electron transport chain (also known as oxidative phosphorylation). These electrons contain a large amount of energy and are passed down a series of proteins located in the membrane of the mitochondria. A series of reactions happen as the hydrogen ions are transported across the membrane of the mitochondria, and the process produces 35–38 molecules of ATP.

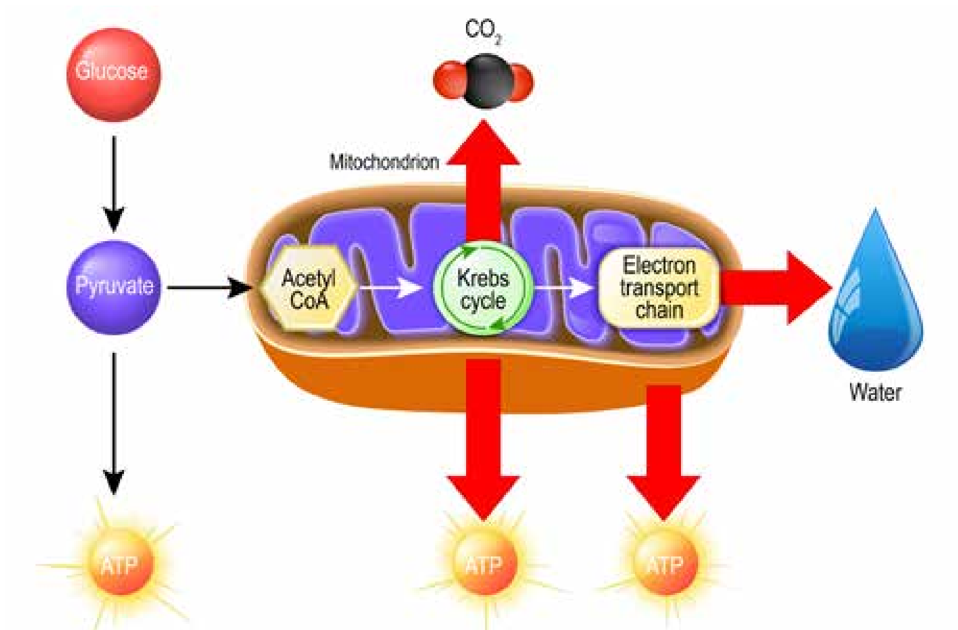


Figure 6.6 The Stages of Aerobic Metabolism

Triglycerides (stored fats) are high-energy substrates. One molecule of fat (e.g., palmitic acid) can produce up to 129 molecules of ATP. The body will prioritize fatty acid metabolism when the body is at rest because energy is not required immediately or in large quantities. However, the body prefers to use sugars for energy since the process of fatty acid metabolism requires more oxygen to execute than the conversion of glucose and glycogen to ATP.

During a process known as beta-oxidation, triglycerides are broken down into fatty acids—or the smaller components of fats. These fatty acids are further broken down into acetyl-CoA, which can then enter the Krebs cycle for aerobic glycolysis. It is important to distinguish that fats can only be used in this way for energy production in the presence of oxygen.

KREBS CYCLE:

A series of chemical reactions inside the mitochondria that use acetyl-CoA to generate ATP and other substrates that contribute to the electron transport chain.

ELECTRON TRANSPORT CHAIN:

A series of proteins in the mitochondrial membrane that transfer electrons and hydrogen ions across the membrane to generate ATP from ADP.

PYRUVATE:

A metabolic intermediate molecule in several energy pathways.

GLUCONEOGENESIS

Amino acids are a "last resort" energy substrate. Gluconeogenesis is the process by which muscle protein is broken down or catabolized. In times of starvation, in very long-duration activities, in situations where glucose is low or insufficient, and in highly trained individuals, amino acids are converted to glucose in the liver. Glucose is then released into the bloodstream and used to generate energy in working cells. The amino acid alanine is the most prominently used amino acid for this process.

Gluconeogenesis is limited by the availability of the enzymes required to drive protein breakdown. During long-duration activities or starvation, **hypoglycemia**—or excessively low blood glucose levels—can occur. Low blood sugar stimulates the production of the hormone glucagon, which in turn stimulates the production of the enzymes required for gluconeogenesis and will stimulate protein breakdown.

HYPOGLYCEMIA:
The condition of lower-than-normal blood glucose.

THE ENERGY SYSTEM OVERLAP

All these energy systems are interconnected, and all three are operating at all times. However, the intensity and duration of activity dictates which energy system dominates energy production at any moment in time.

Anaerobic and aerobic metabolism happen simultaneously during exercise according to the energy system overlap. During low-intensity, long-duration exercise, aerobic metabolism supplies the body with energy, and fatty acids are the primary substrate used. During high-intensity exercise, the body relies on both anaerobic and aerobic energy systems, and carbohydrates are the preferred energy substrate for high-intensity, short-duration exercise. However, these ratios change based on dietary intake.

Amino acids are oxidized when muscle glycogen is used up and quickly used carbohydrates are a limited fuel source. When amino acids are depleted, the body must still maintain blood sugar to fuel the nervous system and other working cells. Gluconeogenesis is the backup fuel generation system for low- to moderate-intensity activity.

People in peak physical condition can use more fatty acids as a primary energy substrate (yielding more ATP), but their bodies may use higher amounts of protein via gluconeogenesis.

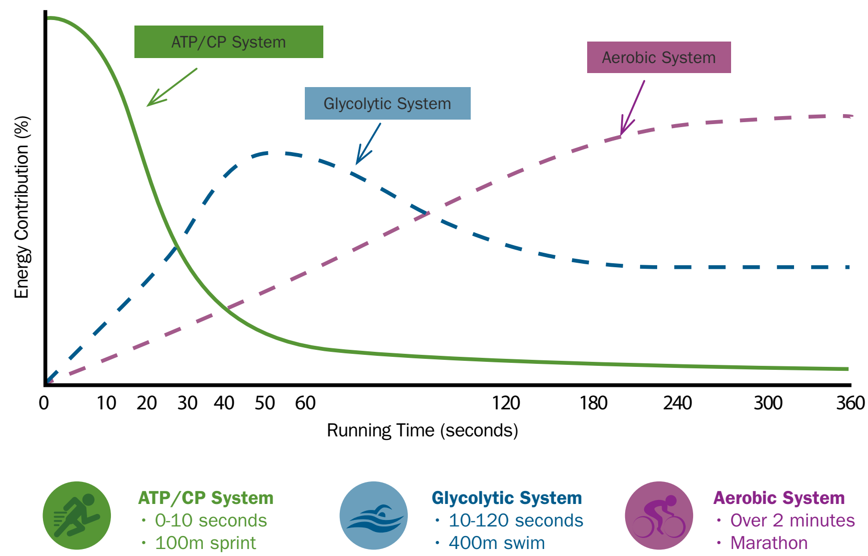


Figure 6.7 Energy System Overlap

Consider a resistance training workout where a client is executing an exercise at a moderate intensity and the exercise lasts for 60 seconds. The client then takes a 2-minute rest before completing the next set. During the first set of activity, they will likely be relying on energy produced during glycolysis—the anaerobic energy system that dominates for activities lasting 1 to 2 minutes. Then during their rest of approximately 2 minutes, the energy demand is relatively low, and the oxidative energy system will dominate during this time.

Similarly, sitting quietly to read this textbook does not require a lot of immediate energy. The body is using the oxidative energy pathway and, in most cases, relying on fatty acid oxidation for energy. If the reader was to quickly stand up and begin sprinting, the dominant energy system will shift based on the duration of the sprint and the body's immediate energy need. A 10- to 15-second sprint will rely on the ATP/CP energy pathway while a 90-second sprint will likely rely on anaerobic glycolysis.

Steady-State versus Intermittent Exercise Metabolism

Aerobic metabolism is a more efficient means of energy production—meaning it yields more ATP per substrate used. In addition, the by-products, carbon dioxide and hydrogen, are more easily eliminated from the body than the by-products of anaerobic processes. However, in the first moments of exercise, aerobic metabolism is minimally active and cannot meet immediate energy needs. Therefore, all activity draws energy first from stored ATP, then from the phosphagen energy pathway, then glycolysis. When the anaerobic threshold is achieved, the body uses the aerobic or oxidative system as its primary output.

STEADY-STATE EXERCISE:
Exercise that maintains a steady level of exertion from start to finish.

EXCESS POSTEXERCISE OXYGEN CONSUMPTION (EPOC):
The amount of oxygen required to restore normal metabolic status.

During **steady-state exercise**, in which the level of exertion stays constant from start to finish, the body reaches an aerobic plateau. Here aerobic metabolism remains the primary source of energy. When exercise stops, oxygen consumption remains elevated for a short time to return the body back to its resting metabolic state. This is known as **excess postexercise oxygen consumption (EPOC)** or oxygen debt. EPOC helps replenish ATP stores used up during exercise and eliminates waste products via respiration. When ATP has been restored and waste products eliminated, the body returns to baseline respiratory rate, temperature, and heart rate.

During most team sports, energy demands are intermittent, that is, lasting for short periods of time with frequent rests, such as football, basketball, and baseball. When energy demands are great, such as during a sprint down the field, energy is provided anaerobically. When the body stops or slows, oxygen consumption stays high to restore ATP. This cycle happens continuously. If high-intensity bouts are short, recovery time is short. If bouts are longer, then recovery will also take longer. Eventually, aerobic energy metabolism kicks in to supply energy for continued short, intense, intermittent activity.

METABOLISM AND ENERGY BALANCE

CALORIES (CAL):
The amount of energy needed to raise the temperature of 1 kilogram of water by 1°C (4,184 joules) at a pressure of 1 atmosphere.

Metabolism is the detailed and complicated chemical process of aerobic and anaerobic metabolism occurring within the cells of the body. The human body requires a certain amount of energy to engage in physical activity and to survive. This energy comes from the external source of food consumed in the diet. The breakdown of the nutrients in food yields **Calories (Cal)**. A Calorie is the amount of energy needed to raise the temperature of 1 kilogram of water by 1°C (4,184 joules) at a pressure of 1 atmosphere. Each of the primary nutrients humans consume (protein, fat, and carbohydrate) yields a specific number of Calories per gram consumed. The term kilocalorie is at times used instead of the term Calorie. For the purpose of accounting for the energy contained in foods these terms may be used interchangeably.

Table 6.1 Calorie Content of Macronutrients

SOURCE	CAL YIELD PER GRAM
Nutritional carbohydrate	4 Cal
Nutritional protein	4 Cal
Nutritional fat	9 Cal

When energy intake in the form of nutrients is equal to energy expenditure, it is known as **energy balance**. A **positive energy balance** means more energy is consumed than expended. The physiological result is weight gain in humans. A **negative energy balance** means more energy is expended than consumed. The physiological result is weight loss in humans.

For the personal trainer, the basic energy balance equation is relatively simple as it relates to clients and is often distilled down to calories in versus calories out. However, there are several factors that affect the energy consumption of the human body beyond cellular metabolism. **Total daily energy expenditure (TDEE)** is a result of the accumulation of three main processes in the body including **resting metabolic rate (RMR)**, the **thermic effect of food (TEF)**, physical activity, and physical growth.

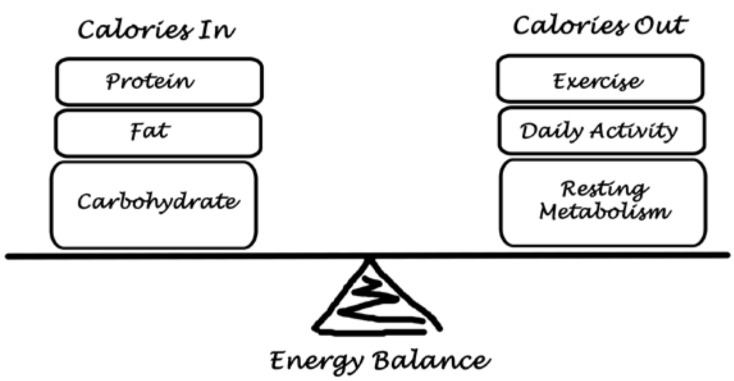


Figure 6.8 The Simplification of Energy Balance

RESTING METABOLIC RATE (RMR)

The RMR is the rate of energy expenditure when the body is at rest. It includes the energy required to support cardiac function and respiration, repair internal organs, maintain body temperature, and balance water and ion concentrations across cell membranes. It consumes about 70 percent of the body's TDEE in a 24-hour period and is the most influential of the physical processes consuming energy.

The RMR is directly correlated to body size and sex. Determining the exact RMR for an individual is nearly impossible. However, accurate formulas have been developed for health and fitness professionals to closely estimate the overall caloric needs for an individual. The Bland-Altman analysis has been widely used to predict an individual's RMR using the following formulas:

Men = 66.4730 + (13.7516 x weight in kg) + (5.0033 x height in cm) – (6.7550 x age in years)

Women = 655.0955 + (9.5634 x weight in kg) + (1.8496 x height in cm) – (4.6756 x age in years)

ENERGY BALANCE: The state achieved when energy intake is equal to energy expenditure.

POSITIVE ENERGY BALANCE: More energy is consumed than expended.

NEGATIVE ENERGY BALANCE: More energy is expended than consumed.

TOTAL DAILY ENERGY EXPENDITURE (TDEE): The accumulated calorie burn made up of resting metabolic rate, the thermic effect of food, physical activity, and physical growth.

RESTING METABOLIC RATE (RMR): The energy expenditure of metabolic and physical processes when the body is at rest.

THERMIC EFFECT OF FOOD (TEF): The energy expenditure associated with food digestion and absorption.

DAILY CALORIE EXPENDITURE (DCE): The total number of calories an individual expends including their resting metabolic rate, activity level factor, and the thermic effect of food.

ACTIVITY LEVEL FACTOR (ALF): Multipliers that reflect varying levels of activity.

CALORIC EXPENDITURE

The Harris-Benedict equation is used to estimate total **daily calorie expenditure (DCE)**. This calculation incorporates the RMR and an **activity level factor (ALF)** that accounts for the individual's daily physical activity level and the TEF.

Table 6.2 Calculating Calorie Expenditure

CALCULATING CALORIC EXPENDITURE		
MALE	metric: **DCE=ALF x [(13.75 x WKG) + (5 x HC) - (6.76 x age) + 66]**	
	imperial: **DCE=ALF x [(6.25 x WP) + (12.7 x HI) - (6.76 x age) + 66]**	
FEMALE	metric: **DCE=ALF x [(9.56 x WKG) + (1.85 x HC) - (4.68 x age) + 655]**	
	imperial: **DCE=ALF x [(4.35 x WP) + (4.7 x HI) - (4.68 x age) + 655]**	
WHERE		
ALF = Activity level factor	**AND ALF HAS THE FOLLOWING VALUES**	
DCE = Daily caloric expenditure	Sedentary:	ALF = 1.2
HC = Height in centimeters	Lightly active:	ALF = 1.375
HI = Height in inches	Moderately active:	ALF = 1.55
WKG - Weight in kilograms	Very active:	ALF = 1.725
WP = Weight in pounds	Extremely active:	ALF = 1.9

Understanding an estimation of how many calories the body is expending along with how the body will use consumed calories is a key component of success. Simply counting calories will not lead to changes in body composition. Instead, the ideal energy balance must be achieved for body composition change.

The heat liberated from a particular food during digestion, whether it is fat, protein, or carbohydrate, is determined by its individual molecular structure, and this structure determines its thermic effect. The higher the thermic effect of any particular food, the higher the metabolic rate will be. A fitness professional must understand what the body is consuming and, more importantly, know how the body will use the consumed calories for energy production.

DIET-INDUCED THERMOGENESIS: The thermic effect of macronutrient digestion and absorption.

THERMIC EFFECT OF FOOD (TEF)

The TEF is the energy associated with the breakdown of food by the body. The TEF accounts for the heat loss when the body digests carbohydrate, fat, and protein in food and makes up about 10 percent of TDEE. Also referred to as **diet-induced thermogenesis**, the TEF varies based on the macronutrient. For example, fats have a lesser thermic effect during digestion and absorption than protein and carbohydrates. The overall macronutrient composition of food consumed will also affect the TEF. Foods heavier in carbohydrates or protein will increase the body's heat production more than meals heavier in fats.

PHYSICAL ACTIVITY

Physical activity is second only to the RMR in terms of its contribution to daily energy expenditure, making up about 20 percent of TDEE. Physical activity can be split into two distinct categories: **exercise activity thermogenesis (EAT)** and **non-exercise activity thermogenesis (NEAT)**. EAT includes planned, structured, and repetitive movement with the goal of improving or maintaining physical fitness. It contributes approximately 5 percent to TDEE. NEAT involves any other movements carried out by the muscles that require energy like simple activities of daily living, such as bathing, doing laundry, and cooking. It contributes approximately 15 percent to TDEE. The more someone moves or exercises, the more energy they will expend. Energy expenditure from physical activity can be calculated using the heart rate as compared to resting heart rate data or through diaries of physical activity and this will be covered in training applications. Individuals with smartwatches and activity trackers can also use these technologies to estimate calorie expenditure from physical activity.

EXERCISE ACTIVITY THERMOGENESIS (EAT): Energy expended as a result of planned, structured, and repetitive movement with the goal of improving or maintaining physical fitness.

NON-EXERCISE ACTIVITY THERMOGENESIS (NEAT): Energy expended as a result of any movements of the body that require energy. This includes all activities of daily living outside of planned and structured workouts.

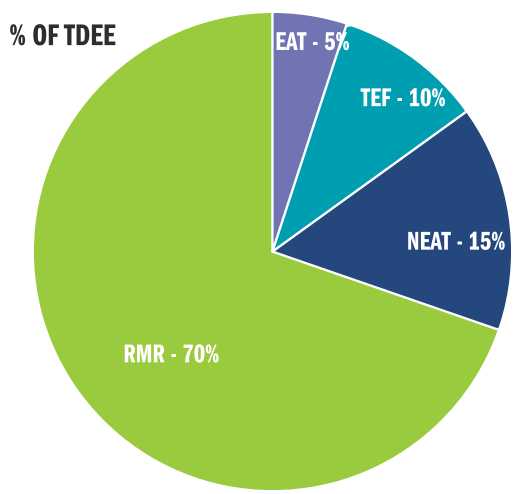


Figure 6.9 Breakdown of Total Daily Energy Expenditure (TDEE)

GROWTH

The body is constantly growing, changing, and repairing. Millions of cells die daily, and millions of cells are created to replace them. For babies, infants, and youth, their bodies are maturing and growing into their adult sizes at a rapid rate, meaning more cells are being created than are dying daily. The same applies for pregnant and lactating females. The energetic cost of physical growth can be an important factor for a personal trainer to consider when creating exercise programming for a youth who is still growing and for a pregnant or lactating client.

LIFESTYLE AND METABOLISM

The lifestyles people lead include their dietary patterns, activities, and even their opinions and behaviors. A personal trainer is initially focused on the activities of a client and, secondarily, on their dietary patterns as they relate to health and fitness goals.

In general, an eating pattern with an excess of a particular macronutrient will cause the body to use that nutrient preferentially over other macronutrients for energy production. For example, an eating pattern high in carbohydrates will use that energy substrate preferentially. A low-carbohydrate eating pattern that is high in fat will cause the body to use fat for energy. Training intensity also influences which substrate the body will use for energy.

WEIGHT MANAGEMENT

WEIGHT MANAGEMENT: The physiological processes and techniques one uses to achieve or maintain a specific body weight.

An additional concept for metabolism and energy balance a personal trainer will want to understand at a high level is that of **weight management** or the physiological processes and techniques one uses to achieve or maintain a specific body weight. Much of weight management involves optimal nutrition, proper calorie intake, and exercise in combination as opposed to independently.

Fitness and nutrition programs vary depending on a client's needs and goals. Most effective nutrition programs though are more similar than different. The goal of a nutrition program is to help clients focus on what really matters by bringing awareness and attention to all nutrition components. Paying close attention to calories and the types of food consumed is a key factor in building muscle, losing fat, and improving overall health. All effective eating patterns recommend consuming nutrient dense and minimally processed foods to help eliminate nutrient deficiencies. This requires monitoring levels of appetite and managing food intake. It does not mean having to count calories all the time, but rather finding sustainable hunger and satiety levels and promoting regular exercise.

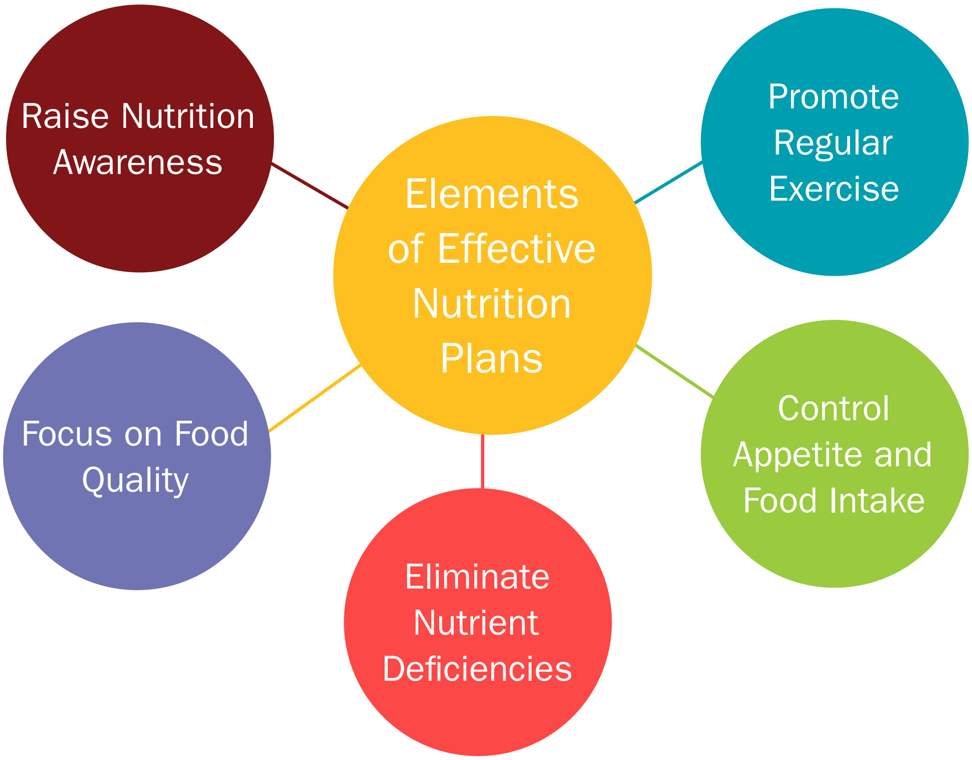


Figure 6.10 Elements of Effective Nutrition Plans

Energy balance is a complex process that involves factors beyond food and exercise. Individual psychological factors, environmental factors, genetic factors, and hormonal responses influence how much one eats and how many calories the body needs for all activity. Unfavorable changes in energy balance lead to unfavorable changes in reproductive function, brain metabolism, and restorative functions. This includes energy deficits that decrease estrogen and testosterone production and lower the brain's ability to function.

Calories in food are released when the body breaks down and absorbs food. They provide energy in the form of heat, which allows the body to function. The more calories a food has, the more energy it provides. However, eating excess calories can lead to an increase in bodyfat.

TRAINER TIP!

Calculating resting metabolic rate (RMR) is just as important as calculating a client's daily caloric expenditure (DCE) for overall nutrition purposes. The RMR estimates the minimum number of Calories someone should be consuming to support basic body function, while the DCE gives insight into the client's overall Calorie expenditure.

For a fat loss goal, a deficit of 200 to 500 calories per day from the DCE is recommended to create a Calorie deficit but still support body functions. This is a negative energy balance; Calories out are greater than Calories in.

Conversely, for a muscle gain goal, a surplus of 200 to 500 Calories (or more) is recommended to support muscle repair and muscle building. The actual Calorie surplus will be individualized based on the client's training frequency, intensity, and recovery needs. This is a positive energy balance; Calories in are greater than Calories out.

For client's working to maintain their weight, the DCE is important as it provides insight into the number of Calories the client should be consuming to create energy balance; Calories in are equal to Calories out for weight maintenance.

BODY TYPES

SOMATOTYPE:
Categories of physical body type.

Body type, or **somatotype**, helps to classify someone's body structure. While there is no magic pill for diet or training based solely on body type, the characteristics of a client's body can provide insights into their movement patterns, physical abilities, and nutritional needs. There are three general body shapes with generally accepted characteristics for each: ectomorph, endomorph, and mesomorph.

Table 6.3 Body Types and Their Training and Nutritional Considerations

BODY TYPE	DESCRIPTION	TRAINING CONSIDERATIONS	NUTRITION CONSIDERATIONS
Ectomorph	Long and lean with little bodyfat and little muscle mass Narrow shoulders and hips	Can have a hard time gaining weight.	May need a higher carbohydrate and protein diet to maintain body weight and muscle mass
Endomorph	Thicker, rounder build with lots of bodyfat and lots of muscle mass Large upper arms and thighs	Gains weight easily.	May need a diet lower in carbohydrates and high in protein to prevent excess fat storage and support high levels of muscle mass
Mesomorph	Athletic, muscular build with broad shoulders and a healthy body weight	Can gain or lose weight without much effort.	May need a more balanced diet that is focused on daily calorie expenditure for energy balance

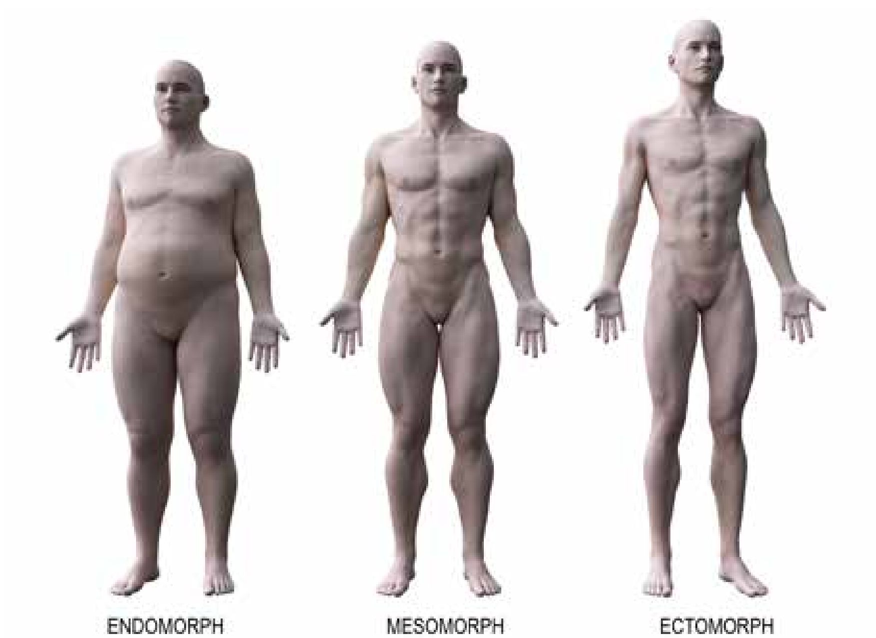


Figure 6.11 Common Body Types


ISSA

CHAPTER 07

CLIENT ASSESSMENTS

LEARNING OBJECTIVES

1 | Explain the purpose and importance of fitness assessments for a fitness professional.

2 | Describe the most common subjective assessments a personal trainer uses and the information they gather.

3 | Define static and dynamic posture assessments and examples of each.

4 | Describe the most common body composition assessments used in fitness.

5 | Name and explain common cardiovascular assessments used by fitness professionals.

6 | List common muscular strength and endurance assessments and their purpose as fitness assessments.

Before meeting with a client to conduct any physical assessments, a fitness professional must collect and review health information. The initial documents and fitness assessments are essential for collecting health and exercise history, building rapport with a client, and understanding a client's limitations, goals, and potential setbacks during an exercise program. In addition to providing a comprehensive view of the client's health, fitness assessments also supply the fitness pro with the important data they need to individualize a client's training program and the baseline measurements to help track progress. There are a variety of different fitness assessments available that can help a fitness pro gather this information. However, it's important to note that the assessments that are selected by the trainer will vary depending on the client. There are two main types of fitness assessments, objective and subjective. **Subjective assessments** include anything that a trainer observes in the client or any information gathered from the client. Subjective data is influenced by the person observing or collecting it. These differ from the objective assessments that collect measurable and repeatable data like body weight, circumference measurements, and bodyfat percentage. Objective data is not influenced by the person collecting it because it is a measurable numeric value.

SUBJECTIVE ASSESSMENTS:
Fitness assessments that require observation or a subjective, opinion-based measure.

Movement assessments are also an important tool in fitness and may be considered subjective or objective. While these assessments do collect measurable, repeatable data, they are also subject to the fitness professional conducting the assessment as well as the client performing them. For example, during a squat, factors like the height of the client will affect how much forward lean is "normal" for that individual. The exact measure of the angle of the torso to the thighs will likely not be consistent across all clients. Fitness professionals should begin with subjective assessments. After the initial client intake forms have been completed, physical assessments, posture assessments, and movement assessments, which are objective data, can be performed. **Objective assessments** also include measuring body composition, girth measurements, and skinfold measurements.

OBJECTIVE ASSESSMENTS:
Fitness assessments that collect repeatable, measurable data such as body composition or circumference measurement.

SUBJECTIVE ASSESSMENTS

Forms completed by a fitness client hold personal information such as the client's contact information, medical history, medications, or health conditions. The purpose is not to gather data so the fitness professional can diagnose or treat a client but rather to provide insight to help the fitness pro design safe and effective training programs. This information must be collected carefully and stored securely to protect the client's information and their privacy. Personal trainers are not considered health care professionals, so it is not required to follow the protective guidelines of programs like the **Health Insurance Portability and Accountability**

Act (HIPAA). However, it is important for fitness professionals to implement methods to keep client information secure and confidential.

This piece of American legislation outlines the security and privacy protocols for protected health information (PHI). PHI is defined as "any information held by a covered entity which concerns health status, provision of health care, or payment for health care that can be linked to an individual." However, there are instances that HIPAA or related privacy obligations would apply like when a medical referral is made or a medical professional shares patient information with a fitness professional with the written consent of the client. The following paperwork should be the first forms a client fills out and is called the **initial interview packet**:

- Client intake form
- PAR-Q
- Health History Questionnaire
- Liability waiver
- Physician's letter of clearance (as applicable)
- Three-day dietary record

HEALTH INSURANCE PORTABILITY AND ACCOUNTABILITY ACT (HIPAA):

An American legislation designed to protect the health care data, information, and payment details of patients.

INITIAL INTERVIEW PACKET:

The first health and liability intake forms that a client will complete before beginning to work with a fitness professional.

CLIENT INTAKE FORM

The **client intake form** is a foundational form that gathers demographic information such as address, phone number, and email from a client. It also asks basic questions such as "Has your doctor ever diagnosed you with a heart condition?" or "Have you ever had a heart attack?" These questions help the trainer begin assessing personal health history. This form also includes questions regarding the client's health and fitness goals. These questions allow the client to think about what they want to achieve in their fitness program and offer the trainer insight into the client's motivation and current barriers to success.

CLIENT INTAKE FORM:

A basic intake form to gather a client's or potential client's demographic information and general health history.

The short and general nature of this form makes it ideal to use for people participating in complimentary or introductory training sessions or classes. The fitness professional can collect enough information to know if there are any health issues, they should be aware of when working with a client. The client intake form also provides an opportunity to have an initial conversation with a client. This can be used to begin the process of rapport building and can even be used as a sales tool in a complimentary session setting. The other forms a client will complete once they commit to an exercise program will provide the trainer with greater detail.

PHYSICAL ACTIVITY READINESS QUESTIONNAIRE (PAR-Q):
An intake form to assess a client's readiness to begin a physical activity program and assess injury potential.

PHYSICAL ACTIVITY READINESS QUESTIONNAIRE (PAR-Q)

The **physical activity readiness questionnaire (PAR-Q)** is an extension of a client's medical history and is completed by the client after committing to their program but before starting the exercise programming. It allows the trainer to understand a client's potential risk for injury and gives an in-depth look at health history within the scope of practice.

The PAR-Q includes several yes-or-no questions, including the following:

- Has a doctor ever told you that you should only perform physical activity as recommended by a doctor?
- Do you know of any reason why you should not participate in physical activity?
- In the past 30 days, have you had chest pain at any point?

At the end of the questionnaire, guidelines are provided for the next steps based on how many questions the participant answered yes to. Generally, if there were one or more affirmative answers, the recommendation is to obtain a doctor's approval and written clearance before beginning an exercise program.

HEALTH HISTORY QUESTIONNAIRE

HEALTH HISTORY QUESTIONNAIRE:
A detailed client intake form that gathers information on a client's present and past health and medical history.

A client's health history is important to a personal trainer, as it will give them insight into potential health concerns, conditions, or medications that may affect their training protocols. The **health history questionnaire** collects data on present and past exercise experience, tobacco use, and nutrition. This information is important to better understand a client's general habits. The questionnaire is typically two to four pages in length and includes questions such as these:

- Have you experienced any of the following conditions? (This typically precedes a long list of many different conditions to select from, such as chest pain, diabetes, high blood pressure, irregular heartbeat, etc.)
- What medications are you currently taking?
- What is your current level of physical activity?

LIABILITY WAIVER:
A short form that, when signed by a client, releases a fitness professional and/or their training facility from any liability should the client be injured while working with them.

LIABILITY WAIVER

A brief **liability waiver** form can offer protection to the fitness professional and the facility they are working in, if applicable, in the form of a waiver of injury liability. Every fitness program has an inherent risk of injury, and by reading and signing this form, the client is accepting any and all risk associated with training and agreeing not to hold the trainer or facility liable should an injury occur during training or within the facility. This form is an industry standard.

It should be noted that this is a legally binding document. The sample liability waiver provided by ISSA is an example, and it is strongly suggested that the fitness professional modify the form for their needs and have it reviewed by a licensed legal professional in their state.

PHYSICIAN'S LETTER OF CLEARANCE

Some clients may be in treatment for or recovering from a condition for which they were under the care of a physician or other licensed health professional. This can include post-surgery rehabilitation, physical therapy, occupational therapy, or injury recovery. Personal trainers are not within the scope of practice to continue such treatments. Other clients that might require this type of clearance may simply be new to fitness and in poor physical condition when beginning a program.

To ensure a client is cleared for activity, regardless of the reason, a **physician's letter of clearance** is strongly recommended. This letter is written by the client's medical professional and states the client has been examined and is cleared to begin an exercise program. Such a letter should also include, in writing, any restrictions or limitations the medical professional would like the client to adhere to. For example, they may only be able to work in specific heart rate ranges or for a specific length of time during each training session.

PHYSICIAN'S LETTER OF CLEARANCE:
A signed letter from a client's health care provider stating they are cleared for physical activity and exercise that should also include any restrictions or limitations they should adhere to.

This letter, if provided, gives the fitness professional the peace of mind of knowing that the client is cleared for a training program. It should be kept securely with all other forms and records. It's important to note that although this letter can be helpful in assuring the client's safety, care must be taken in how it is requested. The fitness professional should ensure the client understands what needs to be included in this letter and exactly why it's needed. A lack of compassion in this situation could result in a client feeling as if they are beyond the ability to improve their physical condition. This could lead to them discontinuing their training program or effectively demotivate them to take control of their health.

THREE-DAY DIETARY RECORD

Versions of the **three-day dietary record** are often used in nutrition coaching. However, most fitness programs have a nutrition component, and nutrition is a major contributing factor to success in an exercise program. The three-day dietary record form gives clients the opportunity to write down the foods and amounts (if known) that they consume daily. Clients should be instructed to be as honest and precise as possible. Inaccurate information will hinder their progress and does not provide the fitness professional with a full, accurate picture of the client's nutritional habits. Some clients may need additional education on things such as portion sizes, food measuring tools, and nutrition-tracking technologies to ensure they are providing accurate information.

THREE-DAY DIETARY RECORD:
A common fitness and nutrition intake form that allows clients to log their food consumption for three consecutive days to observe their habits.

After collecting the completed forms for health history, previous injuries, nutrition habits, lifestyle habits, and medical conditions, a personal trainer should take time to review the details with the client and ask any follow-up questions. This is when a fitness professional can begin to understand a client's previous successes and failures with exercise and nutrition before making any recommendations or adjusting an existing program.

Follow-up questions should be general and aimed at gaining clarifications, if needed. They should NOT ask for details on medical conditions, reasons someone is taking certain medications, or lifestyle preferences. For example, asking for the frequency of a certain habit or how long someone has had a condition is okay. Asking about sexual preferences or how someone developed a medical condition is not advised.

The intake forms along with a trainer's notes from the initial client interview establish the basis of the **client profile**. This profile holds all documents, forms, notes, and information on their goals and experience in fitness.

CLIENT PROFILE: The collection of a client's health and intake forms, biometric measurements (physical measurements like weight, height, etc.), training plan, and liability waivers.

Applicable sample intake paperwork for a fitness professional can be found at the end of this chapter.

ABSOLUTE CONTRAINDICATIONS

The fitness professional should review the information collected and look for potential **contraindications** before meeting with the client a second time. Contraindications are reasons that a client should not begin or continue an exercise program because of an increased risk of injury or adverse health consequences.

CONTRAINDICATIONS: Factors that serve as a reason to withhold training because of harm that it may cause.

The following are some examples of instances or reported conditions that are contraindicated for exercise and a fitness professional should NOT accept a client:

- Unstable coronary heart disease (CHD)—a condition where the heart does not get enough blood or oxygen flow.
- Decompensated heart failure—new or worsening signs and symptoms of heart failure.
- Uncontrolled heart arrhythmias—irregular heartbeat that is not controlled.
- Severe pulmonary hypertension—extremely high blood pressure.
- Severe and symptomatic aortic stenosis—narrowing of the aortic valve that causes shortness of breath or fatigue.
- Acute myocarditis, endocarditis, or pericarditis—inflammation of the heart muscle,

heart chambers, or the sac that surrounds the heart respectively.

- Uncontrolled hypertension—high blood pressure that is not under control with medication or dietary interventions.
- Aortic dissection—a tear in the aorta.
- Marfan syndrome—a genetic disorder affecting connective tissue and that commonly affects the heart, eyes, blood vessels, and skeleton.
- Active proliferative retinopathy or moderate or worse non-proliferative diabetic retinopathy—damage to the blood vessels of the eyes.

RELATIVE CONTRAINDICATIONS

Clients who report any of the following conditions may begin a fitness program after consulting with their physician and providing the trainer with written approval and guidelines from the physician:

- Risk factors for CHD—risk factors include high blood pressure, poor cholesterol, diabetes, obesity, smoking, and physical inactivity.
- Diabetes—high or uncontrolled blood sugar.
- Low functional capacity (**Metabolic equivalent (METs)**)—the inability to exert energy and effort for activities such as dressing, eating, and moving around. Adequate functional capacity is anything over four METs and can include walking up stairs, cleaning, swimming, and jogging.
- Musculoskeletal limitations—limitations to mobility, dexterity, or general function, including injuries, post-surgery, and recovery from injury.
- Pacemaker or defibrillator—devices implanted in the body to regulate the heartbeat or return it to normal should it become irregular.

If there are no contraindications for getting started, the next appointment can be set.

METABOLIC EQUIVALENT (METS):
The measure of the ratio of a person's expended energy to their mass while performing physical activity.

OBJECTIVE ASSESSMENTS

The objective fitness assessments are designed to collect measurable data. Unlike subjective assessments, objective assessments have one distinct answer and are not subject to opinion or observer variance. From body composition to cardiorespiratory fitness assessments and strength tests, many objective assessments are at a trainer's disposal based on the needs of each specific client. In combination with the subjective assessments, they provide a personal trainer with a wide range of information that is used for programming, motivation, and client success.

Keep in mind that not every assessment is ideal for every situation. A person's goals, comfort level, access to tools, current fitness level, and even budget can all play a role in which assessment is the right choice.

When completing client assessments, consistency is key to accuracy. The following are considerations for objective assessments:

- Weigh clients at the same time of day. For example, if they weigh themselves first thing in the morning, each subsequent weight measurement should be completed first thing in the morning.
- Take circumference and caliper measurements on the same side of the body each time. There is no requirement to take them on one side or the other; it's important to remain consistent.
- Use the same equipment to take objective measurements. For example, use the same scale, measuring tape, or body fat measuring device for consistency.

TEST TIP!

Easy Ways to Remember Objective and Subjective

Objective: Root word *object*. You are objective whenever you are discussing an object or something concrete that you can touch. The information that makes up your objective statement should also be concrete, solid objects like data or measurements.

Subjective: Something you can't point to. They are based on experience, opinions, facts, and emotions.

BODY COMPOSITION: The physical makeup of the body considering fat mass and lean mass.

LEAN BODY MASS: The fat-free mass of the body calculated by total weight minus the weight of bodyfat.

CHRONIC DISEASE: A condition lasting a year or more that limits daily activities and/or requires ongoing medical attention.

AMENORRHEA: The absence or cessation of a menstrual cycle in females.

BODY COMPOSITION ASSESSMENTS

Since adiposity—or the amount of bodyfat someone has—is a risk factor for most diseases, it is important to track **body composition** for most clients. Body composition is the measure of fat mass and **lean body mass**. Excess fat is a precursor to **chronic disease**, but too little bodyfat can also have negative health consequences, including vitamin deficiencies, a weakened immune system, insulin resistance, **amenorrhea**, and decreased metabolism.

The norms for bodyfat mass differ by sex since the distribution and amount of essential bodyfat also differ by sex. Research suggests that females have between 6 and 11 percent higher bodyfat than males on average. This is attributed to female hormones, including estrogen, and the biological functions of the female body, such as childbearing and lactation. A fitness professional should be familiar with the appropriate bodyfat ranges by sex but understand that these are a guideline. Each individual client will have a “normal” range. For example, depending on body type, some clients may naturally maintain a bodyfat range considered to be low or in an athletic range.

Table 7.1 Bodyfat Percentage Norms

SEX	LOW/ ESSENTIAL	ATHLETIC	FIT	AVERAGE	HIGH/ OVERWEIGHT
Males	4–6 percent	7–10 percent	11–16 percent	17–25 percent	26 percent or higher
Females	10–12 percent	13–20 percent	21–24 percent	25–31 percent	32 percent or higher

In addition to bodyfat percentage, an individual’s distribution of bodyfat is affected by sex, age, body type, and activity levels. Men typically carry bodyfat in the abdominal region, while women tend to store bodyfat on the hips, thighs, and triceps. Measuring body composition determines the amount of fat mass and fat-free mass an individual has, and this can be done in many ways. Once a testing method or methods are chosen, they must be consistently retested to measure progress. The following methods for measuring body composition are organized from most to least accessible: BMI (body mass index) is the easiest test for a trainer to conduct, requiring only height and weight measurements. A DEXA (dual-energy X-ray absorptiometry) scan is the least accessible, requiring additional expense, specialized equipment, and trained staff.

BODY MASS INDEX

Body mass index (BMI) is a measure for predicting disease risk but may not be suitable for more fit clients as it does not consider a person’s lean body mass. Lean body mass is a client’s total weight minus the weight of bodyfat and includes muscle tissue, organs, bone, and other tissues. BMI is calculated by dividing a client’s weight in kilograms by their height in meters squared:

BODY MASS INDEX (BMI):
A predictive health measure of weight divided by height squared.

$$\text{BMI} = \text{weight (kg)} / \text{height (m}^2\text{)}$$

Ranges of BMI measurements can advise a trainer if a client is within a healthy range or not in many cases. However, clients with large amounts of muscle mass may not be accurately represented by BMI.

Below 18.5 = underweight

18.5–24.9 = normal

25–29.9 = overweight

30 or above = obese

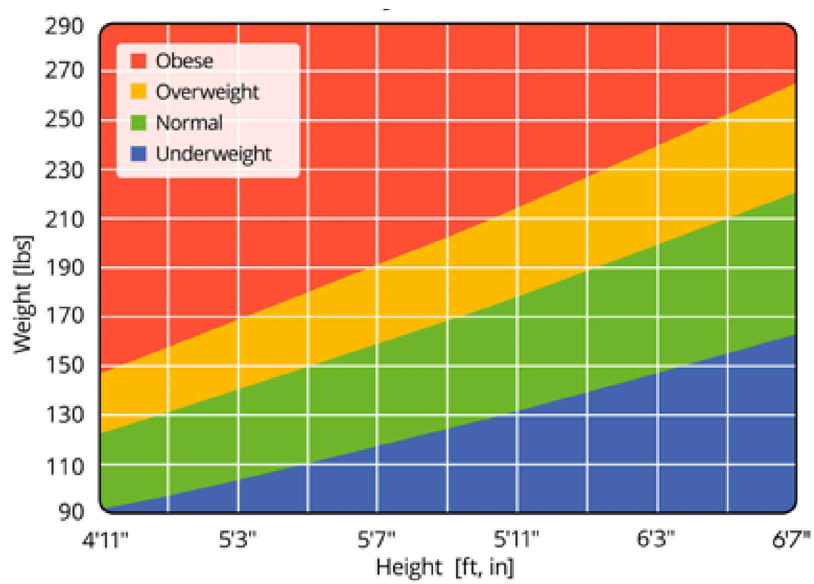


Figure 7.1 Body Mass Index

TEST TIP!

Remember that BMI is a reliable tool, but it only considers height and weight without considering fat or lean mass. Be sure to use other assessment methods along with BMI to get the full picture (including muscle mass) of the client's body composition.

You can have 100 people the same height and weight and they would all have the same BMI, but they could have very different body compositions.

WAIST-TO-HEIGHT RATIO

WAIST-TO-HEIGHT RATIO:
An objective assessment to measure cardiometabolic risk.

Waist-to-height ratio is a measurement used to predict an individual's obesity-related heart disease risk and is easy to obtain. As the name suggests, it measures the waist circumference divided by the client's height.

A flexible tape measure and a regular tape measure will be needed. First, the client should stand with the back of their head, shoulder blades, buttocks, calves, and heels against a wall. The fitness professional can mark the top of the client's head on the wall with a pencil and then measure up to that point from the floor. Height should be recorded.

To measure the waist:

- **Males**: The tape is placed around the waist at the belly button. The tape should be snug against the body without being so tight that it presses into the body. The measurement is then recorded.
- **Females**: The client places their forefinger and middle finger on top of the belly button. The tape is wrapped around the abdomen, resting just on top of the forefinger. The measurement is then recorded.

The measurement may be repeated two additional times, taking the average of the two most similar readings. The following formula is used to determine the client's ratio, and then the table can be used to determine their health rating:

Waist-to-height ratio = (waist circumference / height) × 100

The same unit of measure must be used for both waist circumference and height (for example, inches or centimeters).

A female that is 60 inches (152.4 centimeters) tall with a waist circumference of 28 inches (71.12 centimeters) would determine her waist-to-height-ratio as follows:

Imperial: (28 in. / 60 in.) × 100 = 46.7

Metric: (71.12 cm. / 152.4 cm.) = 46.7

Table 7.2 Waist-to-Height Ratio Norms

MEN	RATING	WOMEN
<35	Underweight	<35
35–43	Extremely slim	35–42
43–46	Slender and healthy	42–46
46–53	Healthy ideal weight	46–49
53–58	Overweight	49–54
58–63	Seriously overweight	54–58
>63	Extremely obese	>58

GIRTH MEASUREMENTS

CIRCUMFERENCE MEASUREMENTS: The measurement of the circumference of specific body regions.

Also referred to as **circumference measurements**, girth measurements assess the circumference around specific body regions, including, but not limited to, the hips, thigh, neck, and chest. A trainer may determine which measurements are the most applicable based on the client's goals. For example, a trainer can measure upper-arm circumference if a client wishes to increase muscle mass and reduce bodyfat percentage. This measurement can be tracked with a flexed or relaxed arm measurement, as long as the measurement used (flexed or relaxed) remains consistent throughout the program. The following measurement instructions are for a relaxed limb which is the most common technique.

Figure 7.2 Circumference Measurement

It is often recommended that measurements be taken on the right side of the body for consistency. If there is a compelling reason to measure on the left side or in an area that is outside of the normal parameters, it should be noted so that future reassessments are administered in the same way. It is best to take each measurement three times to ensure accuracy and take the average of the two most similar readings and record that number.

Neck

The tape measure is placed around the neck, just below the larynx, ensuring the tape is horizontal all the way around.

Upper Arm: Relaxed

The client should stand with their arms at their sides and shoulders relaxed. The trainer should wrap the tape around the thickest part of the upper arm and write down the measurement.

Waist

Males: The tape is placed around the abdomen at the belly button and drawn flat against the skin without pressing into the skin. The trainer can then record the measurement.

Females: The client places her forefinger and middle finger on top of the belly button. The trainer can then wrap the tape around the abdomen, resting just on top of the forefinger.

Hips

The client must stand with their feet together. The trainer can ask the client to find the tops of their hip bones (iliac crest) and then ask the client to place the heel of each palm on top of the hip bones and place their palms and fingers pointing down, resting on their hips. The trainer should stand on the right side of the client and place the tape around the hips, using the fingertips as a guide for where to place the tape. The tape should be horizontal all the way around.

Thigh

From a standing position, the client can rest their arms down their sides. The point where the fingertips reach is where the trainer will measure. Standing on the right side of the client, the trainer can wrap the tape around the thigh, just below the fingertips, and draw the tape flat against the skin without pressing it into the skin. This measurement can also be taken from a certain distance above the top of the patella (kneecap). Typically, five or seven inches above are common placements.

Calf

The client should stand with the feet hip-width apart. The trainer can kneel at the right side of the client and wrap the tape around the visually widest part of the calf. The tape is tightened flat against the skin without pressing into the skin, and the measurement is recorded.

WAIST-TO-HIP RATIO (WHR):
A predictive health measure comparing the circumference of the waist to the circumference of the hips.

Waist-to-hip ratio (WHR) can be ascertained from the circumference measurements and is a measure that can help predict someone's risk of heart disease like the waist to height ratio, regardless of BMI. Certain people will not get accurate results from this measurement, including children, individuals under five feet tall, and those with a BMI of 35 or greater because this measure does not take into account lean body mass, fat mass, or fat distribution, which can vary greatly in these populations.

WHR = waist circumference / hip circumference

The same unit of measure must be used for both waist circumference and height (for example, inches or centimeters).

Table 7.3 Waist-to-Hip Ratio Norms

MEN	HEALTH RISK	WOMEN
0.80 or less	Low	0.95 or less
0.81–0.85	Moderate	0.96–1.0
0.86 or more	High	1.0 or more

BODY DENSITY:
The compactness of the body determined by dividing its mass by its volume.

SKINFOLD MEASUREMENTS

The use of skinfold measurements is valuable for closely approximating **body density** and body composition without being cumbersome, costly, or too intimidating. This test is slightly more accurate than girth measurements but may require more practice to produce accurate results. Highly trained technicians may achieve accuracy of up to 3.7 percent.

Just like girth measurements, it is recommended that measurements be taken on the same side of the body. The trainer should grasp the skin at the site with the thumb and forefinger and then pinch. Next, the trainer should place the calipers one to two centimeters away from the thumb and forefinger, perpendicular to the skinfold, and halfway between the crest and base of the fold. The caliper lever is released while still pinching the skin. The trainer can then read the dial and record the measurement to the nearest millimeter.

When taking skinfold measurements, the data from seven locations on the body can be used. However, a more common and faster method uses three sites. The appropriate sites for the three-site measure differ by sex due to the natural variation in fat distribution on the body.

Triceps measurement: With the arm relaxed and to the side, a vertical skinfold measurement is taken halfway between the shoulder and the elbow.

Subscapular measurement: Locate the middle of the scapula and measure a vertical skinfold about one inch from the spine.

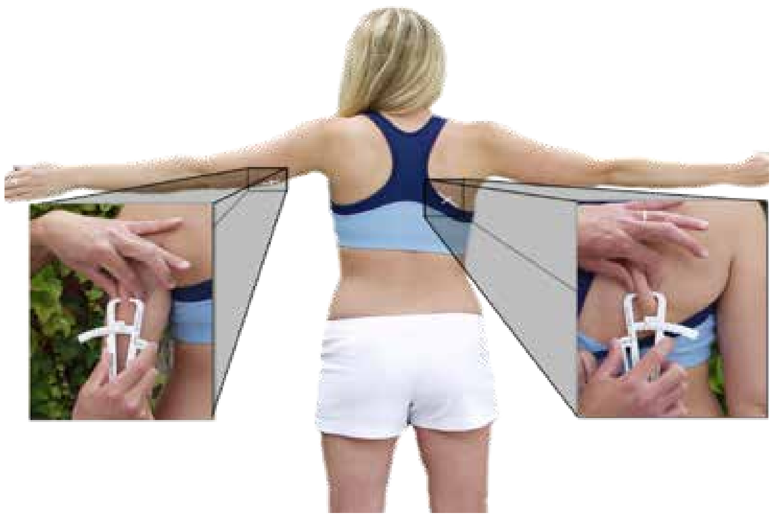


Figure 7.9 Posterior Caliper Sites: Triceps and Subscapula

Chest (pectoral) measurement: Measure about one inch below the collarbone and two to three inches out from the inside edge of the pectoral muscle. *Be sure to stay on the pectoralis and* **avoid breast tissue** *if you are measuring a female*. Pull the skinfold in a vertical direction.

Midaxillary measurement: Measure the fold in a horizontal line at the point where a vertical line from the mid axilla (middle of armpit) intersects with a horizontal line level with the sternum. Pull the skinfold in a vertical direction.

Suprailiac measurement: Measure about halfway between the navel and the top of the hip bone. This should be at or near the area where the oblique and abdominals meet. Pull the skinfold in a vertical direction.

Abdominal measurement: Measure about one inch to the left of and one inch down from the navel. Pull the skinfold in a vertical direction.

Thigh measurement: Measure in the middle of the quadriceps. If the area is too tight, you may need to go up one to two inches. Pull the skinfold in a vertical direction.

Figure 7.10 Anterior Caliper Sites: Chest, Midaxillary, Suprailiac, Abdominal, and Thigh

Table 7.4 Skinfold Measurement Locations and Formulas

SEVEN-SITE BODY DENSITY METHOD	THREE-SITE BODY DENSITY METHOD	
Male and female	Male	Female
Triceps Chest/pectoral Midaxillary Subscapular Suprailiac Abdomen Thigh	Chest/pectoral Abdomen Thigh	Triceps Suprailiac Thigh
Seven-site formula for males	**Seven-site formula for females**	
1.112 – (0.00043499 × sum of skinfolds) + (0.00000055 × [sum of skinfolds^2]) – (0.00028826 × age) = body density	1.097 – (0.00046971 × sum of skinfolds) + (0.00000056 × [sum of skinfolds^2]) – (0.00012828 × age) = body density	
Three-site formula for males	**Three-site formula for females**	
1.10938 – (0.0008267 × sum of skinfolds) + (0.0000016 × [sum of skinfolds^2]) – (0.0002574 × age) = body density	1.0994921 – (0.0009929 × sum of skinfolds) + (0.0000023 × [sum of skinfolds^2]) – (0.0001392 × age) = body density	

Once body density has been determined with the appropriate formula, the Brozek equation can be used to estimate bodyfat percentage for both men and women:

$$[(4.570 / \text{body density}) - 4.142] \times 100 = \text{bodyfat percentage (BF\%)}$$

BIOELETRICAL IMPEDANCE

Bioelectrical impedance analysis (BIA) is a relatively simple, quick, and affordable method for tracking body composition and, ideally, should be used in conjunction with other measurements for a balanced perspective of the client's body composition.

BIOELECTRICAL IMPEDANCE ANALYSIS (BIA):
A method for body composition measurement using a weak electrical current to measure the resistance of body tissues.

Figure 7.11 BIA Device

BIA devices send a safe electric current from one point through the body to another point, measuring the time it takes for the current to travel between the two points. Muscle cells contain more water than fat cells; therefore, the faster the current travels through the body, the higher the lean muscle mass. Although convenient, these measurements can vary depending upon an individual's hydration status and timing of their last meal. Generally, BIA devices have an accuracy of plus or minus 4 percent. Most affordable devices may not adequately measure bodyfat as the electrical current may not be strong enough. It is advised to purchase models with dual frequencies for more accurate readings.

AIR DISPLACEMENT PLETHYSMOGRAPHY (ADP)

ADP is safe and accurate for measuring fat mass and fat-free mass in adults and children. From start to finish, the test takes about five minutes. The accuracy of this device has made it the standard for body composition testing. Body weight is measured before the individual enters the chamber. Body volume is then determined by measuring the volume of the empty chamber compared to the volume of the chamber with the individual inside. Once weight and volume are calculated, body density is calculated, and that value is placed into an equation to determine the percentage of fat. This test requires a private room, the ADP chamber, and specialized training for staff. There may be local facilities offering this test to which the trainer can refer clients, as it can be expensive and is not a portable option.

HYDROSTATIC WEIGHING:
A tool to measure body composition using water displacement and tissue density.

HYDROSTATIC WEIGHING

The **hydrostatic weighing** method is much the same as air displacement plethysmography but uses water rather than air. It is fairly accurate, with a variance of around 2.5 percent. Lean muscle is denser than fat, making lean individuals heavier underwater than individuals with more fat mass. Body weight is measured before the individual steps into a large tank of water. The individual must expel all the air from their lungs and be completely submerged while the underwater weight is measured. This is done three times, and the values are averaged. The technician then uses a special equation to determine lean and fat mass percentages. Much like ADP, this method can be highly accurate but can also be a costly and impractical method, particularly in a health club setting.

DUAL ENERGY X-RAY ABSORPTIOMETRY (DEXA):
An X-ray scanning test to determine body composition.

OSTEOPOROSIS:
A skeletal condition that results in weak or brittle bones.

DYSPNEA:
Difficulty or labored breathing.

DUAL ENERGY X-RAY ABSORPTIOMETRY

Dual energy X-ray absorptiometry (DEXA) is the most accurate bodyfat test available. The X-ray determines the amount of bone, fat tissue, organ tissue, and muscle mass in the body. Because DEXA scans bone mass, it can also determine whether a client has **osteoporosis**, making it a valuable assessment for older clients. Despite the value of the information gained from this method, it is not common for it to be used in the health and fitness profession because of factors like cost and lack of availability or convenience.

CARDIORESPIRATORY FITNESS ASSESSMENTS

The level of cardiorespiratory fitness of a client determines how well their heart, lungs, and muscles will perform during varying degrees of exercise intensity. When testing a client's cardiorespiratory fitness, there are objective and subjective measures. Objective data includes the client's resting heart rate and blood pressure. Subjective data includes client reports of perceived exertion or difficulty breathing—**dyspnea**.

There are two measurements a personal trainer should have for a client before they engage in cardiorespiratory fitness assessments: resting heart rate and blood pressure. Both can be taken by the client or a health professional and reported to the personal trainer for consideration.

Resting heart rate (RHR) should be taken when the client is at rest—first thing in the morning before sitting up is ideal. The average typically can range between 60 and 100 beats per minute. While the measure of RHR can vary, and well-trained athlete can be on the lower end of that range. It is taken by pressing lightly with the first and index fingers on the radial artery (wrist) or the carotid artery (neck) and counting the number of heartbeats in 60 seconds. Often this is done by measuring for a shorter timeframe like 10 seconds and multiplying by six to get an estimate of the 60-second RHR. This can also be done by using a stethoscope, which is a tool used to listen to breathing and heartbeats, on the left side of the sternum.

RESTING HEART RATE (RHR):
The measure of heart rate when completely at rest.

TEST TIP!

There are several factors that can influence a person's heart rate during the day even while at rest.

- High temperatures: Pulse may raise when in higher temperatures.
- Emotions: Stress, anxiety, and excitement can all cause a rise in heart rate.
- Medications: There are medications that can increase or decrease heart rate.
- Stimulants: Caffeine, nicotine, and tobacco can all cause a rise in heart rate.
- Recent exercise: Heart rate will usually remain elevated immediately following a workout.
- Standing up: There will usually be a spike in blood pressure when getting up from a seated position.

Because blood pressure can be influenced by many things, it is ideal to take this measurement after waking up and before getting out of bed for a more accurate reading.

Blood pressure is not typically a measurement that a personal trainer will take. The blood pressure is measured with a blood pressure cuff and stethoscope. When a client reports blood pressure, it is important to confirm what a "normal" range is for the individual as this may vary. Blood pressure readings can also vary throughout the day with the most accurate readings being immediately after waking and before sitting up. Regardless of what time of day blood pressure is measured, it's important that it is taken at the same time of day for

HYPERTENSION:
High blood pressure measuring more than 140/90 mm Hg.

consistency. Chronically high blood pressure, known as **hypertension**, will be a concern for both client and trainer as it can affect exercise selection and programming.

Table 7.5 Blood Pressure Norms

RANGE	READING (MILLIMETERS OF MERCURY)
Normal	Less than 120/80 mm Hg
Elevated	Systolic between 120 and 129 *and* diastolic less than 80 mm Hg
Stage 1 hypertension	Systolic between 130 and 139 *or* diastolic between 80 and 89 mm Hg
Stage 2 hypertension	Systolic at least 140 *or* diastolic at least 90 mm Hg

VO_2 MAX:
The maximum amount of oxygen an individual can use during exercise.

VENTILATORY THRESHOLD (VT):
The threshold where ventilation increases faster than the volume of oxygen.

The general purpose of the cardiovascular assessments is to determine a client's **VO_2 max** measurement. This refers to the maximum amount of oxygen an individual can use during exercise, and it can be improved with training. An improvement in VO_2 max indicates higher cardiovascular fitness and performance as well as reduced risk for heart disease and diabetes. The reading can be used to accurately assess cardiovascular fitness and capacity. **Ventilatory threshold (VT)** is also commonly used and establishes the point where ventilation increases faster than the volume of oxygen available.

TRACK TESTS

Track tests are aptly named as they are typically completed on a track. However, they may be completed on a treadmill as well. These tests are still commonly used to assess the cardiovascular fitness of those new to working out or with a low fitness level because they are performed with less than maximum effort (submaximal). The current physical condition and capability of the client can help in determining the correct test to use. Running may not be a safe or feasible option for some clients, so a walk test would be the best choice.

Cooper 12-Minute Run

This test is suitable for most populations as it can be modified to match the client's fitness level. The total distance completed (walk/run/combination) is recorded at the end of 12 minutes. To find the approximate VO_2 max, either of the following equations can be used:

(35.97 × miles completed) − 11.29 = estimated VO_2 max

(22.35 × kilometers completed) − 11.29 = estimated VO_2 max

The 1.5-Mile Run

The fitness professional will record the time it takes the client to complete a 1.5-mile run and compare the results to the norms table below. These norms are not age-adjusted and may be different for youths, seniors, or clients with different abilities. Information may also be used to set the baseline for tracking progress, rather than be compared to norms.

Table 7.6 The 1.5-Mile Run Standards

RATING	MALES	FEMALES
Very poor	>16:01 minutes	>19:01 minutes
Poor	16:00–14:01 minutes	19:00–18:31 minutes
Fair	14:00–12:01 minutes	18:30–15:55 minutes
Good	12:00–10:46 minutes	15:54–13:31 minutes
Excellent	10:45–9:45 minutes	13:30–12:30 minutes
Superior	<9:44 minutes	<12:29 minutes

Rockport One-Mile Walk

Body weight is measured before this test. The client should walk as fast as possible, without jogging or running, for one mile. At the end, the trainer should immediately take the client's pulse for one minute and note the time it took to complete the mile (may also be completed on a treadmill). The following equation can be used to find estimated VO_2 max:

Males:
139.168 − (0.388 × age) − (0.077 × weight in pounds) − (3.265 × walk time in minutes) − (0.156 × heart rate) + 6.318 = estimated VO_2 max

Females:
139.168 − (0.388 × age) − (0.077 × weight in pounds) − (3.265 × walk time in minutes) − (0.156 × heart rate) = estimated VO_2 max

STEP TEST

The Harvard Step Test is used as a predictive measure of a client's VO_2 max and aerobic fitness level. A variation is the three-minute step test for deconditioned clients. The trainer should instruct clients to inform them immediately if they have pain or discomfort during the test, so the trainer may stop it if necessary.

METRONOME:
A device marking time at a selected rate.

A step or platform that is 12 inches high (30.5 centimeters), a stopwatch, and a **metronome** are needed. This test lasts for five minutes or until the client reaches exhaustion—when they cannot maintain the stepping rate for 15 consecutive seconds. The trainer should ensure clients understand the tempo they are striving for before beginning the assessment. Clients should be instructed not to talk during the test and are not allowed a warm-up prior.

The metronome is set to 96 beats per minute. The client will step on each beat of the metronome with an "up–up–down–down" rhythm. At the end of the test, the client can sit on a chair or bench. After one minute the heart rate can be checked again. The fitness professional should count the number of beats for 60 seconds. The following table can be used to compare the results to peer group norms.

Table 7.7 Step Test Norms (in beats per minute, bpm)

MALES						
Age	**18–25 years**	**26–35 years**	**36–45 years**	**46–55 years**	**56–65 years**	**65+ years**
Excellent	50–76	51–76	49–76	56–82	60–77	59–81
Good	85–93	85–92	89–96	95–101	97–103	96–101
Above average	88–93	88–94	92–88	95–101	97–100	94–102
Average	95–100	96–102	100–105	103–111	103–109	104–110
Below average	102–107	104–110	108–113	113–119	111–117	114–118
Poor	111–119	114–121	116–124	121–126	119–128	121–126
Very poor	124–157	126–161	130–163	131–159	131–154	130–151

Table 7.7 Step Test Norms (in beats per minute, bpm) (CONT)

FEMALES						
Age	**18–25 years**	**26–35 years**	**36–45 years**	**46–55 years**	**56–65 years**	**65+ years**
Excellent	52–81	58–80	51–84	63–91	60–92	70–92
Good	85–93	85–92	89–96	95–101	97–103	96–101
Above average	96–102	95–101	100–104	104–110	106–111	104–111
Average	104–110	104–110	107–112	113–118	113–118	116–121
Below average	113–120	113–119	115–120	120–124	119–127	123–126
Poor	122–131	122–129	124–132	126–132	129–135	128–133
Very poor	135–169	134–171	137–169	137–171	141–174	135–155

Table 7.8 VO_2 Max Norms

MALES (ML/KG/MIN)						
Rating	Age					
	18–25 years	**26–35 years**	**36–45 years**	**46–55 years**	**56–65 years**	**65+ years**
Excellent	>60	>56	>51	>45	>41	>37
Good	52–60	49–56	43–51	39–45	36–41	33–37
Above average	47–51	43–48	39–42	36–38	32–35	29–32
Average	42–46	40–42	35–38	32–35	30–31	26–28
Below average	37–41	35–39	31–34	29–31	26–29	22–25
Poor	30–36	30–34	26–30	25–28	22–25	20–21
Very poor	<30	<30	<26	<25	<22	<20

Table 7.8 VO_2 Max Norms (CONT)

FEMALES (ML/KG/MIN)						
Rating	Age					
	18–25 years	**26–35 years**	**36–45 years**	**46–55 years**	**56–65 years**	**65+ years**
Excellent	>56	>52	>45	>40	>37	>32
Good	47–56	45–52	38–45	34–40	32–37	28–32
Above average	42–46	39–44	34–37	31–33	28–31	25–27
Average	38–41	35–38	31–33	28–30	25–27	22–24
Below average	33–37	31–34	27–30	25–27	22–24	19–21
Poor	28–32	26–30	22–26	20–24	18–21	17–18
Very poor	<28	<26	<22	<20	<18	<17

MUSCULAR STRENGTH AND MUSCULAR ENDURANCE ASSESSMENTS

Before creating exercise programs for clients, muscular strength and endurance assessments can be useful when training intermediate or advanced clients. The client must be sufficiently warmed up before attempting maximal lifts. Moderate intensity general warm-ups are recommended in addition to **specific warm-ups**. Specific warm-ups are exercises or movements executed that mimic the movements that will be performed during sport or in an exercise training session at a lower level of intensity. Beyond warming the muscles and ligaments, specific warm-ups increase muscle force production via neuromuscular facilitation and improve outcomes of maximal strength tests. A rest period between one and five minutes should be allowed between the warm-up and each assessment attempt. Keep in mind that the goal and the current physical condition of the client should be considered when selecting assessments. Those that are beginners or in a deconditioned state are not likely to need their **one-repetition max (1RM)** measured.

SPECIFIC WARM-UPS:
Activities that prepare the body for specific exercise to follow by incorporating movements that mimic the planned activity.

ONE-REPETITION MAX (1RM):
A single maximum-strength repetition with maximum load.

MUSCULAR ENDURANCE TESTS:
Assessments testing the ability of a muscle group to overcome resistance in as many repetitions as possible.

There are established norms for age and sex for bench press, push-ups, and sit-up or crunch tests. However, maximal lifts may also be specific to the client's goals and include squats, rows, deadlifts, biceps curl, power clean, and so forth. When administering one repetition max (1RM) muscular strength tests, a spotter (or two) must be present in addition to the fitness professional. 1RM tests require the participant to lift as much load as possible for a single repetition. **Muscular endurance tests** require the participant to complete as many repetitions as possible within a predetermined technique standard of a particular exercise. If the standard is not met, reps are not counted, or the test is discontinued if safety becomes a concern. These types of assessments test the participant's ability to complete as many repetitions as possible to determine the endurance of a muscle group.

BENCH PRESS TEST

Many average clients should not perform a true 1RM test to avoid injury. More advanced clients, on the other hand, are better suited for this assessment style. Before performing a strength test with any client, a personal trainer should ensure that the client can perform the exercise with proper form. Strength testing of any kind might not be appropriate for some clients. In order to test a client's strength earlier in the process, less complex exercises can be selected; instead of a bench press, for example, a machine chest press can be used. The 1RM can also be estimated using higher repetitions and with the equation below.

To find a safe starting point to test the client's 1RM, the trainer should choose a weight the client can lift for approximately 10 repetitions with good form. If the client can perform more than 20 repetitions, the trainer can allow a three- to five-minute break, increase the load by 5 to 10 percent, and conduct the test again.

The number of completed repetitions is multiplied by 2.5. Then, that number is subtracted from 100. That value is then divided by 100 to get a decimal value. This provides the estimated percentage of 1RM. Next, the weight that was lifted is divided by the estimated percentage of 1RM to *estimate* the 1RM of the exercise. Finally, the estimated 1RM is divided by the client's body weight. This determines a value that can then be used to compare the client to peer norms in the following table.

100 – (number of reps × 2.5) / 100 = estimated percentage of 1RM

Weight lifted / estimated percentage of 1RM = estimated 1RM

Estimated 1RM / body weight = comparable assessment value

For example, a client is a 34-year-old female weighing 142 pounds. She was able to bench-press 65 pounds six times.

6 repetitions × 2.5 = 15

100 – 15 = 85

85/100 = 0.85

65 lb. / 0.85 = 76.47 or estimated 1RM

76.47/142 = 0.54

According to the norms for this assessment (see table below), this client's score is in the "fair" range.

Table 7.9 1RM Bench Press Assessment Standards

VALUES FOR BENCH PRESS STRENGTH IN 1RM/BODY WEIGHT IN POUNDS					
Rating	**Age in Years**				
Men	**20-29**	**30-39**	**40-49**	**50-59**	**60+**
Excellent	>1.26	>1.08	>0.97	>0.86	>0.78
Good	1.17-1.25	1.01-1.07	0.91-0.96	0.81-0.85	0.74-0.77
Average	0.97-1.16	0.86-1.00	0.78-0.90	0.70-0.80	0.64-0.73
Fair	0.88-0.96	0.79-0.85	0.72-0.77	0.65-0.69	0.60-063
Poor	<0.87	<0.78	<0.71	<0.64	<0.59
Women	**20-29**	**30-39**	**40-49**	**50-59**	**60+**
Excellent	>0.78	>0.66	>0.61	>0.54	>0.55
Good	0.72-0.77	0.62-0.65	0.57-0.60	0.53-0.59	0.51-0.54
Average	0.59-0.71	0.53-0.61	0.48-0.56	0.43-0.50	0.40-0.50
Fair	0.53-0.58	0.49-0.52	0.44-0.47	0.40-0.42	0.37-0.40

If a client has any wrist, shoulder, or elbow problems that would prevent them from doing this assessment test, have them consult with their physician to determine how to proceed with the client's upper body strengthening program.

PUSH-UP TEST

When administering a push-up test, the client will complete as many push-ups as possible in a one-minute period. To complete a push-up the hands should be just outside of the shoulders at chest height and the body in a plank position from head to heels. The elbows must bend to a 90-degree angle with each repetition, and the plank position should be maintained throughout the repetitions. The norms below are for standard push-ups; however, this assessment may be modified to suit the individual's current fitness level.

For men, the standard is to perform push-ups from the toes, while women perform push-ups from the knees. The test ends when the client can no longer complete any more push-ups with ideal form.

If using a modified push-up, the trainer should make a note in the client's file (for example, knee push-ups or wall push-ups). Norms will not apply to any modified exercises but may be used as a baseline measurement for future reference. It is important to also use the modification for reassessments.

Table 7.10 Push-Up Assessment Standards (number of reps)

MALES					
Percentile	Age				
	20–29 years	**30–39 years**	**40–49 years**	**50–59 years**	**60–69 years**
90	41	32	25	24	24
80	34	27	21	17	16
70	30	24	19	14	11
60	27	21	16	11	10
50	24	19	13	10	9
40	21	16	12	9	7
30	18	14	10	7	6
20	16	11	8	5	4
10	11	8	5	4	2
FEMALES					
Percentile	Age				
	20–29 years	**30–39 years**	**40–49 years**	**50–59 years**	**60–69 years**
90	31	27	25	19	18
80	27	22	21	17	15
70	21	20	17	13	13
60	19	17	16	12	11
50	18	16	14	11	9
40	14	13	11	9	6
30	13	10	10	6	4
20	10	7	8	3	0
10	6	1	4	0	0

90th percentile = excellent; 70th percentile = above average; 50th percentile = average; 30th percentile = below average; 10th percentile = poor

If a client has any wrist, shoulder, or elbow problems that would prevent them from doing this assessment test, the client should consult with their physician to determine how to proceed with the client's upper body strengthening program.

LOWER BODY STRENGTH TEST

In the same way as the bench press test, the 1RM seated leg press can be used to assess a client's leg strength. A fitness professional can assess clients using the seated leg press machine (weight stack) or with a lying leg press (plate loaded), as long as each time the client is reassessed, the equipment used is consistent for comparison purposes. Through a process of trial and error, the appropriate load and repetitions can be completed to estimate the 1RM for the client. The estimated 1RM will be divided by the client's body weight to determine a value. The value is compared to a standard to determine the client's leg strength rating as found in the following table.

Lower Body Strength = 1RM / body weight (lb.)

Table 7.11 Squat Assessment Standards

VALUES FOR SQUAT STRENGTH IN 1RM/BODY WEIGHT IN POUNDS					
Rating	**Age in Years**				
Men	**20-29**	**30-39**	**40-49**	**50-59**	**60+**
Excellent	>2.08	>1.88	>1.76	>1.66	>1.56
Good	2.00-2.07	1.80-1.87	1.70-1.75	1.60-1.65	1.50-1.55
Average	1.83-1.99	1.63-1.79	1.56-1.69	1.46-1.59	1.37-1.49
Fair	1.65-1.82	1.55-1.62	1.50-1.55	1.40-1.45	1.31-1.36
Poor	<1.64	<1.54	<1.49	<1.39	<1.30
Women	**20-29**	**30-39**	**40-49**	**50-59**	**60+**
Excellent	>1.63	>1.42	>1.32	>1.26	>1.15
Good	1.54-1.62	1.35-1.41	1.26-1.31	1.13-1.25	1.08-1.14
Average	1.35-1.53	1.20-1.34	1.12-1.25	0.99-1.12	0.92-1.07
Fair	1.25-1.34	1.13-1.19	1.06-1.11	0.86-0.98	0.85-0.91

If a client has any knee or hip problems that would prevent them from doing this assessment test, their physician should be consulted to determine how to proceed with the client's leg strengthening program.

MOVEMENT AND POSTURE ASSESSMENTS

Movement and posture assessments allow a fitness professional to determine potential muscular weaknesses or **muscular imbalance** a client may have that can be effectively addressed in a fitness program. An imbalance occurs when the muscle or muscles on one side of the body are stronger, weaker, or more or less active than the corresponding muscle on the other side of the body. Muscular imbalances can lead to poor movement patterns, pain, or even cause injuries if not addressed.

MUSCULAR IMBALANCE: When the muscle or muscles on one side of the body are stronger, weaker, or more or less active than the corresponding muscle on the other side of the body.

THE KINETIC CHAIN

The **kinetic chain** is used in fitness to easily understand how the body moves. By definition, the kinetic chain is effectively a system of links—or joints—that generate and transfer force from one to the other. These links are known as **kinetic chain checkpoints**. Kinetic chain checkpoints are points in the body where movement dysfunction can be consistently and easily observed. As applied to gym exercises, these are points where breaks in technique will usually occur.

KINETIC CHAIN: A system of links—or joints—in the body that generate and transfer force from one to the other.

KINETIC CHAIN CHECKPOINTS: The six anatomical locations of predictable movement patterns where movement dysfunctions can be detected.

There are six critical checkpoints within the kinetic chain that are used to identify movement dysfunctions. They are typically reviewed from the floor up:

1. Foot and ankle
2. Knee
3. Hips
4. Spine
5. Shoulders
6. Head and neck

The kinetic checkpoints can be used as consistent and repeatable locations to observe movement patterns and posture. Whether for an assessment or during activity, these checkpoints offer information regarding muscular weakness, muscular overactivity, and potential injury risk. Generally, muscles that appear to be shortened tend to be **overactive muscles** with high neural activation, while muscles that appear to be lengthened are inhibited, **underactive muscles** (weakened) with low neural activation.

OVERACTIVE MUSCLES: Muscles that are shortened beyond the ideal length-tension relationship with high neural activation that feel tight.

UNDERACTIVE MUSCLES: Muscles that are lengthened beyond the ideal length-tension relationship and are, therefore, inhibited and less capable of producing force.

At each kinetic chain checkpoint, there are groups of muscles that work together to generate various movements. These **muscle synergies** work to refine and better control movement around a joint, and a single muscle can be a part of more than one synergy. An example of this can be found in elbow flexion. The biceps brachii acts as the agonist or prime mover while the brachioradialis, a muscle of the forearm acts synergistically to assist with the elbow flexion.

MUSCLE SYNERGIES: The activation of a group of muscles to generate movement around a particular joint.

MUSCULAR FORCE COUPLE:
Two or more muscles generate force in different linear directions at the same time to produce one movement.

A **muscular force couple** is another example of synergy. A force couple happens when two or more muscles generate force in different linear directions at the same time to produce one movement. To make a right turn on a bicycle, for example, the right arm must pull inward as the left arm pushes outward. Each arm produces force in a different direction, yet it results in one movement.

An example of a force couple in a common exercise is during the deadlift. The glutes pull the back of the hip downward while the abdominals pull the front of the hip upward to produce hip extension during this exercise.

The Foot and Ankle

The joint actions at the foot and ankle include inversion and eversion as well as dorsiflexion and plantarflexion. Movement at the ankle is largely supported by the muscles of the lower leg, but it is also supported by a large network of tendons extending from these muscles. The tendons extend into the toes to control fine motor control of the joints of the toes.

The Knee

The knee joint can flex and extend with a minimal capability for lateral flexion. The muscles supporting the knee joint often cross the knee and an additional joint. For example, the gastrocnemius crosses the knee and ankle joints.

The Hip

The hip actions include flexion and extension, abduction and adduction, and internal and external rotation. Hip rotation can occur when the hip is neutral, flexed, or extended. The hip joint is one of the most flexible joints in the human body and a checkpoint a personal trainer must pay close attention to. Not only does this musculature support the stabilizing **lumbopelvic hip complex (LPHC)**, but it also controls the movement of the lower extremities.

LUMBOPELVIC HIP COMPLEX (LPHC):
The musculature of the hip that attaches to the pelvis and lumbar spine and works to stabilize the trunk and lower extremities.

The remaining muscles associated with the LPHC act to transition the upper body to the lower body and help transmit the forces generated from flexion, extension, and rotation of the trunk. In all, there are between 29 and 35 muscles within the LPHC attaching to the spine or pelvis.

The Spine

There are three sections of vertebrae within the spinal column. The lumbar spine (low back) and the thoracic spine (mid back) are the two sections that will make up this kinetic chain checkpoint.

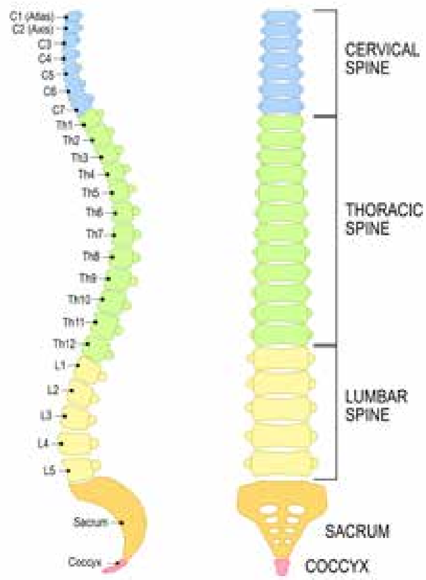


Figure 7.12 Vertebral Column

The Lumbar Spine

The lumbar spine is commonly called the low back and includes spinal vertebrae L1–L5. If there is a muscular dysfunction at the hips, glutes, abdominals, or upper leg, it can manifest here. Fitness professionals can look for hyperextension or flattening of the lumbar spine during gait or squat assessments. These deviations from the ideal lumbar spine positioning can indicate muscular dysfunctions in the LPHC that must be addressed during a training protocol.

The Thoracic Spine

The thoracic spine consists of 12 vertebrae near the middle of the spine. There is a natural curve in the T spine to support the scapula on the back and provide support and strength for the upright human body. The “S” curvature of the spine acts like a shock absorber. During an assessment, rounding through this spinal region can indicate dysfunctions in the chest, upper back, and even the lumbar spine. It will also affect the neck and head movement.

The Shoulder

The shoulder is the most movable joint in the human body and serves as an important part of the kinetic chain during an assessment. However, the large range of motion this joint allows also makes it less stable than other joints. The muscles, ligaments, and tendons closely surrounding or deep to the joint primarily act as stabilizers. The muscles and tendons that are more superficial to the shoulder, the ones you can see, are responsible for moving it.

Generally, anterior muscles are responsible for shoulder flexion and horizontal adduction. Posterior muscles of the shoulder are responsible for extension and horizontal abduction.

The Head and Neck

Finally, the head and neck provide information along the kinetic chain about what is occurring in the **shoulder girdle**, thoracic spine, rib cage, LPHC, and cervical spine. The shoulder girdle refers to the clavicle, scapula, and coracoid bones of the appendicular skeleton. The muscles associated with the shoulder girdle are responsible for moving the scapulae, and they work in conjunction with the muscles of the shoulder to coordinate movements of the upper limbs.

SHOULDER GIRDLE:
The clavicle, scapula, and coracoid bones of the appendicular skeleton.

KINETIC CHAIN MOVEMENT

Within the kinetic chain, there are two types of exercises: open and closed. A **closed kinetic chain movement** keeps the most distal aspect of the body segment in action fixed or stationary. The squat is a closed-chain exercise with the feet grounded on the floor as the lower body flexes and extends. Other examples include the lunge, a push-up, or a pull-up.

CLOSED KINETIC CHAIN MOVEMENT:
A movement keeping the distal end of the body segment in action fixed.

In an **open kinetic chain movement**, the distal aspect of the body segment in action is free (i.e., not fixed). Most open-chain movements are single-joint exercises, like the biceps curl or seated leg extension. However, a combination movement, such as a curl and press, would be considered an open-chain movement since the hands are freely moving.

OPEN KINETIC CHAIN MOVEMENT:
A movement in which the distal aspect of the body segment in action is free (i.e., not fixed).

POSTURE AND MOVEMENT ASSESSMENTS

Subjective assessments to observe posture and movement patterns should be executed next. These are considered subjective because static posture and dynamic movement patterns are subject to the individual, can vary from day to day, and, with such variation, may not be indicative of a chronic muscular issue. For example, a client may have trained one day and have residual muscle tightness that may manifest as a slight tilt in their hips during a postural assessment the following day. While the observable postural deviation can help a trainer identify potential tight or weakened musculature to address, proper recovery and flexibility techniques employed to address temporary muscular dysfunctions will also likely remedy the observed postural dysfunction when the assessment is repeated.

Static posture is typically observed from a standing position from the anterior, posterior, and lateral view. **Movement assessments** are viewed from the anterior, posterior, and lateral angles in most cases. These assessments can offer invaluable information for a trainer for exercise programming and the prescription of flexibility and recovery techniques for optimal

STATIC POSTURE:
Posture when standing upright and still.

MOVEMENT ASSESSMENTS:
Observation and critique of movement patterns or exercise form.

movement. These assessments can also serve as preventative measures to help clients avoid poor movement patterns that may result in injury, discomfort, or pain.

Postural and movement assessments should be repeated periodically throughout an exercise program. The ideal frequency will depend on the client's goals and their desired timeline. Static posture assessments can be repeated on a quarterly basis (every three months), while movement assessments can be reassessed more often—for example, assessing a client's movement patterns at the beginning of their program and then again any time a major acute training variable is changed during their program like resistance (load) or intensity. Reassessing before changing major acute variables ensures the client is moving well, is mastering the required movement patterns, has a functional and optimal joint range of motion, and is not at risk for injury.

POSTURE

There are several postural deviations a trainer will look for during this assessment and when training clients. Each is characterized by different muscular overactivity or weaknesses along the kinetic chain. Fitness professionals should take note of the observable deviations from the floor to the head and use this data to further explore muscular dysfunction. These observations are not for diagnosing structural (bone) malformations or deviations.

Ideal posture is when the feet, knees, and hips are level and even and point straight ahead. The spine will have a normal S curve, the head and neck are neutral (balanced over the body and center of gravity), and the arms hang naturally and evenly at the sides. This is also referred to as a neutral posture. Perfect, neutral posture is not common, and most people will have some degree of deviation.

IDEAL POSTURE:
Optimal body positioning and structural alignment.

Posture is important for health and is needed to keep internal organs in place and allow them to work effectively. For example, excessive low back flexion can cramp the intestines and cause digestive issues. In the same way, excessive rounding of the shoulders can constrict the chest cavity and cause breathing issues.

Posture can affect how the body moves, runs, walks, jumps, and lifts weights. For example, a runner with rounded shoulders and a collapsed chest may have trouble staying upright while running. As a result, they may have trouble generating an effective knee drive or long enough stride—both of which can affect their efficiency.

Many postural deviations will affect the spine. It is a key structure in the human body that supports the weight of the head, trunk, and upper extremities. The spine is also an attachment point for many muscles in the body, like the muscle of the back, the shoulder girdle, and the chest muscles. To allow for proper human movement, the spine must be firm with the ability to be flexible when appropriate. The natural curve of the spine resembles the letter “s” and the average range of motion is between 30 and 40 degrees of spinal flexion and 15 to 20 degrees of spinal extension.

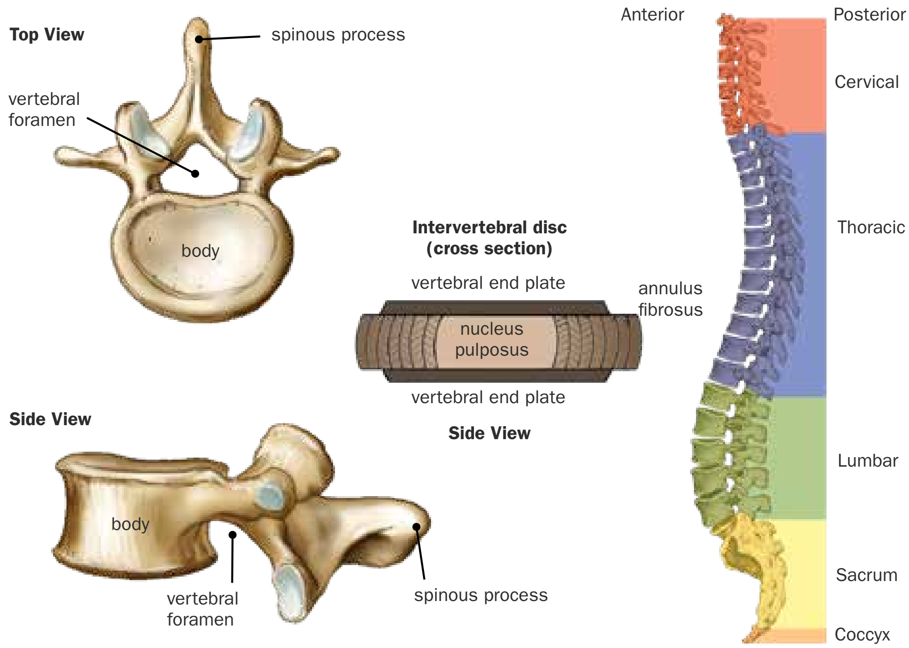


Figure 7.13 The Spine

SPINAL DEVIATIONS

LORDOSIS:
The excessive inward curve of the lumbar spine.

There are several spinal deviations that can be observed during both assessment and general movement. While observing clients for deviations is not intended to diagnose or treat structural issues, it can help a personal trainer identify potentially overactive and weakened musculature that can be addressed within a fitness program. The goal is pain-free movement and injury prevention during training. **Lordosis** is also known as lower cross syndrome. It is characterized by an anterior pelvic tilt, which causes an excessive inward curve at the lumbar spine. The tummy protrudes due to weakness through the abdominals, tightness through the hip flexors causes the pelvic tilt, and the combination can lead to lower back pain.

KYPHOSIS:
The exaggerated rounding of the thoracic spine.

Kyphosis is also an excessive curve of the spine but is found in the upper spine (thoracic) region. Sometimes called upper cross syndrome, kyphosis is common in those who sit with poor posture. The hips are in an anterior tilt and the feet may be flexed and the knees hyperextended. This posture will also cause a forward head position, overexaggerating the S curve of the upper spine.

Flat back posture effectively lessens the S curve of the spine (lumbar flexion) with a posterior pelvic tilt. This causes hyperextension of the knee and, in response, a forward neck and head. The **swayback** posture is similar to flat back but with a larger lumbar curve that protrudes the buttocks.

FLAT BACK: An excessive lumbar flexion and posterior pelvic tilt.

SWAYBACK: A posterior tilt with excessive extension of the lumbar spine that protrudes the buttocks.

Scoliosis is a sideways curvature of the spine, and it is relatively common, especially in youth. The two most obvious symptoms are an observably curved spine with visual examination and uneven shoulders from the anterior or posterior view.

SCOLIOSIS: The sideways curvature of the spine.

The spine is not the only observable posture assessment point along the kinetic chain. The foot and ankle complex can provide a lot of information as to why there may be issues at the knees or hips. A forward head can indicate overactivity through the cervical extensors, and rounded shoulders may indicate overactive pectorals. Again, muscles that appear to be shortened tend to be overactive with high neural activation, while muscles that appear to be lengthened are inhibited, or weak, with low neural activation. Armed with this information, a trainer can design appropriate stretching and strengthening protocols for a client's unique posture.

Table 7.12 Postural Deviations and Associated Muscle Imbalances

MALALIGNMENT	POSSIBLE TIGHT MUSCLES	POSSIBLE WEAK MUSCLES
Lordosis	Lower back (erectors), hip flexors	Abdominals (especially obliques), hip extensors
Flat back	Upper abdominals, hip extensors	Lower back (erectors), hip flexors
Swayback	Upper abdominals, hip flexors	Oblique abdominals, hip extensors
Kyphosis	Internal oblique, shoulder adductors (pectorals and latissimus), intercostals	Erector spinae of the thoracic spine, scapular adductors (mid and lower trapezius)
Forward Head	Cervical extensors, upper trapezius	Neck flexors

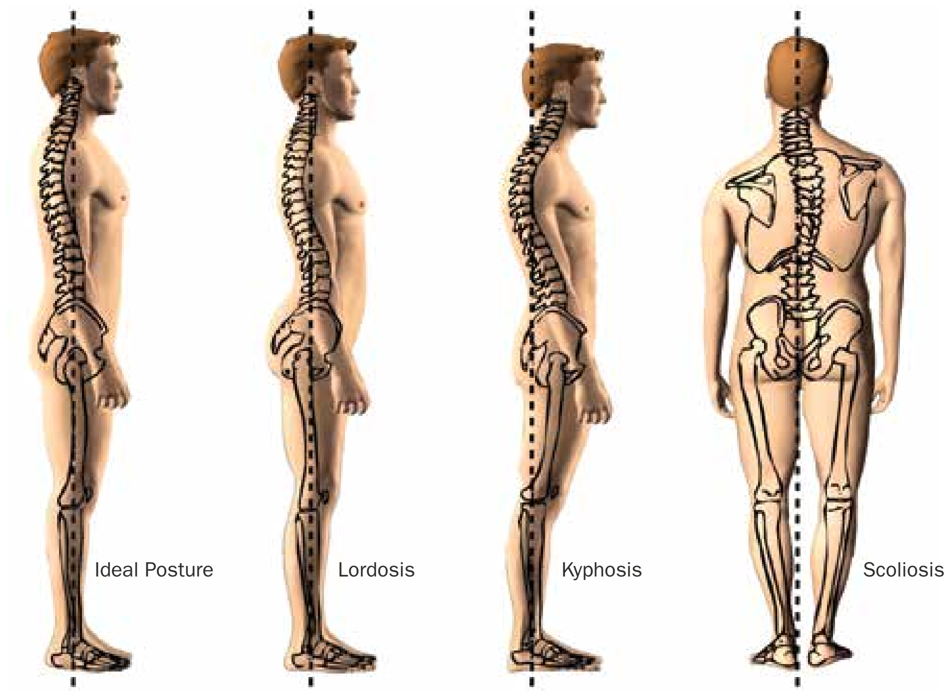


Figure 7.14 Posture Deviations

POSTURE SELF-CHECK

Knowing the status of your own posture will help to assess the posture of your clients. To assess your posture, perform this self-check: Stand with your back against a wall. Your heels, backs of the calves, buttocks, upper back, and head should comfortably touch the wall. If you must strain to make all points of contact, then it's likely that there are some postural deviations.

Another effective method is to secure a string to the ceiling and hang a weight at the end of the string. Stand so that the string is lined up with the nose, and then have a front-view picture taken (or look in a mirror). Notice whether the shoulders are leaning to one side or another or if more of the body is on one side of the line. With good posture, there should be symmetry (alignment matches) on both sides of the string.

To get a graphic representation of how weight is distributed in front of you and behind you, try lining up the string in the middle of your shoulder down to the floor. This method of postural self-check also shows whether you have any major deviations in spinal curvature or positioning of the hips.

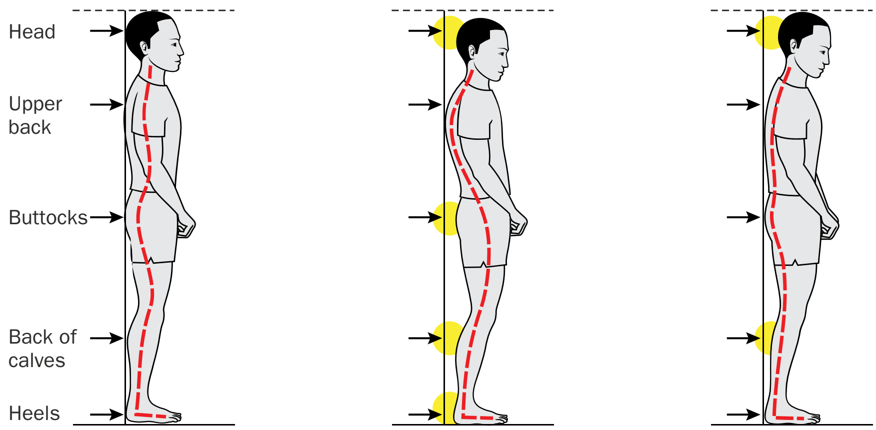


Figure 7.15 Posture Self-Check

OTHER COMMON DYSFUNCTIONS

Outside of the typical standing posture dysfunctions, an individual's foot position and **handedness** should also come into consideration. An individual's handedness refers to which side of their body is prominently used. If someone is right-handed, a trainer may observe a depressed right shoulder and a higher right hip indicating an overactive right side. The opposite can be said of a left-handed individual. Handedness can help to explain observed muscle weaknesses and overactivity, especially in those who perform repetitive movement patterns.

HANDEDNESS:
The tendency to use one side of the body more naturally than the other.

A common observation during posture and movement assessments is **knee valgus** (genu valgum) or **knee varus** (genu varum). Knee valgus, also known as being knock kneed, occurs when the knees are closer to the midline of the body than normal. This posture dysfunction can cause:

KNEE VALGUS:
The position of the knee near the midline of the body (i.e., knock knees).

KNEE VARUS:
The position of the knee away from the midline of the body (i.e., bowlegged).

- bunions;
- ACL issues;
- Achilles tendonitis;
- posterior tibialis tendonitis;
- shin splints;
- tarsal tunnel syndrome; or
- low back pain.

Knee varus, or bowlegged posture, occurs when the knee is farther away from the midline. Both postures affect the **Q angle**. The Q angle (Q for quadriceps) is designated by the line of

Q ANGLE:
The quadriceps angle formed between the quadriceps muscle and the patellar tendon.

pull of the patellar ligament and the mechanical axis of the hip formed by the superior iliac spine and the longitudinal axis of the femur.

A normal Q angle will vary by sex, with females having a larger angle to start—around 15 degrees. Knee valgus increases this angle to 20 degrees or more and knee varus decreases the Q angle below 10 degrees. A trainer can observe and make note of a Q angle that appears to deviate from exercise with the intent of preventing further changes.

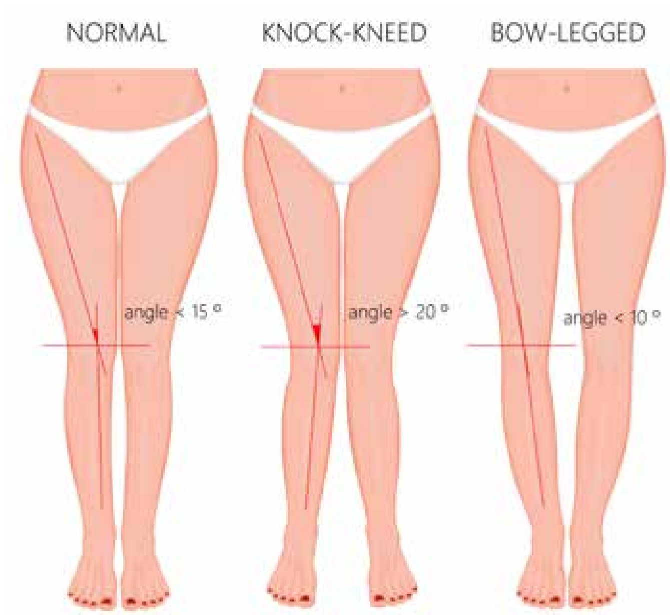


Figure 7.16 Q Angle and Knee Position

DYNAMIC POSTURE ASSESSMENTS

There are several types of movement assessments a trainer can have a client perform. No matter which assessment is chosen, it is important to ensure the client understands the movement they are being asked to perform. For example, if they have never performed a squat, they should be informed on how to perform the basic movement beforehand to avoid injury. The **squat assessment** is a functional subjective assessment for clients of all ages. For this assessment, a client will complete a basic squat. The goal is not to coach them into proper form (yet) but to observe their habitual form during the range of motion. The squat should be completed unloaded (without weight) to prevent influence from external forces and with a moderate, controllable tempo. Five to ten squats are ideal to observe a repetition from the anterior, posterior, and lateral angles without causing fatigue that may exacerbate deviations in the client's posture.

SQUAT ASSESSMENT: The uncoached movement assessment of body mechanics during a squat with the goal of identifying movement dysfunctions along the kinetic chain.

Figure 7.17 Squat Assessment— Lateral, Anterior

Common observations during a squat assessment may include:

- knee valgus;
- forward lean (excessive)
- lumbar spine hyperextension
- heel elevation
- eversion of the foot
- lateral weight shifting

Each observable deviation during the squat assessment can offer insight into overactive and underactive musculature similar to the postural assessment. This information is not used to diagnose structural dysfunctions. Instead, assessment observations can be used to address muscular dysfunctions and prevent injury. A personal trainer will need to have a general understanding of the potentially tight or weakened musculature with each observation to address it in a training program.

Table 7.13 Squat Assessment Observations

MALALIGNMENT	POSSIBLE WEAK MUSCLES	POSSIBLE TIGHT MUSCLES
Knee valgus	Gluteus maximus Gluteus medius Vastus medialis	Adductors Biceps femoris TFL Vastus lateralis
Foot turnout (eversion and external rotation)	Gastrocnemius (medial) Semitendinosus Semimembranosus Sartorius Gracilis	Soleus Gastrocnemius (lateral) Biceps femoris
Forward lean	Gluteus maximus Erector spinae Anterior tibialis	Soleus Gastrocnemius Psoas Rectus femoris Rectus abdominis External obliques
Lumbar extension	Gluteus maximus Transverse abdominus Hamstring complex Multifidus	Psoas Rectus femoris TFL Erector spinae Latissimus dorsi
Heel elevation	Tibialis (anterior)	Soleus
Foot pronation (arch collapse)	Tibialis (anterior and posterior) Gluteus medius Gastrocnemius (medial)	Gastrocnemius (lateral) Biceps femoris TFL
Lateral weight shift	Gluteus medius (same side of shift) Tibialis (anterior) Adductors (opposite side of shift)	Adductors TFL (same side of shift) Gastrocnemius Soleus Piriformis Gluteus medius Biceps femoris (opposite side of shift)

The **overhead squat assessment** is very similar to the standard squat assessment, with the addition of arm range of motion during the movement. The client will complete an unloaded squat while holding their arms overhead.

OVERHEAD SQUAT ASSESSMENT:
The uncoached movement assessment of the overhead squat with the goal of identifying movement dysfunctions along the kinetic chain.

From the start position, the desired movement pattern maintains the elbows back by the ears with arms extended straight overhead and shoulders away from the ears. If a client is unable to achieve this position, it should be noted the arms will likely fall forward during the squat.

Figure 7.18 Overhead Squat Assessment— Lateral, Anterior

As with all other dynamic postural assessments, this overhead squat should be observed from a lateral, posterior, and anterior position. During the overhead squat, look for the same potential deviations as the squat as well as the movement of the arms from the starting position relating to head position, forward lean, and, specifically, flexion and extension of any part of the spine from the lateral view. This assessment is highly effective in identifying core musculature and shoulder girdle dysfunctions.

Table 7.14 Overhead Squat Assessment Observations

MALALIGNMENT	POSSIBLE WEAK MUSCLES	POSSIBLE TIGHT MUSCLES
Knee valgus	Gluteus maximus Gluteus medius Vastus medialis	Adductors Biceps femoris TFL Vastus lateralis

Table 7.14 Overhead Squat Assessment Observations (CONT)

MALALIGNMENT	POSSIBLE WEAK MUSCLES	POSSIBLE TIGHT MUSCLES
Forward lean	Gluteus maximus Erector spinae Anterior tibialis	Soleus Gastrocnemius Psoas Rectus femoris Rectus abdominis External obliques
Foot turnout (eversion and external rotation)	Gastrocnemius (medial) Semitendinosus Semimembranosus Sartorius Gracilis	Soleus Gastrocnemius (lateral) Biceps femoris
Heel elevation	Tibialis (anterior)	Soleus
Foot pronation (arch collapse)	Tibialis (anterior and posterior) Gluteus medius Gastrocnemius (medial)	Gastrocnemius (lateral) Biceps femoris TFL
Lateral weight shift	Gluteus medius (same side of shift) Tibialis (anterior) Adductors (opposite side of shift)	Adductors TFL (same side of shift) Gastrocnemius Soleus Piriformis Gluteus medius Biceps femoris (opposite side of shift)
Lumbar spinal extension (arching)	Gluteus maximus Transverse abdominus Hamstring complex Multifidus	Psoas Rectus femoris TFL Erector spinae Latissimus dorsi
Spinal flexion (rounding)	Erector spinae	Rectus abdominus External obliques Pectoralis major & minor

Table 7.14 Overhead Squat Assessment Observations (CONT)

MALALIGNMENT	POSSIBLE WEAK MUSCLES	POSSIBLE TIGHT MUSCLES
Forward head	Flexors of the cervical spine Extensors of the thoracic spine	Upper trapezius Levator scapulae sternocleidomastoid
Arms fall forward	Middle and lower trapezius Rhomboids Supraspinatus Infraspinatus Teres minor Subscapularis	Latissimus dorsi Pectoralis major & minor Teres major
Shoulder elevation	Middle and lower trapezius	Upper trapezius Levator scapulae sternocleidomastoid

INTERPRETING FINDINGS

Many assessments have norms and standards with which to compare the client's results. Some tests require the trainer to use mathematical formulas to calculate values that can then be interpreted. Other tests are valuable only for subjective data but may require time for the trainer to review photos or videos and note the findings. The trainer should take time to review the assessment results within the context of the intake paperwork, make comparisons to established norms and standards, and determine what the collective data means for the health of the client. These findings will be compiled in the client profile along with all objective assessment data for further review and future reference. Assessment data is also used to guide exercise selection during programming with the goal of keeping clients safe, moving effectively, and working toward their unique fitness goals.

PAR-Q

Physical Activity Readiness Questionnaire

Regular physical activity is part of a healthy, balanced lifestyle. If you are planning to become more physically active, start by answering the following questions. Individuals of any age should check with their doctor before beginning a fitness program. This questionnaire is designed for people aged 15 to 70.

Please answer the following questions honestly with a YES or a NO:

YES NO 1. Has your doctor ever diagnosed you with a heart condition AND told you to only do physical activity they can supervise?

YES NO 2. Does your doctor currently prescribe you drugs for your blood pressure or heart condition?

YES NO 3. Do you feel chest pain during physical activity?

YES NO 4. Do you lose your balance due to dizziness OR have you lost consciousness in the last 12 months?

YES NO 5. Do you have a bone, joint, or soft tissue problem that may be irritated by physical activity?

YES NO 6. In the past 30 days have you had chest pain at any point?

YES NO 7. Do you have any other reason to NOT do physical activity?

If you answered YES to one or more questions:

Talk to your doctor BEFORE you begin physical activity and BEFORE completing any fitness assessments. Discuss the questions you answered YES to with your doctor. Find out what activity you are cleared to partake in and any next steps your doctor wishes you to take.

If you answered NO to all questions:

If you answered no honestly to all PAR-Q questions, you may

- Become more physically active; start slowly and build up gradually.
- Take part in fitness assessments.
- Consult with a fitness professional for guidance.

DELAY becoming more active:

- If you are not feeling well
- If you are or may become pregnant
- If your health suddenly changes

SIGN and RETURN a copy of this form to your fitness professional.

"I have read, understood to my satisfaction, and completed this questionnaire. I acknowledge that my fitness professional may retain a copy of this form for their records and it will be kept with confidentiality in compliance with applicable laws."

Name ______________________________ Date ______________

Signature ______________________________ Witness ______________

Signature of parent/guardian/care provider (if applicable) ______________________________

NOTE: The PAR-Q is intended to be completed prior to participation in a fitness assessment or physical activity. This activity clearance is valid for 12 months from the date completed and becomes INVALID should your health change and you may answer YES to any of the above questions.

Personal Training Liability Waiver

Name:____

Date of Birth: __________________ Email: ____

Address:____

City:____ State:____________ Zip Code: ______________

Primary Phone Number: ____

Name, Relationship, & Phone of Emergency Contact:

____

Training Facility Name: ____

Training Facility Address: ____

Do you have any physical limitations that could be aggravated by exercise (e.g., back, neck, shoulder, or knee problems)?

If so, please explain:____

It is my responsibility to inform my trainer of any physical limitations before beginning a training program.

I represent and warrant that I am in good physical health and do not suffer from any medical condition that would limit my participation in training offered at *The Training Facility*. I understand that it is **my responsibility** to consult with a physician prior to and regarding my participation in any personal training, fitness training, or group training. I understand the risks associated with the activities offered by *The Training Facility* and I agree to follow all instructions so that I may safely participate in training, workshops, or other activities.

I hereby **WAIVE AND RELEASE** *The Training Facility*, its owners, officers, employees, and instructors from any claim, demand, or cause of action of any kind resulting from or related to my participation in the programs offered at the facility. In taking part in personal training, fitness training, or group training at *The Training Facility*, I **understand and acknowledge** that I am fully responsible for any and all risks, injuries, or damages, known or unknown, which might occur as a result of my participation in personal training, fitness training, or group training.

I have read the above release and waiver of liability and fully understand its content. I am legally competent to sign and voluntarily agree to the terms and conditions stated above.

Print name: ____ Signature:_____________________________

Date Signed:_______/_______/_______

If participant is under 18: As Parent or Legal Guardian of ________________________________, I consent to the above terms and conditions.

Print name: ____ Signature:_____________________________

Date Signed:_______/_______/_______

Disclaimer: The form is provided by ISSA as an example. It is strongly suggested that the fitness professional modify the form for their needs and have it reviewed by a licensed legal professional in their state.

INTERNATIONAL
SPORTS SCIENCES
ASSOCIATION

HEALTH HISTORY QUESTIONNAIRE

Print your answers. Please Print Clearly.		
Name:	Date of Birth:	Age:
Address:		
City, State, Zip:		
Home Phone:	Work Phone:	
Employer:	Occupation:	
In case of emergency, please notify:		
Name:	Relationship:	
Address:		
City, State, Zip:		
Home Phone:	Work Phone:	

Physician Information		
Current Physician:	Phone:	
Are you under the care of a physician, chiropractor, or other health care professional for any reason (circle)? If yes, list reason:		Yes No
Are you taking any medications? (If yes, please list) Medication: Dosage/Frequency: Condition:		Yes No
List any and all allergies:		
Has your doctor ever diagnosed you with high blood pressure?		Yes No
Has your doctor ever diagnosed you with a bone or joint problem that has been or could be made worse by exercise?		Yes No
Are you over 65 years of age?		Yes No
Are you used to vigorous exercise?		Yes No

Please note: Possession of this form does not indicate certification status with ISSA. To confirm active certification status, please contact (866) 653-7561. Information gathered from this form is not shared with ISSA. ISSA is not responsible or liable for the use or incorporation of the information contained in or collected from this form. Always consult your doctor concerning your health, diet, and physical activity.

INTL. SPORTS SCIENCES ASSOC.

HEALTH HISTORY QUESTIONNAIRE

MEDICAL INFORMATION - Please answer the following questions (circle one):

1. Have you experienced any chest pain associated with either exercise or stress? Yes No If yes, please explain:
2. Have you experienced shortness of breath with or without exercise? Yes No If yes, please explain:
3. Have you experienced fainting or light-headedness? Yes No If yes, please explain:
4. Have you had a recent hospitalization for any cause? Yes No If yes, please explain:
5. Do you have any orthopedic conditions (including arthritis)? Yes No If yes, please explain:
6. Have you ever experienced a rapid heartbeat or palpitations? Yes No If yes, please explain:
7. Is there any reason why you should not follow a regular exercise program? Yes No If yes, please explain:

Please indicate if a blood relative (parent, sibling, first cousin, etc.) has a history of any of the following conditions (circle one). If there is family history for any condition, please check the box to the left. On the line to the right, please indicate who in the family has or had this condition.

❍ Asthma: ______________________

❍ Respiratory/Pulmonary Conditions: ______________________

❍ Diabetes: Type I: Type II: How Long? ______________________

❍ Epilepsy: Petite Mal: Grand Mal: Other: ______________________

❍ Osteoporosis: ______________________

❍ Coronary Artery Disease: ______________________

❍ Heart Attack: ______________________

❍ Hypertension: ______________________

❍ High Blood Pressure: ______________________

❍ Stroke: ______________________

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INTL. SPORTS SCIENCES ASSOC.

HEALTH HISTORY QUESTIONNAIRE

Lifestyle/Habits - Please check the box that describes your current habits:

1. Do you smoke? Yes / No If yes, how often:
   - ❒ Former user; Date quit:
   - ❒ 1 or fewer cigarettes per day
   - ❒ 2 to 5 cigarettes per day
   - ❒ 6 to 10 cigarettes per day
   - ❒ More than 10 cigarettes per day

2. Do you drink caffeine? Yes / No If yes, how often:
   - ❒ Several times a day
   - ❒ Once per day
   - ❒ Few times per week
   - ❒ Few times per month

3. Do you drink alcohol? Yes / No If yes, how often:
   - ❒ Several times a day
   - ❒ Once per day
   - ❒ Few times per week
   - ❒ Few times per month

4. On average, how many hours of sleep do you get each night?
   - ❒ More than 10 hours
   - ❒ 8-10 hours
   - ❒ 5-7 hours
   - ❒ Less than 5 hours

5. On average, what is your energy level like each day?
   - ❒ High energy
   - ❒ Moderate energy
   - ❒ Low energy

Dietary Factors - Please indicate if you (personally) have a history of the following (circle one):

Anemia:	Yes / No
Gastrointestinal Disorder:	Yes / No
Hypoglycemia:	Yes / No
Thyroid Disorder:	Yes / No
Pre/Postnatal:	Yes / No

INTL. SPORTS SCIENCES ASSOC.

HEALTH HISTORY QUESTIONNAIRE

Cardiovascular - Please indicate if you (personally) have a history of the following (circle one):

High Blood Pressure:	Yes / No
Hypertension:	Yes / No
High Cholesterol:	Yes / No
Hyperlipidemia:	Yes / No
Heart Disease:	Yes / No
Skipped Heartbeat:	Yes / No
Heart Attack:	Yes / No
Stroke:	Yes / No
Bypass or Cardiac Surgery:	Yes / No
Angina:	Yes / No
Gout:	Yes / No
Phlebitis or Embolism:	Yes / No
Other (please explain):	Yes / No

Please list any other diagnosed conditions and the date of diagnoses below:

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HEALTH HISTORY QUESTIONNAIRE

Pain History - Check if you have or have had pain in the following. If yes, please describe:

❍ Head/Neck: ______________________

❍ Upper Back: ______________________

❍ Shoulder/Clavicle: ______________________

❍ Arm/Elbow: ______________________

❍ Wrist/Hand: ______________________

❍ Lower Back: ______________________

❍ Hip/Pelvis: ______________________

❍ Thigh/Knee: ______________________

❍ Arthritis: ______________________

❍ Hernia: ______________________

❍ Surgeries: ______________________

❍ Other: ______________________

Nutrition

Are you on any specific food/diet plan? If yes, please list and advise who prescribed it:	Yes No
Do you take dietary supplements? If yes, please list:	Yes No
Do you notice your weight fluctuating?	Yes No
Have you experienced a recent weight gain or loss? If yes, explain how: Over what amount of time?	Yes No
If you consume caffeine, what types of beverages do you consume that contain caffeine?	
How would you describe your current nutritional behaviors?	
Other food/nutritional issues you want to include *(food allergies, mealtimes, etc.)*	

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HEALTH HISTORY QUESTIONNAIRE

Work and Environment

Please check the box that best describes your work and exercise habits.

- ❍ Intense occupational and recreational effort
- ❍ Moderate occupational and recreational effort
- ❍ Sedentary occupational and intense recreational effort
- ❍ Sedentary occupational and moderate recreational effort
- ❍ Sedentary occupational and light recreational effort
- ❍ Complete lack of activity

How stressful are your environments (circle one)?

Work: Minimal Moderate Average Extremely

Home: Minimal Moderate Average Extremely

Do you work more than 40 hours a week? Yes No

Anything else you would like your personal trainer to know?

PRINTED NAME:

SIGNATURE: DATE:

SIGNATURE OF PARENT:
or GUARDIAN (for participants under the age of 18)

WITNESS:

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3-DAY DIETARY LOG

Page 1 of 4

Name:	Date:

This dietary record must be as accurate as possible. Please do not alter your eating habits or modify your meals to change what is logged. It is essential to be precise and honest because this log will aid your fitness professional in creating the best plan of action for your current behaviors and lifestyle.

Instructions

1. Please keep this log with you at all times and log meals, snacks, drinks, and anything else you consume as accurately as possible.
2. When possible, use a food scale or measuring spoons or cups. If you do not finish an entire serving that was logged, please adjust the log accordingly. Avoid guessing or estimating as much as possible.
3. Please list each food item in a meal separately.
4. For packaged items, use labels to determine quantities.
5. Include the time of day and any relevant notes in the last column.
6. Please log your food/drink consumption for three consecutive days. If there are special events or circumstances that affect your nutrition on a certain day, please note this in the far right column. This will provide your fitness professional with the appropriate insight. If you wish to log for more than 3 days, please do so.
7. Have this log completed and ready for your next session.

Example Log

Food Item (include brand name)	**Quantity** (g, ml, Tablespoons [Tbs], teaspoons [tsp], cups [c], etc.)	**Time of Day/ Additional Notes**
Breakfast		8:00 am - In a hurry
Toast	2 pcs	
Margarine	1 tsp	
Orange Juice	8 oz	
Lunch		12:00 pm - Homemade pizza
Small pizza (pepperoni, mushroom, cheese)	12-inch diameter	
Dinner		5:00 pm
Chicken	4 oz	
Baked Potato	8 oz	
Mixed Frozen Vegetables (peas, carrots, corn)	2 c	

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3-DAY DIETARY LOG

Page 2 of 4

Name:		Date:
Day 1		
Food Item (include brand name)	**Quantity** (g, ml, Tablespoons [Tbs], teaspoons [tsp], cups [c], etc.)	**Time of Day/ Additional Notes**

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3-DAY DIETARY LOG

Page 3 of 4

Name:	Date:

Day 2

Food Item (include brand name)	**Quantity** (g, ml, Tablespoons [Tbs], teaspoons [tsp], cups [c], etc.)	**Time of Day/ Additional Notes**

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3-DAY DIETARY LOG

Page 4 of 4

Name:	Date:

Day 3

Food Item (include brand name)	**Quantity** (g, ml, Tablespoons [Tbs], teaspoons [tsp], cups [c], etc.)	**Time of Day/ Additional Notes**


ISSA

CHAPTER 08

ELEMENTS OF FITNESS

LEARNING OBJECTIVES

1 | Name and describe the common goals of a fitness program and elements of each.

2 | List the elements of a fitness program that should be incorporated for health and optimal physical performance.

3 | Describe the components of each element of an effective fitness program.

There are many reasons why someone would seek the guidance of a certified fitness professional. The most common reasons tend to be associated with weight loss or weight management. However, clients also seek out personal trainers to help improve their athletic performance, have a better quality of life, or support their psychological health. Regardless of the goal, it's critical that a personal trainer uses their knowledge of the different elements of fitness to design unique training programs in alignment with each client and their individual goals.

In addition to the client's goals, a personal trainer should also prioritize the overall health of the client and the fundamental skills associated with daily movement and the management of basic physical needs:

- Grooming and personal hygiene
- Dressing
- Toileting and continence
- Transferring and ambulating
- Preparing food and eating
- Tasks that contribute to income

To design a healthy, balanced, and effective training plan that aligns with a client's goals, a personal trainer should focus on the following five components of fitness:

- **Cardiovascular endurance**
- **Muscular strength**
- **Muscular endurance**
- **Flexibility**
- **Body composition**

These components are often used as a gauge for an individual's overall health. Although improving one component has its own benefits, striving to make improvements to all of them is a key to balanced well-being.

CARDIOVASCULAR ENDURANCE: The measure of the cardiovascular system's (heart and blood vessels) ability to perform over an extended period.

MUSCULAR STRENGTH: The measure of force produced by a muscle or group of muscles.

MUSCULAR ENDURANCE: The ability of a muscle or group of muscles to continuously exert force against resistance over time.

FLEXIBILITY: The range of motion of a muscle and its associated connective tissues at a joint or joints.

BODY COMPOSITION: The physical makeup of the body considering fat mass and lean mass.

Table 8.1 Common Fitness Program Goals

COMPONENT OF FITNESS	PHYSIOLOGICAL BENEFITS
Cardiovascular endurance	• Increases energy • Improves stamina • Helps control blood pressure • Improves blood cholesterol • Helps regulate blood sugar • Burns calories to maintain body composition • Promotes brain health • Improves body's cellular efficiency • Reduces risk of disease • Improves state of mind
Muscular strength	• Maintains body composition • Increases energy • Increases bone density • Enhances strength for activities of daily living • Reduces risk of disease • Improves mental well-being • Decreases risk of injury • Improves posture • Enhances longevity
Muscular endurance	• Improves stamina • Reduces fatigue • Increases metabolism • Reduces risk of injury • Improves mood • Increases sleep quality • Prevents age-related decline in brain function • Promotes ability to exercise longer

TYPE 2 DIABETES: A long-term metabolic disorder that is characterized by high blood sugar, insulin resistance, and relative lack of insulin.

HEART DISEASE: A term used to describe several different heart conditions.

Table 8.1 Common Fitness Program Goals (CONT)

COMPONENT OF FITNESS	PHYSIOLOGICAL BENEFITS
Flexibility	• Reduces risk of injuries • Improves balance • Promotes better posture • Reduces pain • Improves physical performance • Increases range of motion • Improves circulation
Healthy body composition	• Decreases risk of **type 2 diabetes** • Decreases risk of hypertension • Decreases risk of **heart disease** • Promotes a healthier metabolism • Fosters a better range of motion • Provides energy for activities of daily living • Promotes better functioning of organs • Regulates hormones • Helps control weight • Improves circulation • Enhances healthy lung function • Promotes healthy pregnancy • Improves sleep quality

ELEMENTS OF A FITNESS PROGRAM

When designing a well-balanced fitness program, there are specific elements a personal trainer should consider. Each element has specific health and wellness benefits and variability in how they may be executed based on the client's needs and abilities. Not all these elements need to be addressed in every workout, but they should all be considered at some point, to some degree, in a comprehensive fitness program.

The elements of a fitness program are:

- The warm-up

- Flexibility training
- Core training
- Balance training
- Reactive training
- Resistance training
- Cardiorespiratory training
- The cooldown

THE WARM-UP

A warm-up is necessary for preparing the body for the activity or training. A **general warm-up** is simple and will increase blood flow, respiration, body temperature, and neurological activation of the major muscle groups. For example, a warm-up could consist of walking on a treadmill or riding a stationary bike for five minutes before a training session.

A **specific warm-up** intentionally mimics movements that will be part of the workout or activity. In this way, specific movement patterns and the tissues associated with those movement patterns are prepared for the upcoming activity. Warm-ups may include variations of **dynamic stretching** and light cardiovascular activity.

Every training session should include a warm-up for several reasons. First, the increased blood flow reduces muscle stiffness (increases extensibility) and can prevent injury. Second, warm muscles contract and relax faster with a higher rate of contraction and better neuromuscular activation. Third, the increased respiration delivers oxygen to the bloodstream and body more effectively during activity, and, finally, a warm-up can help a client mentally prepare for the forthcoming workout.

FLEXIBILITY TRAINING

Flexibility is a critical element of fitness that is often overlooked. **Flexibility training** uses stretching to increase the range of motion of a joint or group of joints and allow for increased ranges of motion. It is an important aspect of all training programs, as flexibility and range of motion begin to diminish in most people around the age of 25.

Static stretching is ideal for a cooldown rather than a warm-up protocol. It has been shown to change the **length-tension relationship** of a muscle fiber, which can increase the risk of injury or alter performance if it's done before an activity.

GENERAL WARM-UP: Nonspecific, low-intensity activity including dynamic stretching and light cardiovascular activity with the purpose of increasing blood flow, respiration, and body temperature.

SPECIFIC WARM-UP: Movements used to prepare the body for a sport or specific exercises.

DYNAMIC STRETCHING: Movement-based active stretching where muscles engage to bring about a stretch.

FLEXIBILITY TRAINING: An element of fitness using stretching to increase the range of motion of a joint or group of joints and allow for increased ranges of motion.

STATIC STRETCHING: Lengthening a muscle and holding the lengthened position.

LENGTH-TENSION RELATIONSHIP: The amount of tension a muscle can produce as a function of sarcomere length.

CORE TRAINING

CORE TRAINING: Refers to strengthening the musculature of the abdominals, back, and lower body that directly influence the lumbopelvic hip complex (LPHC).

LUMBOPELVIC HIP COMPLEX (LPHC): The musculature of the hip that attaches to the pelvis and lumbar spine and works to stabilize the trunk and lower extremities.

ABDOMINAL BRACING: Activation of the trunk muscles to support the spine.

BALANCE TRAINING: Exercises to strengthen the stabilizer muscles and prime movers of the core and legs to improve dynamic stability.

The abdominal muscles aren't the only muscles included in the core, so core training involves more than just targeted abdominal work. **Core training** refers to strengthening the musculature of the abdominals, back, and lower body that directly influence the **lumbopelvic hip complex (LPHC)**.

Table 8.2 Muscles of the Core and LPHC

Hip adductors	Gluteus medius	Gluteus minimus
Erector spinae	Rectus abdominus	Gluteus maximus
Hamstring complex	Quadriceps	Hip flexors
Transverse abdominus	Internal obliques	External obliques
Multifidus	Pelvic floor muscles	

Core training is an element of fitness necessary for every client. Research suggests that a strong core contributes to increased sports performance, stability, reduced back pain, and increased functional strength for everyday activity.

Proper core training exercises work to stabilize the spine by targeting as many of the core muscles as possible to work in tandem. In addition to specific core training exercises, the technique of **abdominal bracing** during exercise can also help strengthen the core. Abdominal bracing activates the muscles of the trunk to support the spine and hold the pelvis in a neutral position. Examples of exercises that activate the core and use abdominal bracing include planks, hinges, rotational movements, and **balance training**. Because the core needs to be strong and functional in all planes of motion, a well-rounded exercise program will include exercises that challenge the core in all planes of motion.

The standard crunch is an exercise that emphasizes the rectus abdominis muscle. To perform a crunch, lie on the back with the knees bent and the bottom of the feet on the ground and approximately hip-width apart. Contract the abdominals to shorten the distance between the bottom of the ribs and the top of the pelvis. The shoulders should rise off the ground slightly. Slowly return to the start position.

The plank is an exercise that challenges the ability of the core to maintain a neutral position. On the floor facedown, rest the body's weight on the forearms and toes. The goal is to keep the body in a straight line. The ankles, knees, hips, and shoulders should be in line with each other, and the eyes should face down keeping the head and neck in alignment.

The cable woodchop exercise is a rotational exercise that emphasizes the musculature of the hips and torso. Stand with a cable to the side of the body in a high position. Feet should be approximately hip width apart. Grab the handle with both hands above the shoulder and the chest facing the cable. Swing the cable across the body and downward toward the opposite thigh by rotating the hips and torso in a wood-chopping motion. This movement should be initiated and controlled by the hips and torso rather than the arms.

BALANCE TRAINING

Balancing, in everyday life or during athletic performance, requires a significant amount of sensory input. Visual input from the eyes, auditory input from the ears, and input regarding the body in space are gathered by proprioceptors in the muscles and tendons. In addition, motor control and muscle power are necessary to maintain stability. Purposeful movements that require balance and stability include walking, doing laundry, lifting weights, and even relatively simple recreational activities such as fishing. Muscular strength is an important component of balance. Strong muscles stabilize the joints—spine, knees, ankles—and help prevent falls. Reflexive movements, such as recovering from a stumble, also require balance, motor control, and muscular strength.

The body systems involved in balance can be affected by injury, illness, neurological disorders, medications, and advancing age. Balance training involves manipulating and stimulating sensory systems to challenge the ability to maintain one's center of gravity and remain upright.

These systems include the following:

- Visual: opening or closing the eyes
- Vestibular (or inner ear): moving the head by focusing the gaze in different directions during an exercise
- Somatosensory: manipulating body position or using an unstable surface

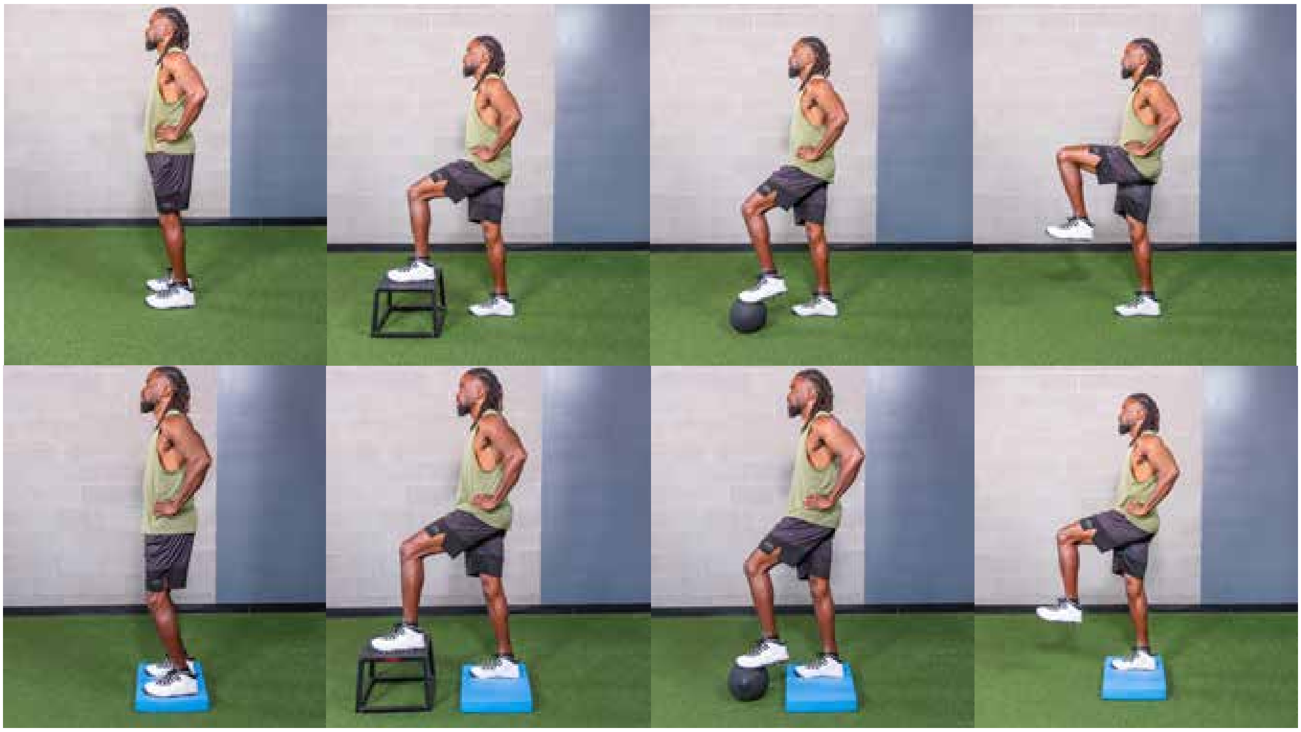
The reported benefits of balance training include

- improved static and dynamic stability,
- reduced incidence of recurrent ankle injury,
- reduced low back pain (with core training), and
- reduced joint pain (with strength training).

Balance training should become progressively more difficult. For example, one might progress a balance training program by practicing the following movements:

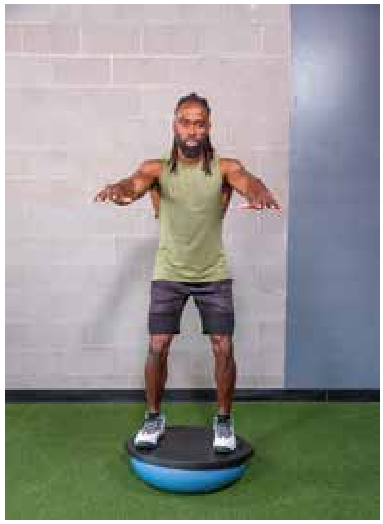
1. Floor: two legs
2. Floor: single-leg with step
3. Floor: single-leg with ball
4. Floor: single-leg
5. Balance pad: two legs
6. Balance pad: single-leg with step
7. Balance pad: single-leg with ball
8. Balance pad: single-leg

Balance training is a key component in preparing the body to progress in a fitness or training program and should be incorporated to help support better movement, performance, and quality of life.



The single-leg balance exercise is an effective way to introduce balance training into a program. Begin standing upright and slowly lift one foot off the ground. The goal is to maintain this position. As balance begins to fail, return to the upright single-leg position as quickly as possible while maintaining control.

The BOSU is a tool that can be used to add an unstable surface to an exercise and therefore add additional challenge to balance. The two-leg balance on the BOSU (standing on the flat side) is a progression from balancing on a stable surface. To perform the exercise, stand on the flat side of the BOSU with a slight bend in the knees and hips. The goal is to minimize movement back and forth and stay on the BOSU.



The step up to balance is a dynamic balance exercise because the step-up portion moves the body from one position to another. This creates momentum, which adds an additional challenge to the balancing leg. To perform the exercise, use a short, stable step at approximately knee height. Step one foot forward and place it on the step. Drive through the front foot to lift the body and back foot over the step. The body should end in an upright position with the back foot coming up into a high-knee position. Hold the top position until fully balanced and under control.

The step up to balance on a BOSU has all the elements of the step up to balance but adds the unstable surface of the BOSU. To perform the exercise, use the BOSU as the stepping surface. Step one foot forward and place it on the dome side of the BOSU. Drive through the front foot to lift the body and back foot over the BOSU. This is the point where balance and control are tested differently than with a stable step, as the surface is soft and unstable. The body should end in an upright position, with the back foot coming up into a high-knee position.

Hold the top position until fully balanced and under control.

REACTIVE TRAINING

Although sports are most often associated with the need for speed, agility, and quickness (SAQ), nonathletes can benefit from the incorporation of reactive training into their fitness programs as well.

Defined as quick, powerful movements with an eccentric action followed by an immediate concentric action, **reactive training** trains the body to be explosive, fast, and agile. Speed, agility, and quickness are required for most athletic endeavors. **Speed** is the ability to move the body in one direction as fast as possible. **Agility** is defined as the ability to accelerate, decelerate, stabilize, and change direction with proper posture. **Quickness** is the ability to react and change body position with a maximum rate of force production. Success in athletic performance is usually attributed to one or all these. However, so are general function and locomotion.

REACTIVE TRAINING: Quick, powerful movements with an eccentric action followed by an immediate concentric action.

SPEED: The ability to move the body in one direction as fast as possible.

AGILITY: The ability to accelerate, decelerate, stabilize, and change direction with proper posture.

QUICKNESS: The ability to react and change body position with a maximum rate of force production.

COUNTERMOVEMENT: A movement or other action made in opposition to another action.

Though reactive training is commonly used to develop explosive, powerful movements, a by-product of training in this manner is the improvement of the body's ability to safely accept the forces created, thereby providing an increased level of injury resistance. Day-to-day life may, at times, provide a challenge in which a client needs to avoid a fall or rapidly respond to something unexpected, such as a cup falling off a table. Speed, agility, and quickness are critical skills that can help an individual catch themselves from that fall or react to grab the falling cup.

Many studies have proven the benefits of training for speed, agility, and quickness. Here are some of the findings:

- Improved performance in sprints, jumping performance in **countermovement**, and continuous jumping (bounding)
- Improved power performance in sports

- Improved VO_2 max, agility, visual vigilance, and cognitive performance
- Increased time to exhaustion
- Improved muscle strength for movements in all directions
- Improved efficiency in reception and processing of brain signals
- Enhanced development of all motor skills
- Reduced time to reaction
- Improved balance
- Improved measures of functional ability
- Improved body composition; cardiovascular, aerobic, and anaerobic fitness; strength; agility; and performance-related measures for athletes

Training abilities in SAQ innervates the nervous system, making movement patterns nearly automatic and therefore more efficient. Training more efficient movement patterns helps prevent injuries during extreme training and in sports competitions.

Some elements and methods used in training SAQ include medicine balls, agility ladders, cones, ropes, hills, parachutes, hurdles/gates, boxes, and **plyometric training**.

PLYOMETRIC TRAINING: Reactive training seeking maximum force in the shortest amount of time.

The lateral shuffle drill helps to improve or assess quickness, agility, and body control as it relates to lateral movement. Set two cones 5 to 10 yards apart. Be sure to record the chosen distance if using this drill as an assessment. Start in an athletic position. Feet about hip width apart and a slight bend in the hips and knees. Facing the same direction the entire time, start by one of the cones and side shuffle back and forth between the cones, touching each cone with the outside hand. The goal is to shuffle, without crossing the feet, as quickly as possible while maintaining body control. Count the number of times shuffled back and forth in 20 seconds.

The box drill is another valuable exercise that can be used to improve agility, speed, quickness, change of direction, and body control. This drill can also be used as a test to record improvements in those same attributes. It is performed by running around four cones that are set up ten yards apart in a square configuration.

To successfully complete the drill, the participant will do the following:

1. Start next to cone 1
2. Sprint to cone 2
3. Side shuffle to cone 3
4. Back-pedal to cone 4
5. Finish by turning and sprinting past cone 1

The participant must go around the outside of each cone. If performing this drill as a test, a stopwatch must be used to record the time taken to complete the drill.

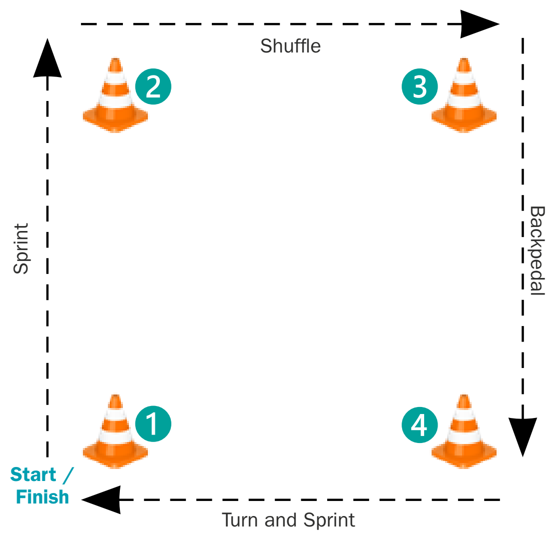


Figure 8.1 Box Drill

PLYOMETRICS

Plyometric exercises are those involving repeated maximum stretching and contracting of muscles in the shortest amount of time. Methods used in plyometric exercises include hops, jumps, leaps, bounds, depth jumps, split lunges, box jumps, explosive push-ups, and medicine ball throws.

STRETCH-SHORTENING CYCLE (SSC): The cycling between the eccentric (stretch) action of a muscle and the concentric (shortening) action of the same muscle.

Plyometric exercises increase muscle power by enhancing the **stretch-shortening cycle (SSC)**. The SSC is an almost instantaneous cycle of muscle actions made up of three phases. First is the eccentric contraction phase (lengthening of the muscle), where the muscle stores energy; next is the transitional period (amortization phase); and last is the concentric contraction phase (shortening of the muscle), where the stored energy is released.

Compressing a spring builds tension in the coils, storing energy for the rebound. Applying more force or speed to compress the spring builds more energy, causing the spring to rebound higher or further. In a fitness application, a “run up” creates a higher or longer jump compared with jumping from a stationary position. This springlike action enhances athletic performance in both explosive and endurance sports.

The squat jump is an example of a plyometric exercise for the lower body. To perform the exercise, start in an upright position. Then quickly drop down into a squat position to load energy into the muscles of the legs and hips. Immediately drive through the ground explosively to extend the hips and knees and jump into the air. Land softly, bending at the ankles, knees, and hips to spread the force of the landing throughout the lower-body musculature.

Plyometrics are effective for:

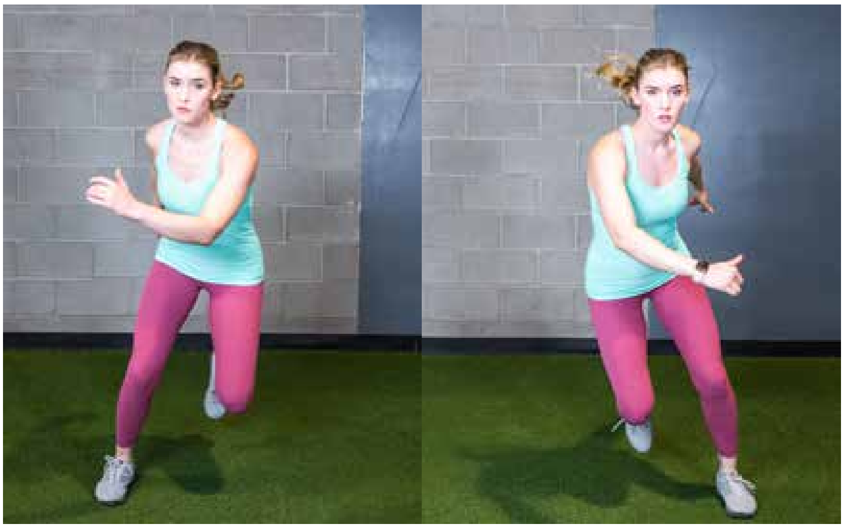
- promoting positive changes in neural and musculoskeletal systems, muscle function, and athletic performance;
- enhancing bone mass in prepubertal/early pubertal children, young women, and premenopausal women;
- changing the stiffness of elastic components of the muscle-tendon complex of plantar flexors;
- improving lower-extremity strength, power, and SSC muscle function; and
- reducing the risk of lower-extremity injuries in female athletes.

The body adapts to plyometric exercise in many ways, including

- improved intermuscular coordination,
- increased muscle size,
- improved storage and use of elastic energy,
- increased active muscle working range,
- enhanced involuntary nervous reflexes,
- increased muscular pre-activity, and
- enhanced motor coordination.

The split jump is a lower body plyometric exercise. The exercise is performed in a split stance (one foot forward and the other foot back). From this position, quickly lower into a lunge position for the eccentric phase of the exercise. This is immediately followed a concentric contraction of the lower musculature of the body to propel (jump) into the air. Switch the positioning of the legs while in the air (the front leg will move to the back while the back leg moves to the front). Land softly and under control, keeping the knees in alignment with the feet. From here, immediately lower into the lunge position and explode into the next rep (again switching the position of the legs in the air). Repeat for the desired number of reps.

The speed skater is a lower body plyometric exercise that focuses on lateral agility. The movement is a lateral back and forth hop. Starting in an athletic position (slight bend in the hips and knees), push off the left foot to hop laterally, landing on the right foot. Land in an athletic position with control of the body. Immediately press off with the right foot to jump back to the starting position, landing on the left foot. Continue to repeat the process for the desired number of repetitions. Special attention should be given to the landing leg and the trail leg. Be sure to control the lateral momentum that will influence the landing leg by keeping the knee in alignment with the foot. The trail leg will have momentum as well. Control it and do not let it cross past the body or the landing leg.



An example of an upper-body plyometric is the plyometric push-up. To perform the exercise, begin in a standard push-up position (arms extended), then quickly drop down by bending at the elbows and shoulders to load the upper-body musculature with energy. Immediately and explosively push back toward the starting position and leave the ground. Land softly, bending at the elbows and shoulders to absorb the force of the landing.

RESISTANCE TRAINING:
The category of training that includes physical activities designed to increase muscle mass, improve strength, muscular endurance, or muscular power.

DELAYED ONSET MUSCLE SORENESS (DOMS):
Muscle pain or stiffness resulting from microtearing of tissue during eccentric muscle action that is felt several days after unaccustomed exercise.

RESISTANCE TRAINING

Resistance training, also called strength training, involves exercises with the explicit intent of increasing strength, endurance, muscle size (hypertrophy) or power. To promote muscular adaptation, resistance training must be challenging enough to tear the muscle fiber. As a result, many people experience muscle soreness and **delayed onset muscle soreness (DOMS)** with resistance training. DOMS is specifically caused by muscle microtearing that occurs during eccentric (lowering) muscle action. Muscular strength is divided into several categories to distinguish purpose and execution.

TARGET HEART RATE (THR):
The estimated beats per minute that needs to be reached to achieve a specific exercise intensity.

RATES OF PERCEIVED EXERTION (RPE):
A subjective sliding scale of a client's perception of their exercise intensity.

HEART RATE ZONES:
Percentages of maximum heart rate associated with a desired physiological adaptation.

CARDIORESPIRATORY TRAINING

The cardiorespiratory system serves several primary functions including:

- Delivery of oxygen and nutrients to the cells
- Removal of carbon dioxide and metabolic waste products
- Regulation of body temperature
- Maintenance of pH balance (a measure of acidity and alkalinity)
- Delivery of hormones to target tissues

Training the cardiorespiratory system requires continuous, rhythmic exercise involving large muscle groups. The body's response to exercise is directly proportional to the oxygen demands of the skeletal muscles. When exercise intensity is low, oxygen uptake and cardiac output is low. When intensity increases, oxygen uptake and cardiac output increase to match. This type of exercise may include walking, jogging, running, cycling, swimming, aerobics, rowing, stair climbing, hiking, cross-country skiing, and dancing.

Cardiorespiratory training uses **target heart rate (THR)**, **rates of perceived exertion (RPE)**, and **heart rate zones** to determine intensity and drive physiological adaptations. The THR denotes a specific percentage of estimated **maximum heart rate** (220 minus a person's age) to achieve during training, while the RPE is a subjective sliding scale of a client's perception of their exercise intensity.

STEADY-STATE ACTIVITY

Continuous activity performed at a fixed level of exertion is called **steady-state exercise**. Walking, running, cycling, and swimming are examples. The heart requires a constant supply of oxygen for continuous activity. At rest, the myocardial capillaries absorb 70 to 80 percent of blood oxygen. Skeletal muscles absorb only about 25 percent. The body adapts to regular steady-state exercise by increasing blood flow to the heart to keep up with its aerobic energy demands.

In addition, blood volume increases in response to regular steady-state activity. Oxygen uptake and delivery increase three to four times (from 4 or 5 mL of oxygen per 100 mL of blood to 15 or 16 mL per 100 mL). The blood vessels branch out and form additional capillaries to deliver more blood to the working muscles. Pulmonary ventilation increases almost immediately at the onset of exercise. Respiratory centers in the brain stem and proprioceptors in moving joints and limbs send signals to the body to increase respiration.

The heart adapts as well, increasing the size and strength of the left ventricle to increase contraction strength and blood capacity. A stronger left ventricle increases the stroke volume, or the amount of blood pushed out during contraction. Because the heart is stronger and pushes more blood per beat, the resting heart rate is lower in trained individuals.

MAXIMUM HEART RATE:
The estimated maximum number of times the heart should beat per minute during exercise. Calculated by subtracting a person's age from 220.

STEADY-STATE EXERCISE:
Exercise that maintains a steady level of exertion from start to finish.

INTERVAL TRAINING:
Training that varies between high- and low-intensity work to challenge the cardiorespiratory system.

HIGH-INTENSITY INTERVAL TRAINING (HIIT):
Interval training with short intervals at near maximum effort and less intense recovery periods.

INTERVAL TRAINING

Interval training involves a series of low- to high-intensity workouts combined with periods of rest or lower-intensity activity. Interval training has been proven to produce many of the same adaptations as steady-state training but with less volume (up to 90 percent) and time commitment. In fact, steady-state training would have to be performed up to four times longer than interval training to produce the same physiological adaptations.

A common form of interval training is **high-intensity interval training (HIIT)**. High-intensity segments are brief—10 to 45 seconds—at 85 percent or more of VO_2 Max. Each training session has less than or equal to just 10 minutes of high-intensity work. HIIT is a low-volume workout that produces training adaptation with less time spent. A simple example is sprinting around a track as the work intervals with either walking or jogging in between as the rest intervals.

Just as with cardiovascular endurance training, interval training has been found to have the following benefits:

- Increases in oxidative capacity of skeletal muscles
- Strengthening of the left ventricle
- Increase in stroke volume
- Improvement in peripheral vascular structure and function (veins and arteries in the arms, legs, hands, and feet)

THE COOLDOWN

A post-activity **cooldown** has both physiological and mental benefits. Taking time to slow down and reduce the resistance of exercise before ending a training session allows the body temperature, blood pressure, heart rate, and breathing rate to return to a level closer to normal. This is an ideal time to static stretch and perform **self-myofascial release (SMR)** to promote muscle recovery and optimal length-tension relationships within muscle fibers.

Mentally, a cooldown allows the exerciser to focus their energy, recap what they just completed, and prepare for recovery and the remainder of their day. Skipping a cooldown means muscle tissue abruptly stops contracting. This may lead to blood pooling in the extremities, muscle cramps, or muscle stiffness. The interruption of blood flow is cited as a top reason not to forgo a cooldown period. Research also suggests that neuromuscular recovery increases and the risk of injury in subsequent training decreases with a gradual slowing of the body after activity or sport.

TEST TIP!

The cooldown is an ideal time for static stretching. The body is still warm from activity which means the muscles are more pliable. Additionally, muscles may tighten during a workout so the static stretching can aid in restoring a normal resting length to the musculature.

COOLDOWN:
Gradually slowing the body after activity to return to homeostasis or close to homeostasis.

SELF-MYOFASCIAL RELEASE (SMR):
Applying manual pressure to an adhesion or overactive tissue to elicit an autogenic inhibitory response, which is characterized by a decrease in the excitability of a contracting or stretched muscle arising from the Golgi tendon organ.


2.5 KG

CHAPTER 09

PRINCIPLES OF PROGRAM DESIGN

LEARNING OBJECTIVES

1 | List and describe the most common acute training variables in fitness.

2 | Describe each of the primary principles of program design and how a fitness professional uses them to create exercise programming.

3 | Describe the common types of exercise periodization.

4 | Define overreaching and overtraining in exercise and fitness.

5 | Define the elements of an effective fitness program.

FITNESS PROGRAM DESIGN:
The systematic development of a fitness program or process using assessments, the elements of fitness, periodization, and periodic reassessment.

PERIODIZATION:
An organized approach to training involving progressive cycling of various aspects of a training program during a specific time.

PRINCIPLES OF PROGRAM DESIGN:
Fundamental propositions to serve as the foundation for effective fitness programming.

ACUTE TRAINING VARIABLES:
The components that specify how an exercise or training program is performed.

Fitness program design is defined as the systematic development of a fitness program or process using assessments, the elements of fitness, **periodization**, and periodic reassessment. A fitness program must work through the following elements:

- The warm-up
- Flexibility training
- Core training
- Balance training
- Reactive training
- Resistance training
- Cardiorespiratory training
- The cooldown

However, program design is not as simple as creating workouts for each element and putting them together. The **principles of program design** are fundamental propositions that serve as the foundation for *effective* fitness programming. These principles outline the ways that training adaptations occur along with the variables within a fitness program. Variety and creativity in exercise programming are dictated by these principles as well.

Each of the principles considers the **acute training variables**. In fitness, acute training variables detail *how* an exercise is performed. They are the most fundamental components of designing training programs, and they are essentially what drive the potential adaptations of the body. To understand the principles of fitness, a fitness professional must first understand the acute training variables.

ACUTE VARIABLES OF FITNESS

The acute training variables are modified on the basis of the client's abilities, desired training outcomes, and progress through their training program. They include the following variables:

- Type
- Exercise selection
- Exercise order
- Intensity
- Sets
- Repetitions
- Frequency
- Range of Motion

- Time
- Tempo
- Time under tension
- Rest

Proper manipulation of these variables leads to achieving training goals in an optimal and efficient manner. The possible muscular adaptations that occur due to training are increases in **muscular endurance**, **hypertrophy**, **strength** and **power**.

TYPE

Exercise **type** refers to the techniques, equipment, or methods used to complete an activity. This includes all modalities of exercise—cardio training, resistance training, flexibility, plyometrics, etc. The exercise type describes the equipment used as well—for example, alternating a client between a lying leg press and a back squat for a similar movement pattern performed a different way or using the elliptical trainer for cardiovascular training in one session and a stair mill in another.

Using their knowledge of the training session's location and the equipment available, a trainer will need to appropriately select and vary the type of equipment used for effective and safe energy system training and muscle activation.

EXERCISE SELECTION

Exercise selection refers to the specific exercises executed in a workout session. In many programs, this is one of the most important training variables to adjust to ensure optimal adaptation. For example, in a strength training program, a hip thrust will be more effective for glute muscle activation than a barbell back squat. On the other hand, a barbell back squat is the optimal choice if overall lower-body strength development is the goal. The training goal should dictate exercise selection and how exercises are prioritized in exercise programming.

Exercises that fill time or allow the prime movers to rest are most effective if they do not target the same prime mover—for example, performing a lying leg raise while allowing the arms to rest after a heavy biceps curl.

MUSCULAR ENDURANCE: The ability of a muscle or group of muscles to continuously exert force against resistance over time.

HYPERTROPHY: An increase in muscular size as an adaptation to exercise.

STRENGTH: The amount of force that can be created by a muscle or group of muscles.

POWER: The combination of strength and speed—the ability for a muscle to generate maximal tension as quickly as possible.

TYPE: The techniques, equipment, or methods used to complete an activity.

EXERCISE SELECTION: The specific exercises executed in a workout session.

EXERCISE ORDER

Exercise order refers to the order in which exercises are completed. High-intensity **compound exercises**—multi-joint movements that require multiple muscles or muscle groups such as squats, bench presses, Olympic lifts, box jumps, etc.—are made a priority before completing **accessory exercises**. In other words, it makes sense to do the exercises that require the most effort and control first and save the less intense exercises for the end of a training session.

EXERCISE ORDER: The order in which exercises are completed within a training session.

COMPOUND EXERCISES: Multi-joint exercises that require the use of multiple muscles or muscle groups.

ACCESSORY EXERCISES: Supplementary focused movements or exercises that strengthen synergist and supporting muscles to help a person better perform a primary movement.

Accessory exercises are additional, focused movements that strengthen synergist and supporting muscles to help a person better perform a primary movement. For example, during a workout focused on the pulling muscles of the back, core training and exercises for shoulder stabilization should be completed after the main movements. Done this way, the high-intensity compound exercises can be given the full focus and energy they require at the beginning of the workout. The accessory exercises, which require less energy are done later in the workout. They will help increase core strength and improve the stability of the shoulder during both pushing and pulling movements.

INTENSITY

Intensity is the measurable amount of force or effort given to an activity or exercise. High-intensity is often associated with higher anaerobic energy demand, while lower intensity is associated with aerobic energy demand. Low-intensity activity, such as steady-state cardiovascular training, can elicit aerobic adaptations with longer-duration sessions. High-intensity efforts can be associated with muscular strength and power adaptations. Intensity is often expressed as a percentage of effort compared to the maximum effort—for example, 70 percent of **one-repetition maximum (1RM)** (the maximum **load** that can be moved for one repetition) or 70 percent of maximum heart rate.

INTENSITY: The measurable amount of force or effort given to an activity or exercise often expressed as a percentage of effort compared to a person's maximum effort.

ONE-REPETITION MAX (1RM): A single maximum-strength repetition with maximum load.

LOAD: A term used to describe the amount of resistance used in a strength training exercise.

Load is a term used specifically to describe the amount of resistance used (intensity) in a strength training exercise. During strength training, the type and amount of resistance will vary depending on the tool used. This resistance can come from free weights, bands, cables, machines, and body weight. Load is correlated to muscle fiber recruitment; in other words, the greater the load, the greater the amount of muscle fiber recruitment necessary to move the load.

A common misinterpretation of this terminology is that "high-intensity" means difficult and "low-intensity" means easy. This is not necessarily the case. High intensity means a high amount of force or effort. A single maximum high jump would be defined as a high-intensity effort. On the other hand, power walking is generally considered a low-intensity effort, even though power walking for an hour may be a challenging workout. This means that a single maximum high jump is the more intense activity, but power walking may, in fact, be the more challenging workout overall.

Table 9.1 Resistance Training Intensity Protocol By Training Goal

TRAINING GOAL	INTENSITY (% 1RM)
Muscular endurance	67 percent or less
Hypertrophy	67 – 85 percent
Maximum strength	85% or greater
Power Single-repetition event Multiple-repetition event	80 – 90 percent 75 – 85 percent

SETS

A **set** is the number of times an exercise or group of exercises (superset) is completed. The number of sets executed in a training session will be adjusted based on the client's training goals. Each training outcome has an ideal range of sets for each exercise to promote the desired adaptation. The number of sets will also depend on the number of repetitions and relate closely to the workout time and, in many cases, intensity.

SET:
The number of times an exercise or group of exercises is completed.

Table 9.2 Sets Protocol By Training Goal

TRAINING GOAL	SETS
Muscular endurance	1–3 sets
Hypertrophy	3–4 sets
Maximum strength	3–5 sets
Power	3-5 sets

REPETITIONS

The term **repetitions (reps)** describes the number of times an exercise is completed within a set. Each repetition contributes to muscle fatigue, muscle damage, and the physiological response during recovery. They can be varied within a training program to induce or avoid

REPETITIONS (REPS):
The number of times an exercise is completed within a set.

INTRASET MUSCLE FATIGUE:
Muscle fatigue that occurs within a single set of an exercise.

intraset muscle fatigue. Intraset muscle fatigue is the fatigue that occurs within a single set of an exercise—for example, one training day limits repetitions to 10, but during another training session, the repetitions continue until maximum fatigue is achieved with the same load.

Table 9.3 Repetition Protocol By Training Goal

TRAINING GOAL	REPETITIONS
Muscular endurance	15 or more repetitions
Hypertrophy	6 – 12 repetitions
Maximum strength	1 – 6 repetitions
Power	1 – 5 repetitions

FREQUENCY

EXERCISE FREQUENCY:
The number of times training occurs within a specific period, or the number of times or how often an exercise is executed.

Exercise frequency describes the number of times training occurs within a specific period. Frequency can also apply to the number of times or how often a specific exercise is performed. This variable is linked to the desired training outcome. For example, those looking for improved cardiovascular endurance (distance runners or swimmers) may increase the frequency of training sessions each week to force this adaptation. The increase in frequency will, in turn, increase the time spent performing an activity (assuming other variables remain constant), which drives endurance. Those looking to add to the total weekly volume in their weight training routine may move from a weekly training frequency of three days per week to four days per week.

Other reasons for adding frequency to a workout or specific exercise could be when the goal is improving skill, increasing or maintaining flexibility, or simply increasing total daily activity. Examples include the following:

- Daily body weight squats to improve the skill of performing the movement with good form
- A daily flexibility routine to counteract sitting at a desk all day
- Adding morning and evening walks to add to total daily activity

RANGE OF MOTION

RANGE OF MOTION (ROM):
The measurement of movement around a specific joint or body part.

Range of motion (ROM) is the amount of movement in a joint measured in degrees. In an exercise, particularly those in which multiple joints are moving, the range of motion will be the total movement of all primary joints involved, which adds up to the total distance the joint travels in a single repetition of the exercise. For a fitness professional, it is imperative to help clients understand that the proper ROM or the proper form for an exercise can be specific to the individual. In other words, proper ROM means the distance that a person can move through an exercise with coordination and timing and without pain.

Partial repetitions are an example of adjusting the range of motion in an exercise. Partial reps are repetitions of an exercise intentionally done with a reduced ROM. There are a few reasons partial reps may be used, including:

- working around a part of the ROM that is dysfunctional or uncomfortable,
- maximizing overload of a particular muscle within a movement, and
- prioritizing the weakest points in a range of motion to strengthen the movement as a whole.

PARTIAL REPETITIONS:
Repetitions of an exercise intentionally done with a reduced range of motion.

TIME

The **time** is the duration of an activity or training session. The overall duration of an exercise bout is, again, tied to the desired training outcome. Endurance typically requires the use of the aerobic energy system with longer sessions; resistance training sets and sessions may not take as long in total to be effective. In many cases, resistance training is based on the time *necessary* to complete the selected exercise prescription, while endurance and aerobic training are based on *increasing* the time spent doing aerobic activity to make the aerobic energy system more efficient.

TIME:
The duration of an activity or training session.

TEST TIP!

Acute variable mnemonics: how to remember the acute training variables.

FITT Principle—applies most often to cardiovascular training

F – Frequency: number of times a cardiovascular exercise is performed (per week)

I – Intensity: the amount of effort expended during the activity (level, speed, incline)

T – Type: the type of cardiovascular exercise completed (bike, treadmill, stair mill)

T – Time: the duration of the activity

The Five Rs—applies most often to resistance training

R – Repetitions: the number of times the range of motion is completed consecutively

R – Rest: the time spent resting between repetitions or between sets

R – Recovery: the time spent recovering between exercise sessions

R – Resistance: the load (weight) used for an exercise

R – Range of motion: the total amount of joint movement used during an exercise

TEMPO:
The speed at which an exercise or movement pattern is completed.

TEMPO

The **tempo** is the speed at which an exercise or movement pattern is executed. This includes the time spent on the eccentric, isometric, and concentric muscle actions. Slower tempos will increase the time spent per repetition and, thus, per set.

As with all other acute training variables, the tempo of an exercise should be aligned with the training goal. Slower tempos can be used for practicing exercise technique or for creating programming that increases the total time in each set. Faster tempos allow for training fast, explosive muscular contractions.

Tempo is written as

eccentric count : isometric hold count : concentric count : isometric hold count

For example, completing a biceps curl with a tempo of three-count eccentric (lowering), no isometric hold, one-count concentric (lift or contract), and no isometric hold would read as 3:0:1:0.

Table 9.4 Tempo Protocol By Training Goal

TRAINING GOAL	TEMPO
Muscular endurance	4:0:6:0
Hypertrophy	3:1:3:1
Maximum strength	3:0:1:0
Power	Fastest controllable tempo

Another consideration regarding tempo is the time it takes a client to learn new movements. To successfully learn a new movement or exercise, the client should start by using slow tempos. This will help the participant gain competence and confidence in their ability to perform the movement safely and effectively.

TIME UNDER TENSION (TUT):
The amount of time a muscle is engaged as a set, completed from start to finish.

TIME UNDER TENSION

Time under tension (TUT) is directly related to tempo. It refers to the amount of time a muscle is engaged, or under tension, in a set. The main takeaway for time under tension is that increasing TUT will also increase training volume and time. The table below shows the effect of tempo on TUT for a set and an entire training session.

Table 9.5 Time-Relate Training Variables Compared to Number of Repetitions

NUMBER OF REPETITIONS	TEMPO	TUT FOR THE SET (IN SECONDS)	NUMBER OF SETS	EXERCISE VOLUME (NO. OF REPS) IN TRAINING SESSION	TUT FOR ENTIRE TRAINING SESSION (IN SECONDS)
8	2:0:2:0	32	5	40	160
4	5:0:5:0	40	5	20	200
3	10:0:10:0	60	5	15	300

Adapted from M. Wilk, A. Golas, P. Stastny, M. Nawrocka, M. Krzysztofik, and A. Zajac, "Does Tempo of Resistance Exercise Impact Training Volume?" Journal of Human Kinetics 62, no. 1 (June 13, 2018): 241–50, https://doi.org/10.2478/hukin-2018-0034.

REST

Rest is the amount of time spent in recovery between sets. When considering the time between training sessions, rest is also referred to as **recovery time**. The rest periods are important not only for cardiovascular recovery but also for metabolic (energy system) recovery. The intensity of the set of an exercise performed will determine which energy system is dominant and, therefore, the amount of rest that is needed between sets. Additionally, to drive specific adaptations (e.g., strength or endurance), rest between sets must be taken into account and monitored to ensure the desired result.

REST: The amount of time spent in recovery between sets or repetitions.

RECOVERY TIME: The rest time allowed between training sessions.

The need for recovery also applies between training sessions. As the intensity and volume of training sessions increases, the time needed to optimize recovery between sessions will also increase. Methods of recovery will include restful sleep, sound nutrition, and low-intensity movement or **active recovery** practices that will promote blood flow and flexibility. Active recovery is low-intensity exercise or activity that can promote and accelerate muscular and metabolic recovery. It is generally more beneficial for promoting and accelerating recovery from higher-intensity activities.

ACTIVE RECOVERY: Low-intensity exercise or activity that can promote and accelerate muscular and metabolic recovery.

Each variable can change based on the ability of the exerciser, the stage of training, and the goals of training. The variables may also affect each other as they are modified. For example, the number of sets or repetitions can vary within a workout. Generally, as the number of sets decreases, the number of individual exercises in a workout will increase. In the same manner, as the number of repetitions increases, the load used will likely decrease. As load decreases, the exerciser may increase the tempo of the exercise along with their perceived intensity throughout a set. As the intensity increases, the rest needed will increase or decrease depending on the phase of training the exerciser is in and the desired adaptation. Those seeking the adaptation of endurance may shorten rest periods, while those seeking power may increase the rest period.

Table 9.6 Rest Protocol By Training Goal

TRAINING GOAL	REST BETWEEN SETS
Muscular endurance	30 – 60 seconds
Hypertrophy	30 – 60 seconds
Maximum strength	2 – 5 minutes
Power	1 – 2 minutes

TEST TIP!

There are five variables to focus on for most clients: sets, reps, intensity, tempo, and rest.

Sets are variable based on the training goal. Beginners will only need one to two sets per exercise. As the body adapts, the number of sets can increase.

Repetitions play a large role in muscle adaptation. The phase of training will determine the ideal rep counts, such as 2–12 reps for hypertrophy or 15–25 reps for endurance.

The intensity of an activity or exercise is also based on the training phase and goals. Strength training should maintain an intensity of no more than 20 percent more than the exerciser's 1RM to achieve the desired training outcomes. Resistance training has an inverse relationship between reps and intensity—as the reps decrease, the intensity increases.

Tempo is especially important when working with athletes but should not be overlooked with the general population. It is written as "eccentric : isometric : concentric : isometric," or "lowering : pause : lifting : pause." For example, a squat may be performed at a 3:1:3:1. TUT for each repetition of the squat described is eight seconds; therefore, a set of 10 squats performed at this tempo would have a TUT of 80 seconds. Slower tempos produce higher TUT and are typically associated with physiological adaptations such as muscular endurance and hypertrophy, whereas quicker tempos produce lower TUT and are typically associated with maximal force production.

Finally, rest is necessary to avoid injury and promote optimal performance. The intensity or resistance used will determine the rest needed. For loads less than 60 percent of maximum, 45 seconds to two minutes is recommended. Activities of 90 percent or more of maximum can require three to five minutes of rest.

THE PRINCIPLES OF FITNESS

The principles of fitness outline the ways that training adaptations occur as well as the variables within a fitness program. These science-based principles should be the basis for the programming decisions a trainer makes when creating fitness programs and selecting exercises and acute variables for each individual client.

PRINCIPLE OF SPECIFICITY

The **principle of specificity** states that training must be specific to one's goals, as the adaptations they will see will be based on the type of training completed. All clients should begin with training that is right for their current fitness level. As fitness develops, they may progress to advanced exercises or exercise techniques. For example, a client training for a marathon must incorporate running into their training program, and, ideally, running is the main component of the program. Complementary exercises would then balance the program and help prevent overtraining.

PRINCIPLE OF SPECIFICITY:
The concept that training must be specific to an individual's goals, as the adaptations they will see will be based on the training completed.

An individual training for an obstacle course event must train for the specific requirements of that race—grip strength, muscular endurance, mental toughness, and proprioception are examples of these requirements.

Figure 9.1 Soccer Skill Training versus Soccer Gameplay

SAID PRINCIPLE

SAID PRINCIPLE:
Specific adaptations to imposed demands—stress on the human system, whether biomechanical or neurological, will require the body to adapt specifically to those demands.

The **SAID Principle** reinforces the principle of specificity. SAID is an acronym that stands for specific adaptations to imposed demands. The body adapts specifically to the stress placed upon it, and each sport or activity has its unique mix of physical requirements. Performance is dependent upon the body adapting to those specific demands and becoming stronger, faster, leaner, or more powerful. The specificity of training will be metabolic, muscle fiber–specific, mechanical, or neuromuscular. This means if someone is working to improve their aerobic capacity for endurance, their training should focus on type I muscle fibers and the aerobic energy system.

For example, training for a 200-meter dash is much different from training for a 10K or endurance event. A sprinter may vary resistance to gain speed by running up hills or stadium stairs to train type II muscle fibers, anaerobic muscular capacity, and the cardiovascular system for fast oxygen uptake and transport. An endurance athlete will vary the duration of their workouts to improve muscular endurance and aerobic cardiovascular capacity.

Table 9.7 Specific Adaptations to Physical Demands

SPECIFIC ADAPTATIONS TO ANAEROBIC AND AEROBIC EXERCISE	ANAEROBIC TRAINING (HIGH POWER OUTPUT)	AEROBIC TRAINING (LOW POWER OUTPUT)
Performance		
Muscle endurance	Increases	Increases
Muscle strength	Increases	No change
Vertical jump	Increases	No change
Aerobic power	No/slight increase	Increases
Sprint speed	Increases	No/slight increase
Anaerobic power	Increases	No change
Body composition		
Fat-free mass	Increases	No change
Percent bodyfat	Decreases	Decreases
Muscle fiber		
Capillary density	No change or decreases	Increases
Fiber size	Increases	No change or slight increase
Fast heavy chain myosin	Increases	No change or decreases
Type II muscle fiber conversion	Almost all convert	Most convert

Table 9.7 Specific Adaptations to Physical Demands (CONT)

SPECIFIC ADAPTATIONS TO ANAEROBIC AND AEROBIC EXERCISE	ANAEROBIC TRAINING (HIGH POWER OUTPUT)	AEROBIC TRAINING (LOW POWER OUTPUT)
Mitochondrial density	Decreases	Increases
Bone and connective tissue		
Bone density	No change or increases	No change or increases
Collagen content	May increase	Varies
Ligament strength	Increases	Increases
Tendon strength	Increases	Increases
Metabolic energy stores		
Stored creatine phosphate	Increases	Increases
Stored adenosine triphosphate	Increases	Increases
Stored triglycerides	Increases	Increases
Stored glycogen	Increases	Increases
Enzyme activity		
Myokinase	Increases	Increases
Creatine phosphokinase	Increases	Increases
Lactate dehydrogenase	No change or varies	Varies
Phosphofructokinase	No change or varies	Varies

PRINCIPLE OF VARIABILITY

Another principle is the **principle of variability**. Training programs must include variations in intensity, duration, volume, and other aspects of practice. The acute variables of a fitness program must be changed to prevent plateaus, overuse injuries, boredom, and burnout. Also, modifying the variables changes the mode of exercise and the results realized. It is important to consider the following research:

Seventeen young male participants followed either a hypertrophy training program or a strength training program.

PRINCIPLE OF VARIABILITY:
Training programs must include variations in intensity, duration, volume, and other aspects of practice.

Hypertrophy program: three sets of 10 repetitions at 10RM (max weight that can be lifted 10 times) with a 90-second rest

Strength program: seven sets of 3 repetitions at 3RM (max weight that can be lifted 3 times) and three minutes of rest between sets

At the end of the eight-week study, there was no difference in muscle thickness between the two groups. However, the strength training group significantly increased 1RM in bench press and squat.

Although both types of training—hypertrophy and strength—produced similar results in muscle thickness, only strength training increased muscular strength. The specific training protocol used was more effective than a general program for improving maximal strength.

PRINCIPLE OF INDIVIDUAL DIFFERENCES OR DIMINISHING RETURNS

Everyone is different. Individuals within the same family—even twins—have a different genetic blueprint, cellular proteins, and gene expressions. Genetics influences everything from body size and shape, chronic health conditions, muscle fiber type, recovery time, and propensity for injury. And genes at least partially determine the degree to which a client will see results and how quickly a client will see results from their program. The **principle of individual differences** states that there is no one specific way to train every individual.

PRINCIPLE OF INDIVIDUAL DIFFERENCES:
The concept that there is no one specific way to train every client due to the uniqueness of each person.

In the early '80s, researchers assessed a collegiate swim team throughout an intense 75-day training program. They measured four physiological parameters and found that even though each person followed the same training protocols, results varied. For example, during the peaking program, different physiological and performance profiles were noted among the athletes.

This research emphasizes the need for trainers to seriously consider individual differences. The goal should always be to help clients reach their goals in the safest, most timely manner. In addition to the genetic differences between individuals, the fitness professional must consider lifestyle differences. These include dietary and training preferences, previous and current medical conditions, sex, motivation, and past experiences.

DIMINISHING RETURNS:
A concept stating that everyone has a set genetic limit to their potential, and, eventually, the effort put into training will no longer produce the same results.

Finally, the concept of **diminishing returns** suggests that clients will eventually hit a ceiling in their fitness performance. This theory states that everyone has a set genetic limit to their potential. Eventually, the effort put into training, which initially lead to a great deal of result, will begin to yield less and less results.

PRINCIPLE OF PROGRESSIVE OVERLOAD

For fitness to progress, the body must be forced to adapt to or overcome a stress greater than what is normally encountered. This is known as the **principle of progressive overload**. Put simply, to increase biceps strength, a client must lift a resistance greater than one they are unaccustomed to for an adaptation to occur.

PRINCIPLE OF PROGRESSIVE OVERLOAD:
The body must be forced to adapt to or overcome a stress greater than what is normally encountered.

Progressive overload must be incremental to be effective. This applies not only to resistance training but also to various exercise methods and variables:

- Range of motion: progress is made by lifting the same load with a slightly increased degree of range of motion in the joints involved—for example, squatting a few inches lower than before.
- **Training volume**: altering training volume allows a person to lift the same load for more repetitions or perform more sets with the same load and number of repetitions.
- Intensity: increasing intensity means increasing the load or lifting the same load with greater speed and acceleration.
- **Training density**: training density is the amount of work done in a specified amount of time. Rest times can be manipulated so that more work is done in the same amount of time or so that the same amount of work is completed in less time. For instance, a fitness professional can prescribe a circuit of five exercises to be completed as many times as possible within a 30-minute window. This is also known as "as many reps as possible," or AMRAP.
- Frequency: increasing frequency means doing the same amount of work more often during a given period of time (e.g., a week).

TRAINING VOLUME:
The total amount of work performed, typically measured as Sets x Reps x Load (or intensity).

TRAINING DENSITY:
A combination of volume and time equaling the total volume of work in a specific amount of time.

PRINCIPLE OF REVERSIBILITY

Put simply, the **principle of reversibility** means "use it or lose it." A sedentary client will see significant gains within the first few weeks of training due to neuromuscular facilitation. After a few more weeks, observable changes occur through physiological and structural adaptations. However, training effects will diminish if clients discontinue physical activity for two weeks or more. This is known as **detraining**. But it's important to note that the detraining effects can be reversed when training is resumed.

PRINCIPLE OF REVERSIBILITY:
Clients lose the effects of training after they stop working out.

DETRAINING:
The diminishing of physical adaptations after two weeks or more of not training.

GENERAL ADAPTATION SYNDROME (GAS): The three stages of adaptation the body goes through in response to stress—alarm, resistance, and exhaustion.

SUPERCOMPENSATION: The post-training period during which the trained function/parameter has a higher performance capacity than it did before the training period.

GENERAL ADAPTATION SYNDROME

The **general adaptation syndrome (GAS)**, first discussed in the 1930s, states that the body goes through three stages of adaptation in response to stress. This idea is the reason periodization is used in training. If a training stimulus is intense enough, fitness will *decrease* for a brief time. However, the body then goes through a period of **supercompensation**, where the trained function has a higher performance capacity than the baseline.

The three stages of stress adaptation are the alarm stage, resistance, and exhaustion.

Alarm Stage

The alarm stage is the body's initial response to stress. Symptoms include fatigue, weakness, or soreness. Individuals will see gains in strength but mostly through neuromuscular changes. This stage may last from two to three weeks.

Resistance Stage

After continued exercise, the body will enter the resistance stage around four to six weeks. At this point, changes in the body include biochemical, mechanical, and structural. Clients may experience improvements in muscle size and strength.

Exhaustion Stage

The exhaustion stage may happen at any time in GAS. Symptoms in this stage mimic those of the alarm stage, but without adequate rest or recovery, the client may experience burnout, overtraining, injury, or illness.

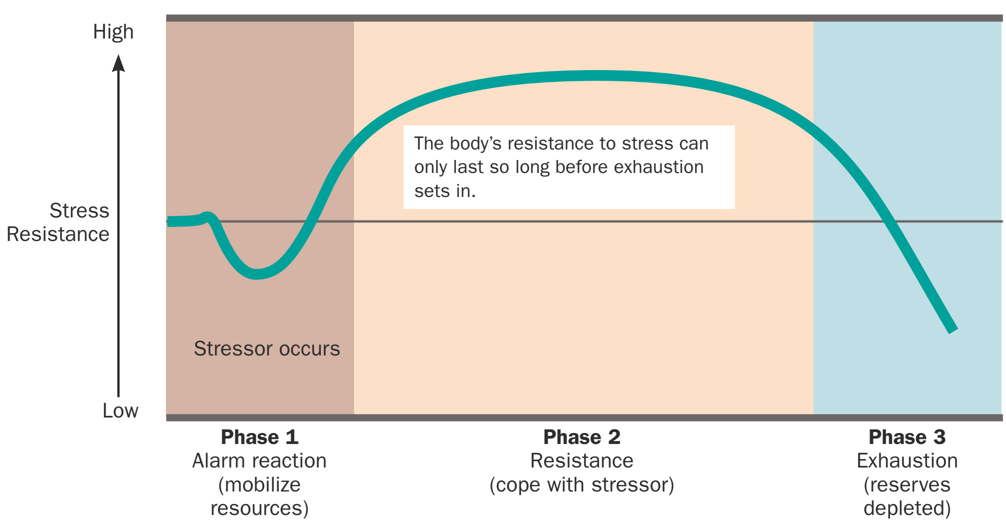


Figure 9.2 General Adaptation Syndrome Stages

An extension of the GAS is the **stimulus-fatigue-recovery-adaptation principle**. Training stimuli produce a general response based upon the level of intensity of the training stressor. The greater the workload, the more fatigue accumulates and the longer it takes for the body to completely recover and adapt. As the individual recovers from and adapts to the stimuli, fatigue dissipates, and preparedness and performance increase. The more the individual is exposed to a stimulus with proper recovery, the better the body will adapt.

STIMULUS-FATIGUE-RECOVERY-ADAPTATION PRINCIPLE: The concept that training response is based on the stimulus intensity, and the greater the stimulus intensity is, the longer the recovery needed to produce the adaptations will be.

Studies have shown that although recovery is an important part of the training equation, it is not always necessary to reach a state of full recovery before engaging in another workout session. The training schedule can take advantage of recovery timing to accelerate or enhance training adaptations.

PERIODIZATION

To periodize a training program means to break it into different phases, each of which is designed to elicit specific physiological adaptations. The primary goals of periodization are as follows:

- Manage fatigue and reduce the possibility of overtraining
- Improve readiness for competition or sports season
- Help set and manage short-term and long-term goals

There are several methods of organization used by fitness professionals. Linear, reverse linear, undulating, block, and conjugated periodization are the current types discussed in the fitness industry. Each method divides the overall program into three periods: macrocycle, mesocycle, and microcycle.

A **training macrocycle** is typically one to four years long. Although, a macrocycle may be a shorter period. For example, many popular training packages last 12 weeks. This represents a training program as a whole.

A **training mesocycle** lasts from three to nine weeks while the **training microcycle** is the shortest training cycle. It can be a single training session or, typically, a single week. The method used to organize these training cycles will vary based on the individual and their training goals.

TRAINING MACROCYCLE: The overall training period, usually one year or more.

TRAINING MESOCYCLE: A training phase in the annual training plan made up of three to nine microcycles.

TRAINING MICROCYCLE: A one-week-long cycle of training sessions, or a single session.

Table 9.8 Training Cycles

JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Macrocycle											
Mesocycle			Mesocycle				Mesocycle		Mesocycle		
13 microcycles			18 microcycles				8 microcycles		13 microcycles		

LINEAR PERIODIZATION

LINEAR PERIODIZATION: Progresses from low-intensity to high-intensity across the entire macrocycle.

Linear periodization progresses from low-intensity to high-intensity across the entire macrocycle, generally progressing from high repetitions of lighter resistance to low repetitions of higher resistance. Linear periodization is also known as traditional periodization. As time progresses, training volume decreases while intensity increases, and exercise selection *remains constant*.

In this model, eventually the client will reach 100 percent of their maximum strength. When this happens, the individual will only perform one maximal lift per set or a 1RM. Linear periodization is more effective when used over a mesocycle.

Table 9.9 Example of Linear Periodization

	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5
Repetitions	10	8	6	5	2
Percentage of 1RM	65 percent	70 percent	75 percent	80 percent	85 percent

UNDULATING PERIODIZATION

UNDULATING PERIODIZATION: Short durations of hypertrophy training alternated with short durations of strength and power training.

Undulating periodization follows an alternating pattern. Training volume and intensity roll through a program and may change either daily or weekly. This method was developed to prevent the neural fatigue experienced when training at a high intensity.

Daily Undulating Periodization

Volume and intensity change from day to day during the microcycle.

Table 9.10 Example of Daily Undulating Periodization

DAY 1	DAY 2	DAY 3	DAY 4
70 percent 10IRM	80 percent 10IRM	75 percent 10IRM	85 percent 10IRM

Weekly Undulating Periodization

Volume and intensity vary from week to week. Mesocycles last about 14 days, and three or four different workouts are staggered throughout. One week, for example, intensity is high, and volume is low. The next week, volume is high, and intensity is low.

Table 9.11 Example of Weekly Undulating Periodization

	WEEK 1	WEEK 2	WEEK 3	WEEK 4
Intensity	High	Low	High	Low
Volume	Low	High	Low	High

Following a strict undulating model, volume and intensity remain within a set range, and exercises are consistent. The variables of resistance, sets, and repetitions change throughout.

BLOCK PERIODIZATION

During a block-periodized program, each mesocycle has a specific purpose. In many cases, training progresses through the following training categories:

- Foundational training: elements of flexibility, mobility, core, and balance training
- Strength training: resistance training that includes both body weight and loaded activity
- Metabolic training: aerobic and anaerobic energy system training including cardiovascular exercise and intervals
- **Speed, Agility, and Quickness (SAQ) training**: elements of agility and plyometric training

All periodized training should build from one cycle to the next, which is known as **phase potentiation**. **Block periodization** offers a general format for progression. However, not all clients will progress to later phases such as power or plyometrics.

SPEED, AGILITY, AND QUICKNESS (SAQ) TRAINING: The training category including reactive, ballistic, plyometric, and agility training.

PHASE POTENTIATION: The strategic sequencing of programming categories to increase the potential of later training and increase long-term adaptive potential.

BLOCK PERIODIZATION: Highly concentrated, specialized workloads focused on achieving maximum adaptation.

PROGRAMMING WITH PERIODIZATION

Periodized programs are designed to systematically develop fitness. Each cycle should build a level of fitness necessary to complete the next cycle so the program may progress. Training progressions typically progress as follows:

- Stable ▶ unstable
- Static ▶ dynamic
- Unloaded ▶ loaded
- Slow ▶ fast
- Simple ▶ complex

MOBILITY: The ability of a joint to move freely through a given range of motion.

Stability is a major concept of biomechanics. It should always be a focus before **mobility** as it can help a client improve skeletal misalignments, muscular imbalances, and ideal movement patterns. Hence the importance of the assessment process with a focus on identifying movement and muscular dysfunctions.

OVERREACHING AND OVERTRAINING

OVERREACHING: An accumulation of training or non-training stress resulting in a short-term decrease in performance capacity.

OVERTRAINING: An accumulation of training or non-training stress resulting in a long-term decrease in performance capacity.

OVERTRAINING SYNDROME (OTS): A maladapted response to excessive exercise without adequate rest, resulting in perturbations of multiple body systems (neural, endocrine, and immune) coupled with mood changes.

Without adequate rest and recovery, clients may suffer from **overreaching**, **overtraining**, or, rarely, **overtraining syndrome (OTS)**. Overreaching is a cumulative training effect in which stressors cause a short-term decrease in performance capacity. Overtraining takes this one step further, with a long-term decrease in performance capacity because of stress. Overtraining syndrome is a systemic response to excessive stress.

Many clients, especially deconditioned clients, may experience some of the following symptoms as part of developing fitness. However, fitness follows fatigue, which drives adaptation. When symptoms are chronic or long-lasting, then overtraining may be occurring.

For well-conditioned clients, very intense training may cause severe fatigue. However, periodizing the program means planning for these intense cycles and then for rest and recovery to prevent overtraining.

OVERTRAINING SIGNS AND SYMPTOMS

There are two forms of overtraining. One affects the sympathetic nervous system and the other the parasympathetic nervous system. Each client is different, but if a client experiences any one or more of the following signs and symptoms, it may mean that it is time to cut back on training. Symptoms of overtraining may include

- physical performance decline even as training continues;
- change in appetite;
- weight loss;
- sleep disturbances;
- elevated resting heart rate;
- elevated resting body temperature;
- muscle cramps;
- irritability, restlessness, excitability, anxiousness;
- loss of motivation and vigor in training;
- lack of mental concentration and focus; and
- lack of appreciation for normally enjoyable things.

CAUSES OF OVERTRAINING

Scientists have not yet determined the cause of overtraining syndrome. However, there are several theories, some of which include the following causes or contributing factors:

- **Low glycogen**: low stores of glycogen cause fatigue and a decline in performance.
- **Cumulative microtrauma**: repeated stress on muscles, bones, tendons, and nerves causes cellular damage that can get worse over time.
- **Decreased glutamine**: immune dysfunction increases sensitivity to infection, which could be caused by decreased glutamine**.**
- **Oxidative stress**: when the body is unable to fight free radicals caused by exercise, muscle damage and fatigue result.
- **Autonomic nervous system stress** symptoms of OTS often occur when the parasympathetic nervous system works overtime.
- **Hypothalamic causes**: symptoms of overtraining syndrome may result if the hypothalamus or hormonal axes are not working properly.
- **Cytokine release**: inflammation and cytokine release can cause many symptoms of OTS.

TEST TIP!

Avoiding overtraining

Following a periodized training program does not guarantee the avoidance of overtraining, but it is a start. Here are additional tips to avoid overtraining:

Use a training journal.

Heart rate, oxygen uptake, and blood lactate levels are the best predictors of overtraining. Record sets, repetitions, exercises, rest between sets, and heart rate during exercise. Record the client's perceived exertion, sleep quality, and nutritional habits. If performance declines or the client feels overly taxed, it will be easier to determine the possible cause.

Vary training methods.

Following a periodized plan reduces the risk of overtraining. Programs should be periodized and progressive to yield the best results.

Apply preferred therapies.

There are many therapies available to reduce muscle soreness and ease discomfort. It is best to find cost-effective therapies that provide relief quickly.

Get enough sleep.

Sleep is a critical part of recovery. Both quality and quantity matter. Many researchers believe deep sleep is the most restorative phase of sleep. During deep sleep, muscles relax, blood supply to muscles increases, growth hormone is released, and tissues are repaired.

Avoid or minimize other stressors.

It may not be possible for all clients to avoid or neglect stress outside of the exercise session. However, the body reacts to all stress in a similar fashion. Therefore, minimizing environmental, social, biochemical, and other stress is recommended to avoid overtraining.

Increase resilience.

Techniques such as meditation, mindfulness, visualization, and hypnotherapy may help reduce stress. They can also help improve mindset and mental toughness. Because a major factor in training is the "mental game," the mind must also be part of the recovery process.

TRAINING CATEGORIES AND THE ELEMENTS OF A FITNESS PROGRAM

The progressions of a training protocol provide a flexible outline a trainer can use to create client workout programs. Whether within a single workout or over the course of a few weeks, the elements of fitness can be divided into four training categories:

- Foundational training
- Strength training
- Metabolic training
- Speed, agility, and quickness training

FOUNDATIONAL TRAINING

FOUNDATIONAL TRAINING: The basic training elements of flexibility, balance, and core training.

Foundational training encompasses the elements of flexibility, mobility, core, and balance training. These are foundational concepts that serve to prepare the body for movement. These elements are also ideal parts of a dynamic warm-up and are easy to incorporate into every training session, regardless of how developed a training program has become. The difficulty or intensity of the elements will likely progress as the client's program advances—

for example, starting with a basic forearm plank for 30 seconds as part of core training. With each new workout, the trainer can increase the acute variable of time spent in the plank. When the desired maximum time is achieved, the type of plank can be altered to make it more challenging.

Table 9.12 Example of Foundational Training Progression

TRAINING SESSION	WEEK 1: DAY 1	WEEK 1: DAY 2	WEEK 1: DAY 3	WEEK 2: DAY 1	WEEK 2: DAY 2	WEEK 2: DAY 3
Type of plank	Forearm plank	Forearm plank	Forearm plank	Forearm plank with alternating leg lift	Forearm plank with alternating leg lift	Forearm plank with alternating leg lift
Duration of plank hold	30 sec	45 sec	60 sec	30 sec	45 sec	60 sec

STRENGTH TRAINING

Strength training is a category that includes resistance training. Resistance can include body weight as well as tools such as dumbbells, kettlebells, barbells, and resistance bands to build strength, increase muscle mass, and improve muscular endurance.

STRENGTH TRAINING: The category of training that includes resistance training for increased muscle mass and improved strength and muscular endurance.

Following the principle of progression, a trainer may have an unconditioned client begin resistance training with simple body weight exercises. This creates the opportunity to correct improper movement patterns and begin to improve neuromuscular efficiencies before adding load. Next, resistance bands can be added, then weights in the form of dumbbells, barbells, etc. Again, this progression of load can happen within a microcycle (single workout) or over a mesocycle based on the client's abilities and goals.

For example, a progressing load within a training session might look like this:

traditional push up >> standing resistance band chest press >> barbell bench press

The training variables of tempo, repetitions, volume, rest, and time under tension (TUT) are of great focus during resistance training. Using the desired adaptation, hundreds of variable combinations can be made. The tempo of resistance exercise affects the volume and TUT most closely.

Table 9.13 Resistance Training and Acute Variables

TRAINING GOAL	TEMPO (EXAMPLE)	REPETITIONS	VOLUME	REST	TIME UNDER TENSION
Strength	2:0:2:0	1–5	3–5 sets	1–3 minutes	<20 seconds
Muscular endurance	6:0:4:0	13+	1–3 sets	1–2 minutes	>70 seconds
Hypertrophy	3:1:3:1	6–12	3–4 sets	1–3 minutes	~40 seconds

METABOLIC TRAINING

METABOLIC TRAINING:
A style of training that typically uses high-intensity intervals to train both the aerobic and anaerobic energy systems.

Metabolic training is geared toward the training of both the aerobic and anaerobic energy systems. The technical definition of metabolic training is any exercise that helps to improve the performance of the energy systems. This category typically uses high-intensity intervals to train both the aerobic and anaerobic energy systems. The exercise choices can be traditional cardiorespiratory exercises, such as using a treadmill or elliptical, or compound resistance training movements. These would be done with a relatively fast tempo and little to no rest. The total volume would depend on the goal and fitness level of the individual.

This style of training addresses conditioning of all three energy systems, is a good choice for maximizing calorie burn, and trains the body to perform dynamic movements. Many of these dynamic movements would be power exercises and being plyometric in nature, would fall into the category of SAQ.

Table 9.14 Energy Systems and Metabolic Training

ENERGY SYSTEM	WHEN IT DOMINATES	TRAINING EXAMPLE
ATP/CP	0-10 seconds	40-yard full sprint
Glycolytic	10-120 seconds	Single kettlebell circuit (15 swings, 8 snatches each arm, 10 goblet squat jumps)
Aerobic	2 minutes +	20-minute elliptical session

SPEED, AGILITY, AND QUICKNESS (SAQ) TRAINING

SAQ training is a category that not all clients will work through, or they may only use certain parts of it. For example, agility training is a functional aspect of any training program to improve balance and prevent falls and injury. However, jump training or **ballistic training** for explosive power may not be within the goals of every client.

BALLISTIC TRAINING: A form of power training involving throwing weights or jumping with weights to improve explosive power.

The speed at which the elements of SAQ training must occur to be effective will increase the heart rate, elicit higher calorie burn, and challenge the metabolic systems on the basis of duration. Therefore, these elements can be used for metabolic training and high-intensity intervals. However, they do require a strength and mobility foundation before they can be implemented.

Example exercises that can be used with both the general population and athletes include ball slams, squat jumps, ladder drills, and explosive push-ups.

When used for athletic performance, SAQ training should follow the principle of specificity and relate to the movements of the athlete’s sport. Keeping exercise selection specific and applicable will guarantee skill advancement with the appropriate manipulation of training variables.

Table 9.15 Acute Training Variable for Power Training

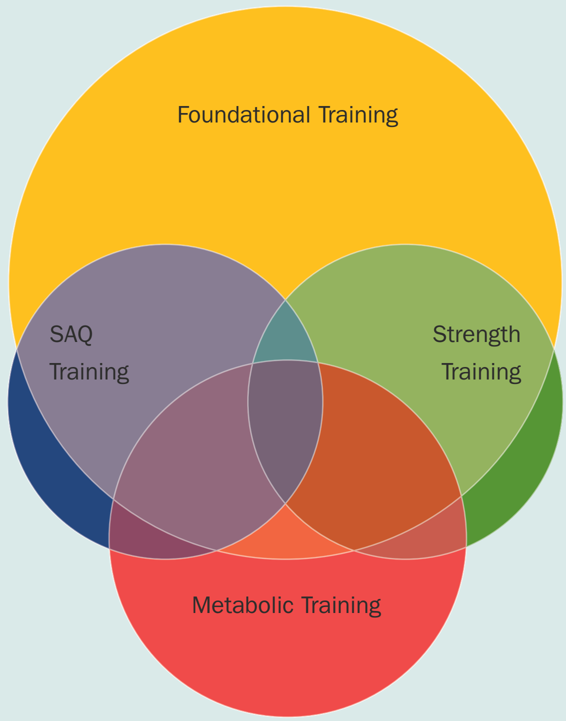
TRAINING GOAL	TEMPO (EXAMPLE)	REPETITIONS	VOLUME	REST
Power	Fastest controllable tempo	1–5	3–5 sets	1-2 minutes

Table 9.16 Training Categories and Elements

TRAINING CATEGORY	FITNESS PROGRAM ELEMENT(S) AND TYPES
Foundational training	**Flexibility training** **Core training** **Balance training**
Strength training	**Resistance training**
Metabolic training	High-intensity interval training (HIIT) **Cardiorespiratory training**
Speed, agility, and quickness training	Reactive training Ballistic training Plyometric training Agility training

**Bolded program elements are usually part of most fitness programs, regardless of training goal.*

TEST TIP!



The training categories each hold unique elements of fitness. However, based on the needs and goals of a client, the order and time spent in each category will vary. A personal trainer will use training cycles to establish a timeline for a client to reach their goal or milestone. Then, within those training cycles, the trainer can distribute the categories and elements to best elicit the desired adaptations.

A trainer should always consider the important principles of program design, such as specificity, overload, and progression to ensure safe, effective training advancement.

CHAPTER 10

CONCEPTS OF FLEXIBILITY TRAINING

LEARNING OBJECTIVES

1 | Describe the benefits of flexibility training.

2 | Identify and explain the acute variables for flexibility training.

3 | Explain the difference between static and dynamic stretching and how to use them in an exercise program.

FLEXIBILITY:
The range of motion of a muscle and its associated connective tissues at a joint or joints.

RANGE OF MOTION (ROM):
The measurement of movement around a specific joint or body part.

CONNECTIVE TISSUES:
Tissues that support, connect, or bind other tissues or organs.

Flexibility is defined as the **range of motion (ROM)** of a muscle and its associated **connective tissues** at a joint or joints. It is an element that has great variability based on the involved joint or joints and an individual's physical state. A client who increases their flexibility can improve a joint's ROM—the extent of movement of a joint measured in the 360 degrees of a circle. Increasing flexibility can have a positive impact on many fitness qualities including posture, balance, ROM, and general performance.

Although flexibility has many benefits, having flexible muscles has not been directly linked to a reduced risk of injury. However, many of the named benefits of flexibility have been found to reduce injury risk. In other words, having adequately flexible muscles may not limit injuries by itself, but better balance as a result of adequately flexible muscles can limit falls and therefore injuries. Improved balance, posture, and muscle strength are a few of the benefits associated with optimal flexibility.

Table 10.1 Benefits of Flexibility Training

BENEFIT	DESCRIPTION
Improved ROM	Many additional benefits of flexibility are related to having a greater ROM. Tight muscles reduce the ROM at joints, limiting a person's ability to perform activities of daily living (ADL) such as reaching overhead, standing up straight, or optimal positioning for picking up heavy loads.
Improved posture	Poor posture is often the result of overactive muscles, which can pull joints out of alignment. Muscles with sufficient ROM can reduce imbalance and allow joints to move in a proper ROM to maintain ideal posture.
Improved balance	Joints that move through a full ROM help keep the body balanced during movement. Better balance, especially as people age, helps prevent falls and injuries.
Decreased chronic pain	Tight muscles create pain by putting strain on bones, ligaments, and tendons. Flexible muscles have less tension, thereby reducing pain. Stretching—along with hydration and dietary habits—reduces the occurrence of muscle overactivity and altered length-tension relationships.
Improved muscle strength	Overactive muscles often have a reduced capability to create muscular force due to the altered length-tension relationship of the muscle fibers. Flexibility improves this length-tension relationship, which can increase the muscular strength of the same fibers.

Table 10.1 Benefits of Flexibility Training (CONT)

BENEFIT	DESCRIPTION
Improved performance	Flexible muscles and ideally aligned joints allow the body to move more efficiently. Flexible and optimally strong muscles lead to enhancements in sports performance or ADL performance when the correct training variables are applied.
Improved mood	With reduced pain and tightness, being flexible has been found to improve mood by eliciting feelings of relaxation and comfort.

Genetics plays a significant role in an individual's flexibility, so some clients will be naturally more flexible than others. The structure and shape of the joint have a direct effect on the amount of flexibility in that joint. No matter the starting point, flexibility can be enhanced by committing to a relatively brief stretching routine at least three times a week.

While flexibility is important, so too is strengthening the muscles around the joint to prevent injury. There needs to be adequate strength throughout the joint's ROM, including working antagonist muscles equally. Using light weights and going through the full ROM will promote improved flexibility. As fatigue sets in, ROM decreases because the muscles tighten due to the workload. Therefore, stretching after a workout is essential to maintaining full ROM.

Most people tend to lose flexibility as they age, but that is due, in part, to inactivity. When not in use, the connective tissue in the joints becomes shortened, can stiffen, and can lose elasticity. Regular exercise and dynamic and **static stretching** can help maintain the full ROM and counteract the natural loss of function that comes with age. Past injuries also can affect overall flexibility. Generally, women are considered to be more flexible than men, but anyone can make flexibility improvements.

STATIC STRETCHING: Lengthening a muscle and holding the lengthened position.

For the general population who need to improve or maintain ROM, clients should be advised to stretch daily. If needed, they should allow adequate recovery between intense stretching bouts, typically one or two days. If flexibility is a necessary component of the client's lifestyle, as for a gymnast, then flexibility should be a major focus during the preseason and throughout the competitive season. Joints with a history of injury or immobility should be simultaneously strengthened and stretched during the off-season training cycles. Additionally, there is a portion of the population that experiences **hypermobility**, meaning they have excessive amounts of ROM in a joint or joints. A focus on strengthening those areas as opposed to additional flexibility training is best in this situation.

HYPERMOBILITY: The condition of having excessive amounts of range of motion in a joint or joints.

ACTIVE STRETCHING:
A muscle actively contracting to stretch another.

DYNAMIC STRETCHING:
Movement-based active stretching where muscles engage to bring about a stretch.

PASSIVE STRETCHING:
An external force such as a stretching strap or the hand to move a joint to the end of a range of motion.

SELF-MYOFASCIAL RELEASE (SMR):
Applying manual pressure to an adhesion or overactive tissue to elicit an autogenic inhibitory response, which is characterized by a decrease in the excitability of a contracting or stretched muscle arising from the Golgi tendon organ.

ADHESION:
Area of scar-like tissue that causes organs and tissues to stick together.

BALLISTIC STRETCHING:
Uses the momentum of the body or limb to move it through and beyond a normal range of motion. This technique uses bobbing, bouncing, pulsing, or jerking to achieve a stretch.

METHODS OF FLEXIBILITY TRAINING

Stretching can be characterized by the way in which it is performed. **Active stretching** involves a muscle *actively* contracting to stretch another. No external force is applied to perform the stretch. For example, while lying on the floor in a supine position, a client can lift one straight leg up toward the ceiling to stretch the hamstrings. To hold or enhance the position, the hip flexors and quadriceps can actively fire to continue the stretch of the hamstrings. Active stretching should not be confused with **dynamic stretching**, which involves movement through a ROM. **Passive stretching**, on the other hand, involves an external force such as a stretching strap or the hand to move a joint to the end of a ROM. For example, a client could complete a standing quadriceps stretch with the foot in the hand.

Flexibility training includes several components to promote optimal length-tension relationships and joint mobility. It is a modality that should be included often throughout training periodization as part of a balanced and effective training protocol. Flexibility and its components are critical in maintaining optimal movement patterns, and flexibility is also a large component of corrective exercise to improve movement patterns, reduce chronic pain, and prevent injury. Optimal flexibility training may include the following components:

- Static stretching: This technique involves holding a joint at the end of its ROM for a period of time, generally up to 60 seconds.
- Dynamic stretching: This includes actively moving a joint through its entire ROM.
- **Self-myofascial release (SMR):** This technique involves applying manual pressure to an **adhesion** or overactive tissue to elicit an automatic muscle inhibition response.
- **Ballistic stretching:** Often referred to as bouncing stretching, this technique uses the momentum of the body or limb to force it beyond a normal ROM by bouncing in and out of a stretched position. Examples include a client bending forward to reach for the toes and bouncing at the bottom or a person in martial arts who is practicing kicking as high as possible. These techniques could benefit a client who is prepping their body for dynamic athletic activities. However, because this technique is bouncy and completed under less control, a potential issue that can occur is the tearing of soft tissue (muscle or connective tissue), particularly without a proper warm-up.

- **Proprioceptive neuromuscular facilitation (PNF) stretching:** This is an advanced technique that incorporates the contraction *and* relaxation or stretching of a muscle.

RANGE OF MOTION

The main components of flexibility also have merit when discussing ROM specifically. A **passive range of motion** is a movement that is not produced by the person themself but rather by an external force. This happens, for example, when a physical therapist moves a client's shoulder through a full ROM. An **active range of motion** occurs when a person fires a muscle or group of muscles to create a ROM. For example, a client moves their own shoulder through a ROM during circumduction.

Flexibility training promotes an ideal ROM at one or more joints which, in turn, can improve a client's **resisted range of motion**—that is, the ROM available while a load is also being moved through that ROM. This is illustrated, for example, when a client completes scaption (scapular elevation) with a dumbbell in hand.

FLEXIBILITY AND THE PRINCIPLE OF SPECIFICITY

The principle of specificity states that training should be specific and relevant to the sport, activity, or movement pattern and individual to be effective. This training principle can be directly applied to flexibility training as well. The stretch selection, tempo, and ROM should correlate to the movement pattern to be trained for optimal benefit.

POSITION AND SPEED

For maximum effectiveness, stretching exercises must be similar in form and speed to the skill needing improvement. For example, slow, static stretching will not improve high and fast kicking movements in the same way that dynamic stretching movements will. Conversely, dynamic stretching methods have limited ability to improve a static skill, such as a split on the floor.

STRENGTH AND RESISTANCE

Safe and effective resistance training programs have a beneficial effect on joint mobility. In flexibility training, the primary concern is that there be adequate strength throughout a joint's full ROM. If, during an exercise, a relatively high load is used in a relatively weak portion of the ROM of the movement, loss of control and injury could occur. For this reason, resistance training should incorporate a joint and a muscle's full ROM and work antagonist muscle pairs evenly.

PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION (PNF) STRETCHING:
A flexibility technique used to increase range of motion and neuromuscular efficiencies.

PASSIVE RANGE OF MOTION:
The range of motion achievable when aided by an external force.

ACTIVE RANGE OF MOTION:
A muscle or group of muscles contract to create a range of motion.

RESISTED RANGE OF MOTION:
Range of motion available while a load is also being moved through that range of motion.

FLEXIBILITY TRAINING PROGRESSION

Just as periodized training has an ideal progression, so too does a flexibility regimen. Ideally, after a general warm-up, dynamic stretching and SMR are performed to promote ideal muscle length (a length-tension relationship) and reduce altered joint movement. Once muscle overactivity (tightness) has been addressed, a specific warm-up related to the upcoming training session, activity, or sport is performed. This includes **muscle activation exercises** as appropriate. Activation exercises are low-level resistance movements employed to increase blood flow to a muscle or muscle group and activate the nervous control of a muscle. Static stretching and additional SMR should follow the completion of the training session or activity to promote recovery and aid in a proper cooldown.

MUSCLE ACTIVATION EXERCISES:
Low-level resistance movements to activate blood flow and activate the nervous control of a muscle.

The flexibility training progression is as follows:

1. General warm-up
2. Dynamic stretching, SMR
3. Specific warm-up
4. Exercise bout
5. Static/passive or pre-contraction stretching, SMR

ACUTE VARIABLES FOR FLEXIBILITY

Many of the same acute variables applied to fitness programming for resistance training can and should be manipulated in flexibility training for optimal results.

INTENSITY

Tension in a stretch is like intensity or resistance during exercise. Stretching methods can range from **intuitive limbering**—stretching after waking or when standing up from the desk at work—to aggressive stretching regimens as performed by dancers, martial artists, and gymnasts. The former is useful for releasing adhesions and microscopic tissue bonding after periods of inactivity, while the latter is designed to radically increase a joint's ROM.

INTUITIVE LIMBERING:
Stretching after waking or when standing up from a prolonged seated position.

Discomfort and pain are subjective experiences, and everyone has varying tolerances to both. Stretching to the point of mild to moderate discomfort is recommended if the goal is to improve ROM. However, lighter stretch intensities have been found to be effective for recovery and fluid circulation during or after a training session.

TIME

The ideal amount of time or duration for holding a stretch depends on many factors. The main thing to consider is the type of stretching method being used. Dynamic stretching involves movement through a ROM that lasts only a moment or so each repetition. Static and pre-contraction stretching involve holds lasting 10 to 30 seconds each, up to one minute overall. Stretching sessions need not last any longer than about 20 minutes to be effective.

BREATH CONTROL

During stretching, clients should breathe normally. Muscles require oxygen in varying levels to function. Clients should avoid holding their breath because this can increase blood pressure and prolong muscle tension while diminishing the flow of oxygen throughout the body.

FREQUENCY

Frequency is a variable that must be considered with flexibility training. Consistency is a key factor in making gains or simply maintaining ROM throughout the body. For a general fitness program, it is recommended that static stretching be done two to three days per week.

STRETCH SELECTION

The specific stretches employed will be based on the needs and activities of each client as well as when they will be used in relation to a workout. Specific types of flexibility are optimal before, during, or after an exercise session and on recovery days.

BEFORE ACTIVITY	DURING ACTIVITY	AFTER ACTIVITY	REST/RECOVERY DAYS
☐ Dynamic Stretches	☐ Dynamic Stretches (Active Recovery)	☐ Static Stretches	☐ Self-Myofascial Release
☐ General Warm-up		☐ PNF Stretches	☐ PNF Stretches
☐ Specific Warm-up		☐ Self-Myofascial Release	☐ Dynamic Stretches
☐ Ballistic Stretches			
☐ Self-Myofascial Release			

Figure 10.1 Flexibility Technique Timing

A fitness professional should choose individual stretches based on the upcoming activity if completed before an exercise session and to target tight muscles after training and on days designated for recovery.

DYNAMIC STRETCHING

In dynamic stretching, momentum is used to propel the muscle into an extended ROM without holding the position at the end. In most cases, these movements mirror those that will be performed during the ensuing workout or sport, and the movements should be controlled to prevent injury. Dynamic stretching differs from static stretching in that the positions are not held and the muscles themselves bring about the stretch.

Typically, 10–15 minutes is all that is required for a warm-up and flexibility protocol before a training session. Stretching should be done to the point of mild discomfort to increase ROM. A fitness professional should advise clients to breathe normally during stretching to enhance relaxation and improve the lengthening effect.

For athletes, whether competitive or recreational, the stretching and flexibility training should be specific to the activity to be performed. The most commonly used movement patterns should be the focus, and dynamic or ballistic stretching should start at low intensity and progress as the body warms up. An example of this is a baseball player doing dynamic rotation through the hips and torso prior to swinging the bat.

ARM CIRCLES

A client should start in a standing position with the feet hip width apart and the arms down at the sides of the body. The client should laterally abduct their arms until they are parallel to the floor, keeping the shoulders relaxed and away from the ears. They will slowly create the movement of circumduction with the arms, starting with small circles toward the front. Every two to three circles, a fitness professional should instruct the client to begin making the circles a little bigger. The client should repeat the movement in the forward direction until the arm circles are as large as possible and the client achieves the largest ROM possible around the shoulder (glenohumeral) joint. Then the client should return the arms to parallel to the floor and begin the small circles again, this time rotating the arms in the opposite direction. Again, every two to three circles, the fitness professional should instruct the client to make the circles bigger. The client should continue until the arm circles are as large as possible and a full ROM is achieved at the shoulder joint.

DYNAMIC TIP:

Arm circles can be done bilaterally (with both arms at once) or unilaterally (with one arm at a time).

SHOULDER FLEXION AND EXTENSION

As the name suggests, this dynamic stretch simply executes flexion and extension at the shoulder joint. This exercise starts with a client standing with the arms at the sides of the body, palms facing the midline. Then the client can actively flex one or both shoulders to elevate the arm(s) overhead to the end of range, avoiding spinal hyperextension (extending beyond neutral or upright). Once at the end of range, the client can allow momentum to bring the shoulder into extension and repeat. The arm will likely move posteriorly beyond the starting position for full extension. Ten to 15 repetitions can be completed before resting.

DYNAMIC TIP:

This dynamic stretch can be completed unilaterally or bilaterally—one arm at a time or both together.

SINGLE-LEG SWINGS—SAGITTAL PLANE

A client should start in a standing position with feet hip width apart and arms free, or, if needed, the client can stand next to a wall for balance support. The client should shift the body weight into the right foot and gently lift the left foot, standing tall from the top of the head to the right heel, while avoiding leaning to the right as much as possible. Allowing momentum to work, the client swings the leg forward to the end ROM and then backward to the end ROM. Some activation of the hip flexors and glutes will occur to move the leg to the end of range. The torso should remain upright and stable during this stretch. This can be repeated 10 to 15 times on the left before switching legs.

DYNAMIC TIP:

The leg swing in the sagittal plane is a faster dynamic stretch. The core should remain braced to prevent excessive lumbar flexion and extension. A fitness professional should pay careful attention to the client's ROM to ensure muscle strain does not occur. Although a faster stretch, the pace of the movement should also be kept moderate and under control.

SINGLE-LEG SWINGS—FRONTAL PLANE

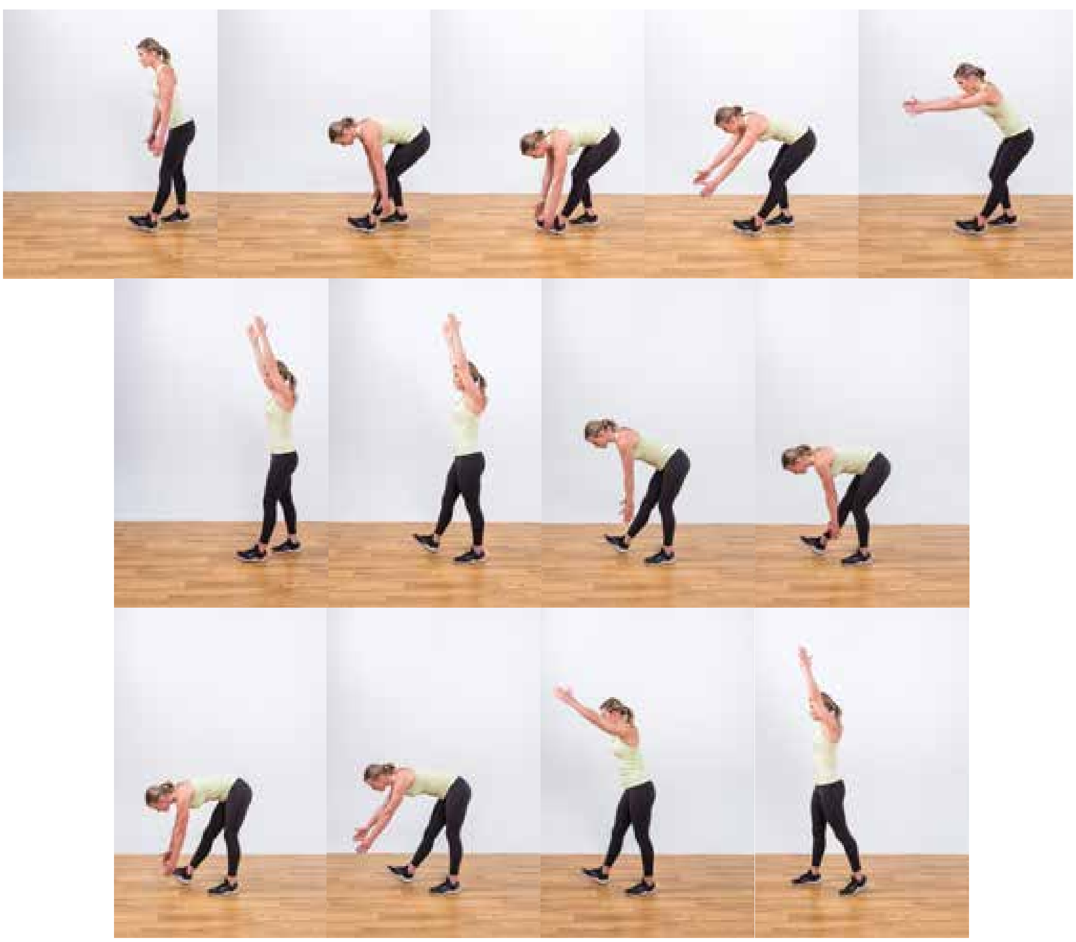
This stretch is similar to the sagittal plane leg swings, except the leg will swing medially and laterally. Some activation of the glute and adductors will occur to move the leg to the end of range. A client's arms can be free, or, if balance is difficult, both hands can be placed on a wall in front of the body for balance (ensuring enough distance between the wall and the body to allow the leg to move freely). Starting from a standing position, with the feet hip width apart, the client should shift their weight to the right leg and gently lift the left foot, allowing momentum to work, and abduct the left leg to the end of range without allowing excessive lateral flexion of the spine. The leg should swing (adduct) and cross the midline as far as allowable, again without excessive lateral spinal flexion. This swing can be repeated 10 to 15 times before switching legs.

> **DYNAMIC TIP:**
>
> To focus this dynamic stretch on the adductors, the client should abduct the leg as far as possible. Ideally, with additional repetitions, the range of leg adduction should increase as the adductors are stretched.

WALKING SCOOPS

Starting from a standing position with feet hip width apart, a client should take a small step forward with the left leg so the left heel is about six inches beyond the right toe. Keeping both legs extended (not locked), the client should use both hands to trace down the left leg while hinging at the hips. The arms and torso will make a sweeping motion down the left leg, as far toward the floor as they can reach, and then make a full circle overhead and back to the starting position. The client should shift their body weight and take a small step forward with the right foot and complete the sweeping motion again. This can be repeated 5 to 10 times for each leg.

> **DYNAMIC TIP:**
>
> It is not necessary to keep the back flat during this dynamic stretch. Allowing the spine to curve will help to dynamically stretch the spinal erectors as well.



ALTERNATING KNEE HUGS

Beginning in a standing position, a client should take a small step forward with the left leg, shift their body weight forward onto the left leg, and bring the right knee toward the chest. With both hands, the client should grab the right knee and gently pull it toward the torso for a one to two count before releasing the leg and taking a step forward with the right leg. Next, the client should shift the body weight forward onto the right leg and bring the left knee toward the chest, gently pulling the knee toward the torso with both hands. Clients minimize excessive extension or arching of the back as the knee is pulled to the torso. A fitness professional can encourage the client to continue to alternate steps and legs for 5 to 10 steps on each side. This stretch also targets the glutes.

DYNAMIC TIP:

Keeping a soft bend in the knee of the extended leg, engaging the glutes, and bracing the core will help with balance. For those unable to keep balance, this dynamic stretch can be executed from a supine position on a mat, alternating bringing one knee toward the chest at a time.

STANDING HIP CIRCLES

From a standing position, with feet hip width apart, a client should shift their body weight to the left leg and gently lift the right leg, avoiding excessive lateral spinal flexion. The client should begin making the circle by flexing the right knee to 90 degrees and extending the hip so the leg is behind the body, then actively abduct and externally rotate the right leg to the end of range. In a controlled circular motion, the client should adduct and internally rotate the right leg back to the starting position. This can be repeated 5 to 10 times before *switching the direction* of rotation with the same leg. The client should start by flexing the hip to elevate the knee before externally rotating and abducting the leg as far as possible and finishing in hip extension and knee flexion. Again, this can be repeated 5 to 10 times before switching legs.

DYNAMIC TIP:

This dynamic hip stretch can be performed while stationary or walking. When walking, the client's feet will alternate, the forward circles are executed when moving forward, and the backward circles are performed when moving backward.

ALTERNATING ARM HUGS

Starting in a standing position with feet about shoulder width apart, a client should have both arms horizontally abducted with the palms facing forward. Keeping the shoulders relaxed (not elevated), the client should horizontally adduct the right arm and use the left hand at the right elbow to pull the arm as close to the chest as possible. The client should hold for a one count and then release both arms back to the starting position and switch arms. Next, the client should horizontally adduct the left arm and use the right hand at the left elbow to pull the arms as close to the chest as possible and then release back to the starting position. A fitness professional can encourage the client to continue to alternate arms for 5 to 10 repetitions for each arm.

DYNAMIC TIP:

Make sure the client keeps their shoulders relaxed during the pull at the end of range.

INCHWORM WALKOUT

A client should start from a standing position with the feet hip width apart. Hinging from the hips, the client places both hands on the floor directly in front of the toes. A fitness professional should have the client bend the knees if necessary. One hand at a time, the client walks the hands out in front of the body, allowing the hips to come down until a high plank position is achieved. The client should hold for a short pause, then they will slowly walk the hands back toward the feet one at a time. Again, the client should bend the knees if necessary. Once the hands are back directly in front of the feet, the client should shift their body weight to the midfoot and slowly return to the tall standing position. This exercise should be completed for the desired number of repetitions.

DYNAMIC TIP:

For an additional challenge, a push-up can be added at the bottom from the high plank position before returning to the start position.

TIN SOLDIER

Similar to the sagittal plane leg swing, the tin soldier uses a bit of momentum and active hip flexion to raise the leg to the end of range. However, it eliminates the hip extension aspect of the swing. Starting in a standing position with feet hip width apart, a client should keep their arms free, or if needed, they can stand next to a wall for balance. Next, the client should shift the body weight into the right foot and gently lift the left foot, avoiding leaning to the right as much as possible. The client should actively flex at the hip and swing the leg forward to the end ROM, then return the foot to the starting position and switch legs. This exercise can be alternated for 5 to 10 repetitions on each leg.

DYNAMIC TIP:

The tin soldier can be a full-body dynamic stretch by adding the arms. As the leg swings forward, the opposite hand reaches for the toes. The hips are allowed to hinge slightly, and the torso can rotate as the hand reaches so long as the core remains braced.

FORWARD LUNGE TO REACH

Starting from a standing position, a client should take a large step forward with the left leg and flex both knees and lower into a lunge, bringing the right knee gently down to the floor into a half-kneeling position. The body weight is shifted forward into the left foot while the chest is tall. The client should bring the right arm overhead and hold for a two count before lowering the arm and returning to the half-kneeling position. The forward shift and arm raise can be repeated 5 to 10 times before returning to the standing position and switching sides.

> **DYNAMIC TIP:**
>
> When reaching the arm overhead, a slight lean can be added in the opposite direction to intensify the stretch. For example, the client can bring the right arm overhead and lean to the left.

REVERSE LUNGE WITH TWIST

Starting from a standing position with the feet hip width apart and hands together at the chest, a client should take a large step backward with the left leg into a lunge position. Hovering the left knee over the floor, the client will rotate the hands, torso, and head to the right as far as possible without leaning to the right or losing balance. Then the client should return to face forward and return the left foot back to the start position. This exercise should be repeated on the right leg with the torso rotation going to the left (toward the leg that is forward).

DYNAMIC TIP:

For clients who have poor balance, the twist can be removed from this dynamic stretch. A client can balance themselves against a wall or a stationary object when taking the step back into the lunge position if necessary.

LATERAL LUNGE SHIFTS

Starting from a standing position, a client should take a large step laterally with the left foot so that both feet are outside of the shoulders. The left knee is flexed, and the body weight is shifted toward the left (as in a lateral lunge) for a one to two count. After returning to the center, the client should flex the right knee and shift their body weight to the right for a one to two count and then again return to center. The client should continue to alternate sides for 10 to 15 repetitions on each side before returning to the standing position. Ideally, the range of the shift will increase with additional repetitions.

DYNAMIC TIP:

When shifting laterally, the client should avoid letting the knee move past the same side's toe. This can be done by hinging slightly at the hips during the shift, pushing the glutes back, and allowing the chest to drop slightly.

HIGH KNEES

A client should start from a standing position with the feet hip width apart and the arms down at the sides of the body. Then the client flexes the right hip and knee to bring the leg up in front of the body as if marching. The left arm will also come forward with the elbow bent at 90 degrees, and the right arm will move back with a 90-degree elbow bend. When full hip flexion is achieved, the client should replace the right foot back to the floor and switch legs. The arms will also switch as the left hip and knee flex. The right arm will be forward and the left leg back. When full hip flexion is achieved, the client should return the left foot back to the floor. The client should continue alternating legs for the desired amount of time or number of repetitions on each side.

DYNAMIC TIP:

To increase the intensity of this dynamic stretch, a fitness professional should instruct the client to speed up the march. It can be progressed to a run in place with a focus on achieving a 90-degree bend at the knee and keeping the foot directly under the knee when the knee is flexed. At a faster pace, the client can move their hands to the front of the body at about belly button height for balance.

GLUTE KICKS

Starting from a standing position with the feet hip width apart and the arms at the sides of the body, a client should bend the elbows to 90 degrees with the arms still at the sides. The client should shift their weight slightly to the left foot. Then they will flex the right knee and bring the right heel as close to the glutes as possible. The client should quickly return the foot back to the floor and shift their weight to the right foot. The knee flexion is repeated on the left leg, bringing the left heel as close to the glutes as possible. Again, the client should quickly replace the left foot back to the floor. The client should continue alternating legs for the desired amount of time or number of repetitions on each leg.

DYNAMIC TIP:

As with the high knees, this dynamic movement can be sped up to increase the intensity. A fitness professional should ensure the client can control the flexion of their knees and maintain balance at the faster pace. For clients who need assistance with balance, they can support themselves with a wall or stationary object if necessary.

WORLD'S GREATEST STRETCH

A full-body dynamic stretch worth mentioning is the world's greatest stretch. The series of movements are intended to be repeated on both sides of the body and dynamically stretches the entire body with a focus on the hips and core musculature. Each step in the series can take up to three or four breaths.

Beginning in a standing position, the client should take a large step forward at hip width with the left leg and flex the left knee while keeping the right leg extended (not locked). After bringing both hands down to the floor on the medial (inside) side of the left foot, the client should allow the hips to sink toward the floor as much as possible while relaxing the shoulders and breathing normally. Their body weight should be shifted forward gently toward the left foot and back toward the right calf, and they should drive the heel toward the floor two to three times. Next, the client should take the right arm and reach under the left knee, allowing the trunk to rotate, and reach as far as possible. Then the client should bring the right arm overhead, rotating in the opposite direction. The hand should not rotate past the right shoulder, but the torso will rotate, and the chest opens to the right. The arm movement can be repeated two to three times, under the left leg and open to the right. The client should return the right hand to the floor before lifting the chest, extending the left knee, and returning to the standing position. The series should be repeated on the opposite side of the body.

DYNAMIC TIP:

This dynamic stretch can be advanced in many ways, including the following:

- Instead of holding the high lunge with hands on the floor, the client can come to the elbows.
- A hamstring stretch can be added by shifting the glutes back toward the back heel and extending the forward leg while reaching for the toe.
- During the high-lunge shifts, the same side's hand can be used to press the knee laterally and rotate the torso toward and away to open the hips.

HIP OPENERS

Beginning in a standing position, a client should take a large step forward at hip width with the left leg and flex the left knee while keeping the right leg extended (not locked). After bringing both hands down to the floor on the medial (inside) side of the left foot, the client should allow the hips to sink toward the floor as much as possible while relaxing the shoulders and breathing normally. Their body weight should be shifted forward gently toward the left foot and back toward the right calf, and they should drive the heel toward the floor for the desired number of repetitions or amount of time.

> **DYNAMIC TIP:**
>
> To intensify the stretch, the client can bring the left hand to the left knee, relax the shoulder away from the ear, and press the knee away from the midline of the body.

STANDING TORSO ROTATION

Starting in a standing position with the feet shoulder width apart, a client should flex the elbows to 90 degrees and abduct the arms to become parallel to the floor. The torso is gently and actively rotated to the left until the end of range with the arms and eyes following. After returning to the center, the client should actively rotate to the right to the end of range with arms and eyes following and then return to the center once again. The client can continue to alternate sides for 10 to 15 repetitions per direction.

DYNAMIC TIP:

The rotation of the torso can extend into the hips as well. As the torso turns, the body weight is shifted into the same side's foot, and the opposite foot will rotate onto the toe, lifting the heel.

LATERAL OVERHEAD REACH

Starting from a standing position with the feet just outside of the hips and the arms at the sides of the body, the client should laterally abduct the left arm and take it overhead. A fitness professional should ensure the elbow remains as extended as possible. Once overhead, the client will laterally flex the spine and lean to the right as far as possible, then return to standing and replace the left arm back to the side of the body. The client should repeat the exercise on the right side. The client will laterally abduct the right arm until it is overhead, then laterally flex the spine and lean to the left as far as possible. Next, the client should return to the upright position and replace the right arm back to the side of the body. This exercise should be repeated for the desired amount of time or number of repetitions on each side of the body.

PRE-CONTRACTION STRETCHING

Pre-contraction stretching is a type of PNF stretching involving contracting the muscle to be stretched or its antagonist before the stretch. When contracting the same muscle, it is referred to as **contract-relax (CR) stretching**, and when contracting the antagonist, it is called **contract-relax antagonist contract (CRAC) stretching**. Pre-contraction stretching is often partner-assisted, but tools such as a towel or stretching strap may also be used to achieve the end ROM.

CONTRACT-RELAX (CR) STRETCHING: Contracting a given muscle before stretching the same muscle.

CONTRACT-RELAX ANTAGONIST CONTRACT (CRAC) STRETCHING: Contracting an antagonist muscle before stretching the agonist.

With this technique, the contraction should last at least five seconds. While most pre-contraction stretching techniques suggest using a maximum contraction—from 75 to 100 percent maximum contraction—research has shown that contractions at 20 to 60 percent are also effective for increasing ROM. After the contraction, the stretch (relaxation) should last from 6 to 10 seconds to improve ROM and muscle **pliability**. Fitness professionals should advise clients to breathe through the stretch.

PLIABILITY: The quality of being easily bent or flexible.

HOLD RELAX

This type of PNF stretching is performed using a stretching band or suspension straps for self-administered therapies. Hold relax (HR) can also be executed with the assistance of a licensed physical therapist, athletic trainer, or massage therapist:

1. The extremity should be passively moved to a painless end ROM.
2. In the stretched position, the client should contract the stretched muscle for 5 seconds, release the contraction and find the new end ROM of the stretch.
3. This sequence can be repeated for up to four repetitions. Ideally, each rep will force a greater end of range.

For the following six examples, a fitness professional should be sure to include step 2 to take advantage of the benefits of hold relax PNF.

Gastrocnemius

Beginning with both feet fully extended in front, a client should wrap their hands or a stretching strap around the ball of the right foot. While sitting erect and relaxing the shoulders, the client should gently pull the stretching strap until the full range of dorsiflexion is found. The client can contract the calf for 5 seconds, release, find the new end ROM and hold for 10 seconds, and then relax before starting the next repetition.

Quadriceps

Starting in a standing position with the feet hip width apart and using a chair or a wall for balance if needed, a client should shift their body weight to the right foot and avoid leaning to the side. The stretching strap is placed over the left midfoot and over the left shoulder. Using the stretching strap for leverage, the client should flex the left knee, bringing the heel toward the left glute without excessive lumbar extension. Keeping the knees together, the client should gently pull the left heel toward the glutes until the end of range is found. Following five seconds of contraction of the quadriceps, the new end ROM can be held for 10 seconds before releasing and moving to the next rep.

PNF TIP:

This stretch can be executed from the floor as well. A fitness professional should have the client lay prone on a mat instead of standing. The client will place the stretching strap over the midfoot on the side being stretched. During the stretch, the fitness professional should instruct them to keep their hips on the floor to the best of their ability as they move the foot closer to the glutes.

Hamstrings

Beginning by lying supine on a mat with both legs extended and arms at the sides, a client should place the stretching strap around the left midfoot. Keeping the leg extended, the client should use the strap as leverage and flex the left hip, bringing the leg to 90 degrees. The strap should be used to gently pull the leg toward the chest while keeping the shoulders relaxed. When the end of range is found, the client can contract the hamstrings for 5 seconds, release, find the new end ROM and then hold the stretch for 10 seconds before relaxing and moving to the next rep.

Glutes

This stretch is like the hamstring HR stretch, but the leg will be held at a different angle. Beginning by lying supine on a mat with both legs extended and arms at the sides, a client should place the stretching strap around the left midfoot. Keeping the leg extended, the client should use the strap as leverage and flex the left hip, bringing the leg to 90 degrees. The strap should be used to gently pull the leg toward the *right* shoulder without allowing the left hip to elevate. When the end of range is found, the client can contract the glutes for 5 seconds, release, find the new end ROM and then hold the stretch for 10 seconds before relaxing and moving to the next rep.

Adductors

This stretch is similar to the hamstring and glute HR stretches, but again, the leg will be held at a different angle. Beginning by lying supine on a mat with both legs extended and arms at the sides, a client should place the stretching strap around the left foot at midfoot. Keeping the leg extended, the client should use the strap as leverage and flex the left hip, bringing the leg to 90 degrees. The strap should be used to gently pull the leg toward the *left* shoulder without allowing the left hip to elevate. In many cases, the foot will move wider than the same side's shoulder for an adductor stretch to be felt. When the end of range is found, the client can contract the adductors for 5 seconds, release, find the new end ROM and hold for 10 seconds before relaxing and beginning the next rep.

Pectorals

Using suspension straps, this stretch begins with a client facing away from the anchor point and with handles in either hand (or both hands). The client slowly moves away from the anchor and allows the arm to elevate (as in scaption) to chest height. Then the client continues to move away from the anchor and allows the arm to horizontally abduct and open the chest. When the end of range is found, the client can contract the pectoral muscles for 5 seconds, release, find the new end ROM and hold for 10 seconds before relaxing and starting the next rep.

PNF TIP:

This stretch can also be performed by using a wall or stationary object for self-application.

STATIC STRETCHING

All resistance training workouts should be followed by a few minutes of static stretching to allow the involved joints to regain their full ROM. Such stretching also helps to reduce muscle soreness after exercise. In addition, static stretching can help maintain balanced musculature, which promotes good posture. Muscles tend to become less elastic once the body cools down after a workout, so stretching immediately after the workout maximizes muscle length and ROM.

To perform a static stretch, a client should hold the target muscle in a stretched position for 10 to 30 seconds. Each stretch should be repeated twice. Studies have not found any additional benefits after two to four repetitions of a stretch. But some studies have found a negative impact on performance at six repetitions. A fitness professional should advise clients to stretch only to the point of mild discomfort, not pain, and to breathe deeply through the stretch.

Static stretching is ideal for a cooldown as opposed to a warm-up protocol. It has been shown to change the length-tension relationship of a muscle fiber, which can increase the risk of injury or alter performance if done prior to activity. The loss of strength resulting from acute static stretching is known as "stretch-induced strength loss." The specific causes for this type of stretch-induced loss in strength are not clear. Some researchers have suggested neural factors, while others suggest mechanical factors.

PECTORALS

Chest Opener

Starting in a standing position with feet hip width apart and a soft bend at the knees, a client should bring both hands behind the body and interlock the fingers. Next, the client should gently press the interlocked hands down while retracting the shoulder blades to open the chest, allowing the chin to lift slightly while breathing normally. This stretch can be held for up to 30 seconds before releasing.

Single-Arm Pectoral Stretch

Starting in a standing position next to a wall on the right side of the body, a client should abduct the right arm and place the palm against the wall at chest height, with fingers facing toward the posterior. Taking small steps, the client should gently turn the body (torso and legs), leaving the hand in place, and keep rotating until the end of range in the right pectoral is found, holding for up to 30 seconds. The client should breathe normally and then release and switch arms.

STATIC TIP:

To keep this static stretch in the pectorals, the client should avoid elevating the shoulder, and the hand should be placed at or below chest height.

ARMS

Overhead Triceps Stretch

Seated or standing, the shoulders are relaxed, and the spine is neutral. A client should bring the left arm into full flexion overhead and flex at the elbow to drop the left hand down toward the left shoulder. The right hand is placed behind the left elbow to keep the shoulder in flexion. The client should breathe normally and hold for up to 30 seconds before releasing the arm and switching sides.

Biceps Stretch

Standing with feet hip width apart, with a neutral spine, and with arms fully extended at the sides, a client should flex the right shoulder to bring the arm parallel to the floor, palm up. The client should take the left hand and gently press the four outreached fingers of the right hand down toward the floor until the end of range is found. The right arm must remain fully extended. The shoulders are relaxed, and breathing is normal. This stretch can be held for up to 30 seconds before releasing both arms and switching sides.

> **STATIC TIP:**
>
> This static stretch can also be performed against a wall. The arm to be stretched should be brought to flexion at chest height, with shoulders relaxed and the palm pressed against the wall as much as possible with the fingers pointing down. Another version is done kneeling. The hands are placed on the ground slightly in front of the knees, shoulder width apart with the elbows fully extended. The palms are down, and the hands are externally rotated until the fingers point posteriorly. Once in this position, sitting the hips back can intensify the stretch if needed.

LATISSIMUS DORSI

Child's Pose

Starting in a kneeling position with the feet and knees just outside the hips, a client should bring the hands to the floor (a mat is optional) in front of the knees and walk them away while keeping the glutes as close to the heels as possible. Next, the client should continue to walk both hands forward as far as possible, allowing the head to fall between the elbows and the chest to fall toward the floor. This stretch can be held for up to 30 seconds before releasing.

> **STATIC TIP:**
>
> For a deeper stretch, the arms can be elevated by placing them atop a stability ball, chair, or bench, and the head can be allowed to fall between the elbows. When elevated, this stretch can be performed unilaterally or bilaterally.

LEVATOR SCAPULAE

Starting in a standing or seated neutral position, a client should take the right arm behind the back and bend the right elbow to 90 degrees. Then the client should raise their left arm and place the left hand on the right side of their head. They will turn their chin to the right while gently pulling the head down and to the left with the left hand. A fitness professional should instruct the client to bring the chin as close to the chest as possible and to keep both shoulders down and away from the ears. This stretch can be held for 20 to 30 seconds before releasing and switching sides.

SPINAL ERECTORS

Knees to Chest

Beginning by lying supine on the floor, a client flexes the hip and brings their knees into the chest as close as possible. They should wrap their arms around the knees for support. A fitness professional should ensure the client's head remains rested on the floor to keep the neck relaxed. The client should actively hug the knees for the duration of the stretch. This stretch should be held for 30 seconds before gently releasing the legs back to the floor.

> **STATIC TIP:**
>
> To intensify this stretch, the client can gently rock their body left and right while hugging the knees into the chest. The fitness professional should ensure the movement remains small so that the client does not roll over to one side uncontrolled.

Forward Fold

This stretch starts from a standing position with the feet about hip width apart and the arms down at the sides of the body. Beginning at the shoulders, a client should drop the chin toward their chest and slowly roll their spine as they hinge at the hips. The arms will remain lengthened, with a soft bend in the knees, and the arms will passively reach toward the floor. They will fold forward as far as possible, keeping the head relaxed and hanging neutrally. Once the fullest spinal flexion is achieved, the client should hold the stretch for 30 seconds before slowly reversing out—stacking the spine one vertebrae at a time. The head will be the last part of the body to reach the upright position.

STATIC TIP:

Not all clients will be able to reach the floor in a forward fold.

To intensify this stretch, when in full spinal flexion, a fitness professional should instruct the client to take each hand and grab the opposite elbow. Keeping the arms relaxed, they can add a gentle sway to the left and right or forward and back.

This stretch can also be completed from a seated position. The client will tuck the chin and slowly roll the spine and hinge at the hips. In the end position, their chest will be near or on their thighs, and the head will hang neutrally at or between the knees.

HIP FLEXORS

Starting from a standing position with feet hip width apart, a client should take a large step forward with the left leg, keeping the toes of both feet pointing forward. Both hands are brought to the forward knee as it is flexed. The client should allow the hips to sink straight down toward the floor while keeping the right leg extended (not locked) and elevated. The right heel may elevate. The shoulders are relaxed, and breathing is normal. The client should hold for up to 30 seconds before returning to the standing position and switching legs.

> **STATIC TIP:**
>
> This can also be executed from a high kneeling position with a shift in weight toward the forward foot. The torso is kept elevated, and the arm(s) can also be elevated overhead.

ABDOMINALS

Cobra

Beginning by lying prone on the floor, a client should relax the feet (plantar flexion) and place the hands even with the chest as if starting a push-up. The client should keep the hips on the floor and press through the palms to elevate the chest. A fitness professional should ensure the chin remains neutral and have the client extend their arms as far as possible. The client should breathe normally and hold the stretch for 30 seconds before slowly lowering the chest back to the floor.

STATIC TIP:

To intensify this cobra stretch, when the client has the arms extended and the chest elevated, they can alternate looking over one shoulder, then the other. When looking over the right shoulder, the fitness professional should instruct them to press the left hip into the floor. The opposite is true when looking over the left shoulder—the client should drive the right hip toward the floor.

GLUTES AND PIRIFORMIS

Pigeon

This stretch starts by kneeling on a mat. A client should bring the left knee straight forward and place the left foot in front of the right hip. The outside of the left shin should now rest on the floor. As much as possible, the right leg is extended behind the body with the front of the thigh resting on the floor. The torso will be propped up on the extended arms, and the hands are placed on each side of the left knee, with palms down. The client should allow the hips to relax down toward the floor and relax the shoulders. The primary stretch is in the left glute. The client should breathe normally and hold for up to 30 seconds before switching sides.

STATIC TIP:

To intensify the stretch, the client can come to the elbows during the hold. Also, not all individuals will be able to bring both hips to the floor during this static stretch. A yoga block or blanket can be placed under the elevated hip to reduce strain and support the hip.

Lying Figure-Four Stretch

Lying supine with the legs extended and the arms at the sides, a client should flex both knees and bring the bottoms of the feet to the floor. The right ankle is crossed over the left knee, and the right hip is allowed to open (external rotation of the femur). The client should reach the left arm around the lateral aspect of the left thigh and the right arm between the thighs and hook them together behind the left knee. The left leg is gently guided toward the chest. The greatest stretch will be felt in the right glute. When the end of range is found, the client can hold for up to 30 seconds before releasing the feet back to the floor and switching sides.

QUADRICEPS

This stretch starts in a standing position with the feet hip width apart and using a chair or a wall for balance if needed. The body weight is shifted to the right foot, and leaning to the side should be avoided. A client should flex the left knee, bringing the heel toward the left glute without excessive lumbar extension, and reach back and take hold of the left foot. Keeping the knees together, the client should gently pull the left heel toward the glutes and hold for up to 30 seconds, while breathing normally, before releasing back to the starting position and switching legs.

STATIC TIP:

This static stretch can also be performed lying prone on the floor to prevent excessive lumbar spine extension. This is a good option for clients with overactive hip flexors or poor balance.

HAMSTRINGS

Standing Hamstring Stretch

Starting in a standing position with the feet hip width apart, a client should take a small step forward with the left foot and plant the heel, keeping the toes elevated. The foot is in active dorsiflexion. Then the client should hinge at the hips while reaching both arms toward the left toes. To maintain a focus on the hamstrings, the client should keep the back flat (to avoid thoracic rounding) and breathe normally. This stretch can be held for up to 30 seconds before returning to standing and switching feet.

STATIC TIP:

The forward foot can be elevated to intensify the static stretch. To place the forward heel, an exercise step, plyometric box, or even a chair can be used. The higher the elevation, the more balance will be required in the stationary leg.

Seated Figure-Four Toe Reach

This stretch begins in a seated position on the floor with both legs extended in front. Sitting erect with the shoulders relaxed, a client should flex the right knee and bring the bottom of the right foot to the medial aspect of the left leg. Keeping the back flat, the client should reach with both hands toward the left toes (or as far as possible). It is important to breathe normally while holding for up to 30 seconds before returning to the seated position and switching legs.

STATIC TIP:

Keeping the back flat on this (and most) hamstring stretch(es) helps to maintain a neutral pelvis. This, in turn, can help lengthen the hamstrings specifically. On the other hand, rounding the spine when reaching for the toes can promote an anterior pelvic tilt, which, while great for elongating the spinal erectors, places the hamstrings in a shortened position.

Lying Single-Leg Hip Flexion

A client should begin by lying supine on the floor with both legs extended and arms at the sides. Keeping the leg extended, the left hip is flexed, bringing the left leg to 90 degrees. Using both hands, the client should take hold of the leg just behind the knee, gently pulling the leg toward the chest while keeping the shoulders relaxed. When the end of range is reached, the stretch can be held for up to 30 seconds before releasing the leg back to the floor and switching sides.

STATIC TIP:

Depending on how tight the hamstrings are, the knee may naturally bend on both legs, whether elevated or not. If necessary, the leg on the mat can be bent, and the foot can be placed flat on the floor to protect the spine and allow for adequate hip flexion on the alternate side.

Butterfly Stretch

Beginning in a seated position with both legs fully extended in front, a client should sit erect and relax the shoulders. Next, the client should flex both knees, bring the soles of the feet together, and then move the heels as close to the body as possible while allowing the knees to fall outward. The hands can rest on the feet or extend out in front of the body. The client can hinge from the hips for a slight lean forward and hold for up to 30 seconds before releasing.

STATIC TIP:

Based on flexibility, some clients may not be able to lean forward much, if at all. Therefore, they can relax their chin toward their chest (while minimizing rounding of the midback) and allow gravity to assist the static hold.

CALVES

The calf complex consists of two muscles: the more superficial gastrocnemius and the deep soleus. Both can be stretched with static holds.

Gastrocnemius

A client should stand facing a wall or stationary object with feet hip width apart for support and place both hands on the wall or object for support. After taking a large step back with the left foot, the client should lean into the hands while keeping the arms fully extended (not locked) and drive the left heel toward the floor. This can be held for up to 30 seconds, while breathing normally, before releasing back to the starting position and switching legs.

STATIC TIP:

The angle of the back foot can change the head of the gastrocnemius, a muscle with two heads (medial and lateral), that is primarily stretched. The heel should be moved toward the midline to focus on the medial head, and the foot should be moved away from the midline to focus on the lateral head.

Soleus

This static stretch is similar to the gastrocnemius stretch with one minor addition to target the deeper muscle group. A client stands facing a wall or stationary object with feet hip width apart for support and places both hands on the wall or object for support. After taking a large step back with the left foot, the client should lean into the hands while keeping the arms fully extended (not locked) and then drive the left heel toward the floor. Next, the client flexes at the left knee as if trying to touch it to the wall to stretch the soleus specifically. The hips will shift toward the posterior to keep the heel as close to the floor as possible. This stretch should be held for up to 30 seconds, while breathing normally, before releasing back to the starting position and switching legs.

FLEXIBILITY AND SPECIAL POPULATIONS

In general, it seems that static stretching is most applicable to athletes who need to be flexible in their sport since ROM determines their ability to perform some of the skills necessary in their sport. Examples might include gymnasts or dancers. Older adults may also benefit more from static stretching than other techniques. Studies have shown that static stretching of the hip flexors and extensors may improve gait in older adults and that 10 weeks of static stretching of the trunk increased spinal mobility.

Further, older adults may need to hold a stretch longer than the recommended 10 to 30 seconds. For example, a recent study found that stretching for 60 seconds resulted in greater hamstring flexibility in older adults.

Studies suggest sex-related responses to different stretching techniques. Some data indicates that males respond better to CR stretching and females benefit more from static stretching.

SELF-MYOFASCIAL RELEASE

Fascia is connective tissue that attaches, supports, encloses, and separates muscles from other muscles and internal organs. Tight fascia—resulting from injury, lifestyle, or inflexibility—often causes pain or movement dysfunction. **Myofascial release (MFR)** stretches and loosens the fascia using gentle, gradual, sustained pressure or stretch on areas of excessive tension. After MFR therapy, muscles move more freely, restoring ROM and reducing pain.

MYOFASCIAL RELEASE (MFR):
Stretches and loosens the fascia using gentle, gradual, sustained pressure or stretch on areas of tension.

MFR can be performed by a practitioner or by oneself. Foam rolling and roller massage are popular forms of this technique called self-myofascial release. It is important to note that when using techniques such as foam rolling, a slow and deliberate approach (rolling an inch per second for example) is best.

Foam rolling, or SMR, is a technique that applies pressure to overactive (tight) tissue. Using **autogenic inhibition**, the overactivity (tightness) of the targeted tissue is released as inhibition from the **Golgi tendon organ** occurs. SMR has been found to increase short-term flexibility with minimal effect on muscle contraction or performance.

AUTOGENIC INHIBITION:
The decrease in excitability of a contracting or stretched muscle arising from the Golgi tendon organ.

GOLGI TENDON ORGAN:
The proprioceptive sensory organ that senses muscle tension in a tendon and inhibits muscle action.

Tools such as a foam roller, lacrosse balls, and hand rollers are readily available for SMR applications. The effects of SMR make it an ideal technique to use before and after training. Foam rolling is done prior to activity to encourage optimal length-tension relationships and increase joint ROM, and it is done after activity to aid in returning muscle fibers back to their optimal length and prevent the formation of tissue adhesions.

SMR can be performed on nearly any region of the body except the lumbar and cervical spine. The thoracic spine has muscles and structures, such as the scapula and rhomboids, that protect the vertebrae from the directly applied pressure. However, the lumbar and cervical spine lack protection, and the application of pressure may directly affect these areas if the spine is contraindicated.

THORACIC SPINE

Starting with the foam roller at approximately the eighth thoracic vertebrae (midback), a client should use their legs to create movement up or down the back. It is important that a fitness professional advise clients to extend their head and neck over the foam roller to achieve full motion and decrease strain on the neck. The foam roller should not be used on the lumbar spine due to the excessive pressure placed directly on the vertebrae.

LATISSIMUS DORSI

A client should lie with the foam roller on the lateral and posterior aspects of their rib cage with their arm extended over their head. The client can use their legs to create the rolling movement over the area, which extends from the inferior edge of the scapula through the posterior arm.

TENSOR FASCIAE LATAE AND ILIOTIBIAL BAND

A client should lie prone (facedown) with the roller under the hips. One side can be completed at a time. To effectively apply pressure to the tensor fasciae latae (TFL; a muscle on the lateral thigh) directly, the arms can be used to prop the body to one side, placing the anterolateral portion of the crease of the hip on the roller. The feet can be staggered or stacked, and the trunk can be supported by the hand or elbow.

The body should be rotated until the lateral (outer) aspect of the hip is on the roller. Moving slowly, the hands can be used to maneuver the body and allow the foam roller to move down the iliotibial (IT) band until an adhesion or tender spot is identified. The client should apply pressure statically at that point for 60–90 seconds before continuing toward the knee.

RECTUS FEMORIS

All heads of the quadriceps are important to foam roll: the rectus femoris, vastus intermedius (deep to the rectus femoris), vastus medialis, and vastus lateralis. Although the vastus lateralis is the largest of the four, the rectus femoris originates at the anterior inferior iliac spine (and the supraacetabular groove) and plays a role in hip flexion while the others are only involved in knee action.

A client should lie prone (facedown) on the foam roller with the trunk propped on the elbows, as with a plank. The feet will be elevated as well. Starting with one leg (though both are on the roller) and beginning at the top of the thigh, the body is maneuvered to roll toward the knee until an adhesion is located. The knee is flexed and extended slowly 6–10 times. Then with the knee in flexion and the ankle dorsiflexed, alternating internally and externally, the femur is rotated to bring the foot toward and away from the midline. The rotations are completed 6–10 times each way before proceeding toward the knee and locating the next adhesion to be addressed.

ADDUCTORS

A client should lie prone on the floor with the foam roller parallel to the hip and thigh. The knee and hip are flexed on the same side as the roller to bring the inner thigh atop the roller. The lower body will look like the number four. The leg and foot can relax to place maximum body weight onto the foam roller. The trunk is propped on the elbows, as with a plank. Starting with the roller on the medial aspect of the knee, the body is maneuvered to move the foam roller toward the groin until an adhesion is identified.

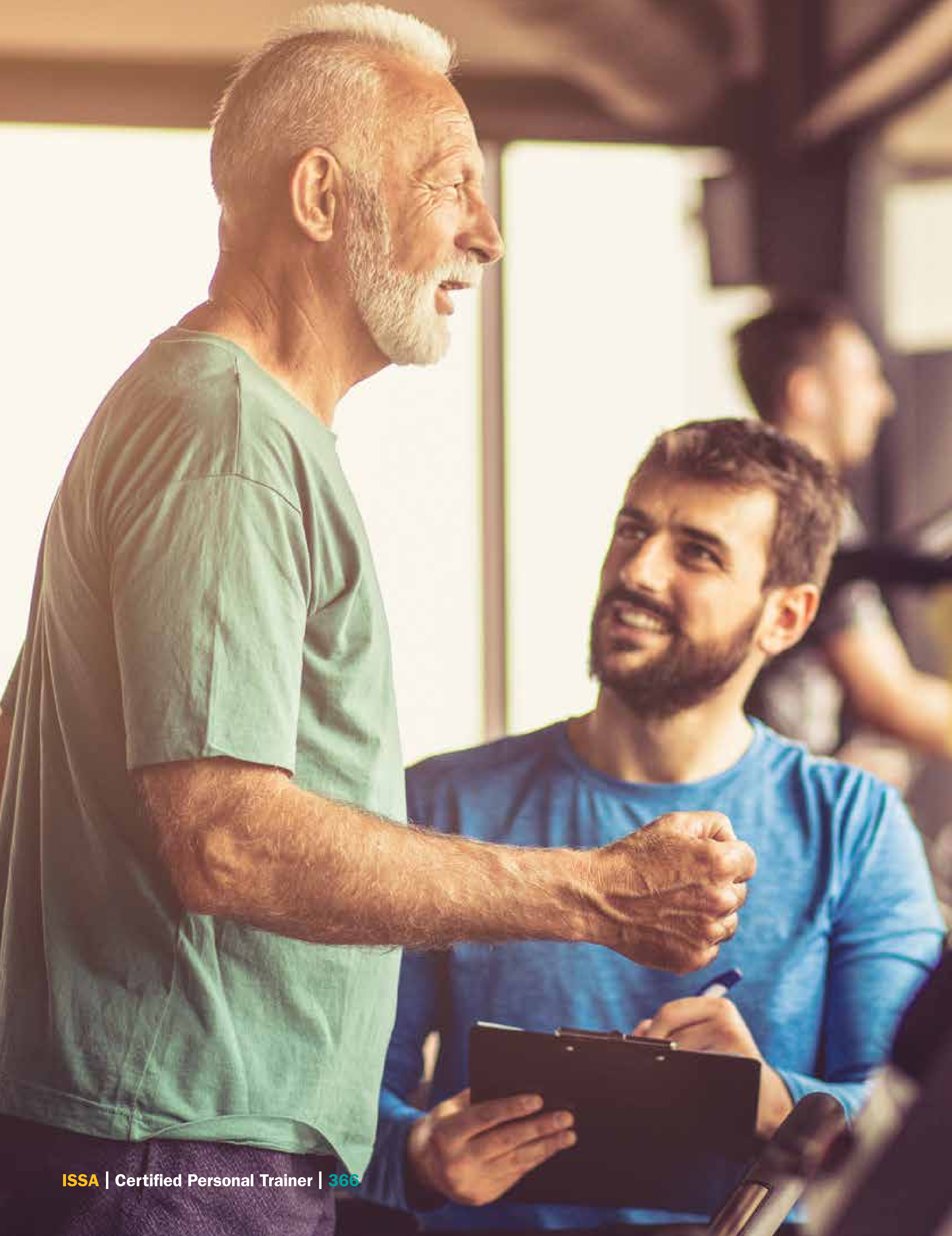
PIRIFORMIS

The piriformis works as an external hip rotator during hip extension and abducts the hip during hip flexion. It works in conjunction with the glutes and lies deep in the gluteus maximus.

A client should be seated atop the foam roller and can choose a side to address first. Crossing that leg and placing the ankle over the knee will allow the external rotation of the femur. The other leg is brought to a flexed position, placing the foot flat on the floor. The client should lean toward the side of the top leg, allowing the torso to be propped up on the hand or elbow. The lateral aspect of the glute will be receiving the applied pressure.

CALVES

Sitting with one or both calves perpendicular to and on top of the foam roller, a client should use their arms to create the rolling movement. Plantar flexion and dorsiflexion of the foot will offer additional exposure of and pressure on adhesions in the calves.



CHAPTER 11

CONCEPTS OF CARDIOVASCULAR EXERCISE

LEARNING OBJECTIVES

1 | Describe the benefits of cardiovascular exercise.

2 | Identify and explain the acute variables for cardiovascular exercise.

3 | Identify common modes of cardiovascular training.

4 | Explain the common environmental influence on physical activity.

From getting out of bed to participating in sports, human movement is an essential component of survival. While the nervous system determines the task and sends the appropriate signals to muscles, which in turn move a person, the cardiovascular system is responsible for supplying nutrients to and transporting waste from tissues. Modern society requires little physical effort from most people; therefore, to stave off various diseases such as cancer, diabetes, and heart disease, cardiovascular exercise is crucial.

Cardiorespiratory *specifically* refers to the heart, blood vessels, and lungs, while cardiovascular *specifically* refers to the heart and blood vessels.

Note: Cardiorespiratory exercise and cardiovascular exercise are used interchangeably in this text.

BENEFITS OF CARDIOVASCULAR EXERCISE

Cardiovascular exercise is an important contributor to overall health and wellness. Performing **aerobic exercise** and stimulating the cardiovascular system helps keep the heart, blood vessels, and lungs healthy. However, there are many other proven benefits to a regular cardio routine, including the following:

AEROBIC EXERCISE: Exercise that improves or is intended to improve the efficiency of the body's cardiorespiratory system in absorbing and transporting oxygen.

- Reduces fatigue
- Improves energy levels
- Reduces depression
- Reduces stress and anxiety
- Prevents some types of cancer
- Enhances self-image
- Slows the effects of aging
- Improves sleep
- Improves mental acuity (sharpness of the mind, determined in memory, focus, concentration, and understanding)

REDUCES FATIGUE

Research shows that sedentary people who begin a regular exercise program reported a reduction in fatigue. This includes symptoms of fatigue such as drowsiness, sore muscles, slowed reflexes, and irritability. This effect occurs in diverse populations, including healthy adults, cancer patients, and people with diabetes and heart disease. In these studies, the average effect of exercise was greater than the effect of stimulant drugs such as caffeine.

IMPROVES ENERGY LEVELS

A more robust cardiovascular system allows the heart to pump more blood per beat, supply more blood to itself between beats, and therefore increase efficiency. Less resistance to blood flow, increased volume of blood filling the heart for transport, and stronger heart contraction produce the efficiency. Research also suggests that improving blood flow simultaneously increases the amount of oxygen being delivered to the brain. Optimal cognitive function (brain function) is supported by sufficient oxygen supply to the brain and can improve alertness and energy levels in people of all ages.

REDUCES DEPRESSION

In the US, 1 in 10 adults struggles with depression and many turn to antidepressant drugs for relief. However, Harvard Health suggests that exercise may work as well as medications to relieve depression. Clients suffering from severe depression should consult their physicians before stopping any form of treatment or before starting physical activity.

High-intensity exercise stimulates the production of **endorphins**, hormones that promote feelings of well-being. This results in acute feelings of happiness. Low-intensity exercise sustained over time releases neurotrophic proteins or **growth factors**. These proteins stimulate nerve cell growth and the creation of new neural pathways and connections. The resulting increases in brain function make people feel better.

ENDORPHINS:
Hormones that promote feelings of well-being.

GROWTH FACTORS:
Proteins that stimulate nerve cell growth and the creation of new neural pathways and connections.

REDUCES STRESS AND ANXIETY

Many of the same mechanisms that help improve depression also help relieve stress and anxiety. When stress affects the brain, the effects are felt throughout the body. The opposite is also true. Exercise can immediately elevate a person's mood for hours after cessation. In addition, research suggests that regular exercise has a protective effect against stress, anxiety, and depression. One study showed that those who engaged in regular vigorous exercise were 25 percent less likely to develop depression or an anxiety disorder within the next five years.

PREVENTS SOME TYPES OF CANCER

New research from the American Cancer Society and the National Cancer Institute links exercise with a lower risk of thirteen different cancers. The findings linked leisure-time physical activity, such as gardening, walking, bowling, and horseback riding, with reduced risk of breast, colon, esophageal, and endometrial cancers as well as kidney cancer, liver cancer, myeloid leukemia, and stomach cancer.

Regular intentional physical activity was strongly associated with a reduced risk of multiple myeloma (a blood cancer) and cancers of the bladder, head and neck, lungs, and rectum.

ENHANCES SELF-IMAGE

People who participate in regular exercise develop strength, muscle density, flexibility, coordination, and balance and in turn, can make positive changes to the look and function of their bodies. Multiple studies suggest that improving physical fitness helps people feel more competent and confident, positively influencing the way they feel about their bodies and boosting self-esteem. When a person perceives an improvement in their physical fitness through physical activity—based on weight loss, muscle tone, strength, endurance, and so forth—it triggers an improvement in body image, which can reinforce exercise as a part of a healthy lifestyle.

SLOWS THE EFFECTS OF AGING

HEALTH MARKERS: Tools at the service of health professionals that objectively measure and evaluate indicators of normal biological processes or pathogenic processes (i.e., blood pressure).

Studies following sedentary and active aging populations have shown that aging is not the same for all people. Older, active people had **health markers** similar to those 20 or 30 years their junior. For example, older adults who engaged in regular cardiovascular activity:

- experienced decreased loss of muscle mass or strength,
- did not increase body fat or cholesterol levels,
- did not experience a reduction in testosterone levels (males), and
- had stronger immune systems with T cell (a type of white blood cell that helps protect the body) counts as high as those of a young person.

IMPROVES SLEEP

SLEEP DEPRIVATION: Achieving a less than ideal sleep duration.

The Centers for Disease Control and Prevention (CDC) estimates nearly one-third of adults get the recommended seven to nine hours of sleep per night and two-thirds of teens are not getting the recommended eight hours per night needed to maintain good health. Chronic **sleep deprivation** leads to an increased risk for physical and mental illness and costs businesses and the health care system billions of dollars each year.

Table 11.1 Sleep Recommendations

THE NATIONAL SLEEP FOUNDATION'S SLEEP RECOMMENDATIONS BY AGE GROUP		
Group	**Age**	**Sleep Recommendation**
Newborns	0–3 months	14–17 hours
Infants	4–11 months	12–15 hours
Toddlers	1–2 years	11–14 hours
Preschoolers	3–5 years	10–13 hours
School-age children	6–13 years	9–11 hours
Teenagers	14–17 years	8–10 hours
Younger adults	18–25 years	7–9 hours
Adults	26–64 years	7–9 hours
Older adults	65+ years	7–8 hours

As little as 10 minutes of aerobic exercise can improve the quality of sleep and increase the overall duration of sleep through all sleep stages. Early morning and afternoon exercise have been found to have the most beneficial effects for people looking for improved sleep quality. Exercising at night may negatively affect sleep quality, but the data is not conclusive. The theory is that increased blood flow, exposure to bright light, and brain oxygenation have an energizing effect on the brain and may impair the body's natural production of melatonin. Better sleep allows people to improve their recovery, allowing them to exercise more regularly.

IMPROVES MENTAL ACUITY

Exercise directly benefits memory and cognition by reducing insulin resistance, reducing inflammation, and stimulating the release of growth factors. The sum benefits of these actions affect the health of brain cells and the creation of new blood vessels in the brain and can enhance the growth and longevity of new brain cells.

Many studies have shown that the prefrontal cortex and medial temporal cortex—the parts of the brain responsible for thinking and memory—are larger in active people than in sedentary people. In addition, engaging in a regular fitness program for as little as six months is associated with an increase in the size of certain areas of the brain.

CARDIOVASCULAR TRAINING PRINCIPLES

The principles and components of program design are a common thread through all areas of physical fitness, from warm-up to flexibility, strength training, and cardiovascular work. Each principle and component helps explain how to best program cardiovascular training for each client. How long, how hard, and how often clients train are determined by the underlying principles.

PRINCIPLE OF SPECIFICITY

The type of cardiovascular exercise and the associated acute training variables chosen for each client must be specific to benefit the client's desires. A marathon runner and a sprinter do not follow the same training program. The more specific the cardiovascular training is to the sport or activity, the greater the improvement in performance the client can expect.

PRINCIPLE OF INDIVIDUAL DIFFERENCES

Fitness assessments provide information about a client's current fitness level and potential challenges. The data collected should be used to determine the appropriate training loads and progression. Periodic reassessments give a fitness trainer insights into how clients have adapted to the prescribed program and what manipulations need to occur to drive success. A program that works for one client should not be assumed to work for another.

PRINCIPLE OF PROGRESSIVE OVERLOAD

As the body adapts to training, systematic and progressive stresses are placed on the body to facilitate its adaptive response. Much like resistance training, changes to volume, intensity, and frequency should all be progressively increased to initiate adaptations to cardiovascular training. Depending on the client's goals, shorter rest periods, longer bouts of exercise, faster bouts of exercise, or more frequent bouts of cardiovascular exercise can be applied to overload the cardiovascular system and elicit change. However, the progression of all variables should be gradual—frequency, intensity, or duration should not be increased by more than 10 percent each week. Furthermore, only one to two variables should be manipulated at a time to prevent overreaching or overtraining.

PRINCIPLE OF REVERSIBILITY

The effects of aerobic exercise are not permanent. Research shows that cardiorespiratory fitness declines sharply within two weeks of stopping intense endurance training. Fitness returns to pretraining levels after 10–32 weeks of detraining. However, systematically decreasing the frequency and duration of exercise while maintaining intensity is beneficial to avoid overtraining and will not significantly decrease **VO_2 max**.

VO_2 MAX:
The maximum amount of oxygen an individual can utilize during exercise.

GENERAL ADAPTATION SYNDROME

The body goes through three stages in response to adequately intense exercise—alarm, resistance, and exhaustion. During the alarm stage, the body experiences symptoms of fatigue, weakness, or soreness. This stage lasts from two to three weeks. During the resistance stage, the body experiences biochemical, mechanical, and structural adaptations to improve efficiency in response to the stress applied during training. Finally, during the exhaustion stage, the body again suffers symptoms of fatigue, weakness, or soreness, though with greater intensity. If training is maintained at the same level, instead of adapting positively, the client may experience burnout, overtraining, injury, or illness.

A properly periodized cardiovascular training program allows adequate and timely recovery to avoid the stage of exhaustion. This includes manipulating **acute training variables** as well as programming rest and recovery.

ACUTE TRAINING VARIABLES:
The components that specify how an exercise is performed.

Fitness-Fatigue Paradigm

Higher-intensity cardiovascular training leads to greater fitness adaptation but also generates greater fatigue. Clients will likely require more rest and time for recovery after intense training bouts or cycles. If training stays at a consistent high intensity, fatigue will increase and result in reduced performance.

If training intensities are low, so reduced are fitness adaptations, fatigue, and performance. However, research has shown that fatigue dissipates at a faster rate than fitness. If appropriate training strategies and periodization are used, then fitness and performance levels will increase while fatigue levels decrease.

Tapering

During a **taper period**, the volume or frequency of training decreases to allow the body adequate rest and recovery. During this recovery time, there must be a focus on low-intensity technique work and nutritional interventions for optimized physical recovery and performance. Tapering is commonly used in conjunction with a periodized program to help athletes and bodybuilders peak and fully recover for competition.

TAPER PERIOD:
A training period where the volume or frequency of training decreases to allow the body adequate rest and recovery.

MODIFYING ACUTE TRAINING VARIABLES

Commonly manipulated acute training variables for cardiorespiratory training are as follows:

- Frequency
- Intensity
- Time/duration
- Type
- Resistance
- Rest
- Recovery

With any programming periodization, only one to two variables are manipulated at a time to allow for adaptation. This also allows a trainer to determine which variables are the most effective at eliciting a desired training response for each client.

FREQUENCY

For aerobic endurance performance, three to six training sessions per week is typical. The "ideal" training frequency depends on the intensity and duration of each training bout, the training goal(s), the training status of the client, and the specific sport season for athletes.

For cardiovascular health, the American Heart Association recommends the following:

Table 11.2 Cardiovascular Frequency Recommendations

RECOMMENDATIONS FOR ADULTS	
Fat loss or endurance goal	150 minutes or 2.5 hours per week or more of moderate-intensity aerobic activity
Strength or hypertrophy goal	75 minutes per week of vigorous aerobic activity
General fitness goal	Any combination of moderate to vigorous-intensity aerobic activity

RECOMMENDATIONS FOR YOUTH	
3–5 years	Should be physically active with opportunities to move throughout the day
6–17 years	60 minutes per day of moderate to vigorous-intensity physical activity
	At least 3 days per week of vigorous intensity activity

Volume

Volume is easily manipulated during each session by increasing the amount of work completed, specifically the amount of time spent performing cardiovascular activity. Increasing frequency or duration or both increases volume.

- Cardiovascular intensity can be measured using several different methods:
- VO_2 Max: the maximum rate of oxygen consumption measured during exercise
- **Target heart rate (THR):** the goal heart rate to reach a specific level of physical exertion for cardiovascular fitness improvement
- **Rate of perceived exertion (RPE):** measured by the Borg rating scale (6–20) or the modified exertion scale (0–10), a quantitative and subjective measure of exertion during physical activity
- **Talk test:** the use of the ability to speak during exercise as a gauge of the relative intensity
- **Metabolic equivalent (MET):** the measure of the ratio of a person's expended energy to their mass while performing physical activity

Table 11.3 Rating of Perceived Exertion: Borg and Modified Borg Scales

BORG RPE	MODIFIED RPE	BREATHING, TALK TEST	THR (PERCENT OF MAX HR)	EXERCISE TYPE
6	0	No exertion	50–60 percent	Warm-up
7		Very light breathing. Can sing "Happy Birthday" easily.		
8	1			
9				
10	2	Deeper breathing but comfortable. Able to hold a conversation.	60–70 percent	Recovery
11				
12	3			
13		Able to talk but difficult to hold a conversation	70–80 percent	Aerobic
14	4			

TARGET HEART RATE (THR):
The estimated beats per minute that need to be reached to achieve a specific exercise intensity.

RATES OF PERCEIVED EXERTION (RPE):
A subjective sliding scale of a client's perception of their exercise intensity.

TALK TEST:
The ability to speak during exercise as a gauge of the relative intensity.

METABOLIC EQUIVALENT (MET):
The measure of the ratio of a person's expended energy to their mass while performing physical activity.

Table 11.3 Rating of Perceived Exertion: Borg and Modified Borg Scales (CONT)

<table>
<tr><th>BORG RPE</th><th>MODIFIED RPE</th><th>BREATHING, TALK TEST</th><th>THR (PERCENT OF MAX HR)</th><th>EXERCISE TYPE</th></tr>
<tr><td>15</td><td>5</td><td rowspan="2">Starting to breathe hard and getting uncomfortable to carry a conversation</td><td rowspan="2">80–90 percent</td><td rowspan="2">Anaerobic</td></tr>
<tr><td>16</td><td>6</td></tr>
<tr><td>17</td><td>7</td><td rowspan="2">Deep and forceful breathing. Uncomfortable and unable to talk.</td><td rowspan="4">90–100 percent</td><td rowspan="4">High intensity, VO_2 max</td></tr>
<tr><td>18</td><td>8</td></tr>
<tr><td>19</td><td>9</td><td>Extremely hard</td></tr>
<tr><td>20</td><td>10</td><td>Maximum exertion</td></tr>
</table>

INTENSITY

Cardiorespiratory training intensity can be measured using the Borg RPE or modified RPE scales, METs, the talk test, THR, or a personal heart rate monitor. Some of the acute variables that can be manipulated to affect intensity are the following:

- Rest: decrease rest time to increase intensity
- Resistance: increase resistance to increase intensity
- Speed: increase speed to increase intensity

There are six standardized types of cardiovascular training. Each is a slight modification of the acute variables as well:

1. Low intensity, long duration or low-intensity steady state (LISS): cardiorespiratory exercise between 60 and 75 percent of **maximum heart rate** that remains within the aerobic threshold
2. Moderate intensity, medium duration: 70 to 85 percent of maximum heart rate effort that aims to remain aerobic. For untrained clients, the percent of maximum heart rate may be lower.

MAXIMUM HEART RATE:
The estimated maximum number of times the heart should beat per minute during exercise. Calculated by subtracting a person's age from 220.

3. High intensity, short duration or high-intensity interval training (HIIT): 80 percent of maximum effort or greater during work periods, with lower-intensity rest periods that are long enough to allow the heart rate to recover
4. Aerobic intervals: sub-maximum effort during work periods to remain within the aerobic threshold
5. Anaerobic intervals (Tabata): maximum effort during 20-second work periods with short 10-second complete rest for eight rounds or four minutes total. RPE 10 effort.

Fartlek ("speed play" in Swedish) is an outdoor running style that uses landmarks and terrain to increase or decrease running speed. Fartlek training is a way to modify several variables at once. There are two common types of Fartlek workouts: time-based and random.

FARTLEK:
A training system for distance runners that continually varies terrain and pace to enhance conditioning and eliminate boredom.

Time-based intervals include the following:

- Fixed time: exercise for a set period for each interval
- Varying time: each interval will be a different length of time
- Varying pace: each interval will have a different speed

Random intervals are completely dependent on the runner. For example, a client may mark intervals using trees or signs—run from this tree to that tree, recover as necessary, and then repeat. Intervals may be based on terrain—walk up hills and run down them. Or a client may change pace whenever a new song comes on the radio. Distance can also be used to mark intervals.

The intensity of a physical activity can be classified based on oxygen requirements. The amount of oxygen the body uses is directly proportional to the energy used during the activity (in the form of adenosine triphosphate [ATP]). METs are used to estimate the energy expenditure for many common physical activities. At rest, the body uses about 3.5 milliliters (mL) of oxygen per kilogram (kg) of body weight per minute. The resting level of oxygen consumption is referred to as 1.0 MET. An 8.0 MET level would equal eight times the amount of oxygen used at rest. Using METs as a reference with clients, grading intensity by multiples of resting levels can assist clients in understanding their intensity. Many modern cardiovascular machines use METs, and METs can be converted to other work measurements such as kilocalories per minute or watts.

Although the MET method can be used for prescribing exercise intensity, it has two limitations. First, environmental factors—heat, humidity, cold, wind, altitude, pollution, differences in terrain, and so forth—can change the way the cardiovascular system responds to a given MET level.

As a result, the cardiovascular system may be working harder at the “same” MET level. If a task gets harder because of, say, heat or altitude, the body requires more oxygen, burning more kilocalories; therefore, the task would not be at the same MET level. For example, brisk walking (3.5–4 miles per hour [mph]) equals 5 METs, but in a hot environment, it may require more work or a higher MET level to accomplish the same task. In another scenario, brisk walking at 3.5 mph while wearing a weighted vest would require more oxygen, increasing the MET level. The more oxygen the body uses during physical activity, the more Calories it will burn. METs are used to estimate the energy expenditure for many common physical activities.

Second, as fitness improves, a client needs to exercise at higher MET levels to continue to advance fitness per the principle of progressive overload. For these reasons, THR and RPE are more commonly used to indicate exercise intensity than the MET because of ease of use. Using the same example of brisk walking (3.5–4 mph) equaling 5 METs, as fitness levels increase, THR and RPE may decrease.

A fitness professional can use the following equation to determine the Calories expended for a client’s favorite activity:

METS × 3.5 × Bodyweight (KG) / 200 = Calories per Minute

TEST TIP!

The acronym for the most common cardiorespiratory training variables is FITT.

F: Frequency

I: Intensity

T: Time

T: Type

TIME/DURATION

The duration of a training session is inversely related to exercise intensity. The longer the exercise session, the lower the intensity. The higher the intensity, the shorter the exercise session.

Calorie burn for individuals will vary based on physical size and fitness level. Here are some examples that can equal approximately a 250-Calorie expenditure:

Table 11.4 Duration of Cardiovascular Activity Equaling 250 Calories

DESCRIPTION	LOW INTENSITY, LONG DURATION	MODERATE INTENSITY, MODERATE DURATION	HIGH INTENSITY, SHORT DURATION
Activity and duration	Slow walking for 60 minutes	Brisk walking for 45 minutes	Moderate jogging for 20 minutes
Speed	3.0 mph	4.0 mph	6.0 mph
Liters of oxygen per minute consumed	0.9 L O_2/min	1.1 L O_2/min	2.7 L O_2/min
Approx. Calories burned	250 Cal burned	250 Cal burned	250 Cal burned

TYPE

Walking, running, swimming, cycling, rowing, circuit training, and many sports are variations of exercise that affect the cardiovascular and respiratory systems. There is no ideal type of cardiovascular training. Activities that a client enjoys and align with their goals should be the primary training type to ensure exercise satisfaction and commitment to training.

RESISTANCE

Incline and speed can be modified on most cardiovascular machines. Cardiovascular training machines such as treadmills, step mills, cycles, and rowing machines also include resistance settings to increase or decrease training intensity. In addition, training intensity can be increased by adding resistance via equipment or by modifying the training environment. Equipment such as ropes, sleds, parachutes, resistance bands, and weights—weighted vests or kettlebells—can be added to aerobic exercises to increase intensity and variability.

Choosing different training environments also changes the intensity and variability of a workout. For example, hills or stadium stairs increase intensity by manipulating the incline or decline of the activity. Training on sand, grass, artificial turf, or rocky trails changes the level of impact to joints (less impact) and increases intensity because the surface shifts underfoot. Training on solid surfaces, such as concrete, increases the impact to joints but decreases the overall level of intensity.

Water can also be used as resistance. Aerobic training in the water can be effective but also gentle on joints. Training intensity can be increased or decreased by adding paddles for more resistance or floatation devices for varied buoyancy.

Though a change in resistance (load), tool, and environment can vary intensity and variability, these changes can also alter movement mechanics. Pushing or pulling a light load on a sled will change the intensity, and a heavier load can enhance or compromise movement mechanics and should be considered with the desired outcome in mind.

RECOVERY

Intense exercise must be followed by adequate rest and recovery to allow positive adaptations and avoid overtraining. If training is the stimulus and nutrition the building blocks, recovery is what allows for and fosters adaptations such as tissue repair. Recovery can be active or passive. For example, foam rolling or stretching is “active,” while and sleep and hydration are “passive.” Recovery is as important a component as training and nutrition, though often overlooked. Many seasoned marathon runners, for example, follow a three- to four-week taper plan to conclude a training cycle or prepare for an event. This means that training volume is reduced during the final two to four weeks before the race. Common practice is to reduce weekly volume (mileage) by 20 to 30 percent each week.

For example, if a client’s highest mileage week is 42 miles, the first taper week mileage would be reduced by 8.5–12.5 miles. Training intensity (speed) will remain at race pace, but the overall training volume will decrease.

Table 11.5 Aerobic Endurance Training Types

TRAINING TYPE	FREQUENCY PER WEEK	DURATION (ACTIVITY PER SESSION)	INTENSITY
Low-intensity steady-state (LISS)	1–2	Race distance or longer (Approx. 30–120 minutes)	Approx. 70 percent of VO_2 max
Pace/tempo	1–2	Approx. 20–30 minutes	At lactate threshold; at or slightly above race pace
Intervals	1–2	3–5 minutes (1:1 work-to-rest ratio)	Close to VO_2 max
Repetition	1	30–90 seconds (1:5 work-to-rest ratio)	Greater than VO_2 max
Fartlek	1	Approx. 20–60 minutes	Varies Between distance and pace/ tempo training intensities

Range of Motion

Range of motion can be manipulated to meet many objectives. For example, if a new client wants to train for a marathon but was previously sedentary, they may complain of low back pain or other issues. Tight hip flexors caused by prolonged sitting or repetitive activities such as jogging or cycling can shift the pelvis, resulting in anterior pelvic tilt. This specific postural deviation causes imbalances throughout the musculature of the lumbopelvic hip complex but specifically contributes to inactivity and weakness in the gluteus maximus. Range of motion training interspersed with cardiovascular training can fix muscle imbalances, improve running efficiency, and reduce low back pain.

MEASURES OF CARDIORESPIRATORY FITNESS

The overall health of a person's cardiorespiratory system is critical to their ability to engage in physical activity and exercise and can be assessed through a process called spirometry. Spirometry uses a **spirometer** to measure the airflow into and out of the lungs, including measurements of the following:

- Maximum voluntary ventilation: the volume of air breathed out in a specified time with maximum effort
- **Vital capacity:** the greatest volume of air that can be expelled from the lungs after taking the deepest possible breath
- **Tidal volume:** the lung volume representing the normal volume of air displaced between normal inhalation and exhalation when extra effort is not applied
- Total lung capacity: the volume of the lungs when fully inflated
- Residual volume: the volume of air remaining in the lungs after maximum exhalation

Figure 11.1 Spirometer

SPIROMETER:
An apparatus for measuring the volume of air inspired and expired by the lungs.

VITAL CAPACITY:
The greatest volume of air that can be expelled from the lungs after taking the deepest possible breath.

TIDAL VOLUME:
The lung volume representing the normal volume of air displaced between normal inhalation and exhalation when extra effort is not applied.

VITAL CAPACITY

The vital capacity of the lungs is the greatest volume of air that can be expelled from the lungs after taking the deepest possible breath. Using a spirometer, vital capacity is measured by how much air is exhaled after a person breathes in as much air as possible. Vital capacity measures the functional portion of a person's lungs and, for healthy adults, typically measures around 3,000 to 5,000 mL, depending on age, sex, height, and mass. Low vital capacity (generally below 3 liters [L] or 3,000 mL) is generally a symptom or a sign of a respiratory problem or disease.

The average adult has a normal breathing rate of 12 breaths per minute. A conditioned athlete may breathe as much as 20 times their vital capacity over one minute, while a deconditioned person may not even reach 10 times their vital capacity in one minute. However, aerobic exercise can improve vital capacity by strengthening the muscles involved in respiration and increasing the efficiency of the lungs.

TIDAL VOLUME

The tidal volume is the lung volume representing the normal volume of air displaced between normal inhalation and exhalation when extra effort is not applied. This means it is a measure of how much air moves into and out of someone's lungs while at rest. On average, tidal volume is about 10 percent of a person's vital capacity.

People with larger bodies have larger lungs than those of smaller stature, which also means they may have a higher natural tidal volume. Although this value will be different among people of varying body size, an average adult tidal volume is about one-half of a liter (500 mL) per breath in healthy males and slightly less (approximately 400 mL) per breath in healthy females.

The following factors influence tidal volume and vital capacity:

- Age: Lungs are at their maximum capacity during early adulthood and decline with age.
- Sex: Female reproductive hormones lower aerobic power and pulmonary function.
- Body size: Smaller bodies naturally have smaller lung capacity.
- Physical conditioning: Lung capacity improves (up to about 15 percent) with frequent aerobic exercise.

During exercise, tidal volume typically increases as breathing becomes deeper. This allows the lungs to take in more oxygen and expel more carbon dioxide. However, tidal volume does reach a plateau based on exercise intensity. During low- to moderate-intensity exercise, research has shown that the increase in tidal volume and breathing rate is roughly proportionate to the exercise intensity. However, at higher intensity efforts, a plateau in tidal volume is reached, and the only way to increase respiration is to increase the number of breaths per minute.

MINUTE VENTILATION

The total amount of air entering the lungs over the course of one minute is called the **minute ventilation**. This cardiorespiratory measurement is directly related to a person's tidal volume and is calculated as:

MINUTE VENTILATION: The total amount of air entering the lungs over the course of one minute.

Minute ventilation (MV) = respiratory rate × tidal volume (TD)

where the respiratory rate describes how many breaths the person takes per minute.

The average adult has a minute ventilation of about 6 L per minute. During exercise, tidal volume and breathing rate increase to supply working cells more effectively with oxygen for metabolism and to remove waste products. Thus, minute ventilation also increases. The average healthy adult's breathing rate increases to 35 to 45 breaths per minute based on intensity during exercise as their tidal volume also increases. Research has shown that healthy adults typically have a minute ventilation of approximately 100 L during heavy exercise. Well-conditioned clients can have a minute ventilation of up to 160 L during maximum-effort exercise.

Unconditioned people, those with chronic health conditions that affect the lungs directly or the surrounding structures, and people with neuromuscular diseases that progressively weaken the muscles involved in respiration may have reduced minute ventilation. These physical conditions can also cause the body to become reliant on muscles outside those typically used for respiration (e.g., the abdominals), and these people may have shallow, rapid, or labored breathing. For a fitness professional, this is important to recognize because it can affect a client's ability to breathe adequately during physical activity, and the intensity or effort may need to be adjusted.

VO_2 MAX

A person's VO_2 max is a calculation of how much oxygen the body can use during intense exercise (V, volume; O_2, oxygen). The more oxygen the body can use during exercise, the more cellular energy can be produced to fuel that exercise. Recent research has shown that although VO_2 max is partially predetermined by genetics, it may also be increased with appropriate training.

VO_2 max is measured as the volume of milliliters of oxygen consumed per kilogram of body weight per minute (mL/kg/min) and is most accurately calculated in a laboratory setting. The Astrand-Rhyming Cycle Ergometer Test uses a bicycle to measure all-out efforts under a strict protocol. While this is not conducted in most fitness settings (some facilities do have the proper equipment and trained staff), the Rockport Walk Test (RWT) is often executed more easily. This assessment requires a one-mile walk on a treadmill as fast as possible and has been found to be relatively accurate for the estimation of VO_2 max in adults aged 20 to 69.

With the Rockport Walk Test, VO_2 max is calculated as:

Estimated VO_2 max (mL/kg/min) = 132.853 – (0.0769 × body weight [lb]) – (0.3877 × age) + (6.3150 × sex) – (3.2649 × RWT time in minutes and hundredths) – (0.1565 × 1 – HR)

where age is in full years (no fractions), the sex variable is zero (0) for females and one (1) for males, and the HR is the beats per minute taken at the end of the mile assessment. The mile walk time is written in minutes and hundredths. For example, a time of 10:30 is 10.5 minutes, or a time of 11:15 is 11.25 minutes.

This estimation has been found to have an error margin of +/– 5, so the result should account for this margin of error. For example, a VO_2 max calculation of 35 mL/kg/min would estimate between 30 and 40 mL/kg/min.

Some research has shown a link between heart rate and a person's subjective RPE and VO_2 max. Specifically, heart rate during activity can be used to estimate the VO_2 max in many clients. A general, though less accurate, calculation of VO_2 max considers estimated maximum heart rate and **resting heart rate (RHR).**

RESTING HEART RATE (RHR):
The measure of heart rate when completely at rest.

VO_2 max = 15.3 × (max heart rate / resting heart rate)

where maximum heart rate is calculated as 220 minus age and resting heart rate is beats per minute at rest (or the number of heartbeats at rest for 30 seconds multiplied by 2).

The norms for VO_2 max also consider sex. It is important to understand that these calculations are merely estimations unless completed under laboratory supervision, but the overall results can be improved with cardiorespiratory training. For consistency, whichever method is used to estimate VO_2 max initially should be repeated for future evaluations.

Table 11.6 VO_2 Max Norms by Sex

VALUE FOR VO_2 MAX						
VO_2 Max Norms for Men as Measured in ml/kg/min						
Age	Very Poor	Poor	Fair	Good	Excellent	Superior
13-19	<35.0	35.0-38.3	38.4-45.1	45.2-50.9	51.0-55.9	>55.9
20-29	<33.0	33.0-36.4	36.5-42.4	42.5-46.4	46.5-52.4	>52.4
30-39	<31.5	31.5-35.4	35.5-40.9	41.0-44.9	45.0-49.4	>49.4
40-49	<30.2	30.2-33.5	33.6-38.9	39.0-43.7	43.8-48.0	>48.0
50-59	<26.1	26.1-30.9	31.0-35.7	35.8-40.9	41.0-45.3	>45.3
60+	<20.5	20.5-26.0	26.1-32.2	32.3-36.4	36.5-44.2	>44.2
VO_2 Max Norms for Women as Measured in ml/kg/min						
13-19	<25.0	25.0-30.9	31.0-34.9	35.0-38.9	39.0-41.9	>41.9
20-29	<23.6	23.6-28.9	29.0-32.9	33.0-36.9	37.0-41.0	>41.0
30-39	<22.8	22.8-26.9	27.0-31.4	31.5-35.6	35.7-40.0	>40.0
40-49	<21.0	21.0-24.4	24.5-28.9	29.0-32.8	32.9-36.9	>36.9
50-59	<20.2	20.2-22.7	22.8-26.9	27.0-31.4	31.5-35.7	>35.7
60+	<17.5	17.5-20.1	20.2-24.4	24.5-30.2	30.3-31.4	>31.4

METABOLIC EQUIVALENT (MET)

The MET is the measure of the ratio of expended energy to the person's mass while performing physical activity. This measure considers the metabolic rate at rest and the metabolic rate required to support an activity. One (1) MET is equal to a person's metabolic rate when at rest. One (1) MET is approximately 3.5 mL of oxygen consumed per kilogram of body weight and is calculated as:

1 MET = weight (kg) × 3.5 mL

For example, a 150-pound person (68.04 kg) would have a 1 MET of 68.04 kg × 3.5 mL = 238.14 mL of oxygen per minute.

A MET value of four would mean this person is using four times the amount of oxygen and has a metabolic rate four times that of their metabolic rate at rest. Energy expenditure can vary by age and fitness level, but for most healthy adults, MET values can be helpful in exercise planning and as a gauge for the effort being put forth during activity.

Several activities have been calculated in METs for the average adult. The approximation of METs can be used to estimate the number of Calories burned during each activity for an individual.

Table 11.7 Estimated MET Values for Specific Activities

LIGHT < 3.0 METS	MODERATE 3.0–6.0 METS	VIGOROUS > 6.0 METS
Sitting at a desk: 1.3	Housework (cleaning, sweeping): 3.5	Walking at very brisk pace (4.5 mph): 6.3
Sitting, playing cards: 1.5	Weight training (lighter weights): 3.5	Bicycling 12–14 mph (flat terrain): 8
Standing at a desk: 1.8	Golf (walking, pulling clubs): 4.3	Circuit training (minimal rest): 8
Strolling at a slow pace: 2.0	Brisk walking (3.5–4 mph): 5	Singles tennis: 8
Washing dishes: 2.2	Weight training (heavier weights): 5	Shoveling, digging ditches: 8.5
Hatha yoga: 2.5	Yard work (mowing, moderate effort): 5	Competitive soccer: 10
Fishing (sitting): 2.5	Swimming laps (leisurely pace): 6	Running (7 mph): 11.5

The Caloric value of an activity can be estimated using the MET value for the activity, body weight in kilograms, and the following formula:

Calories burned per minute = (activity METs × 3.5 × bodyweight [kg]) / 200

For example, consider the 150-pound person again. Their weight in kilograms is 68.04 kg, and they are walking at a very brisk pace with a MET value of 6.3.

Calories per minute = (6.3 × 3.5 × 68.04kg) / 200

= (1500.282) / 200

= 7.5 Calories per minute

7.5 Calories per minute × 60 minutes = approximately 450 Calories burned per hour during this activity.

LACTATE THRESHOLD

Another means for calculating the efficiency of the cardiorespiratory system is the **lactate threshold**. Lactate is a by-product of metabolism that is produced by blood cells, the brain, and muscle tissue. It is used to supply the cells with energy when there is a lack of oxygen or when normal cellular metabolism is disrupted. Lactate is a fuel, not a waste product. However, the threshold where lactate builds up in the tissues faster than it can be cleared is an important indicator of cardiorespiratory endurance performance and can be improved with cardiorespiratory training.

LACTATE THRESHOLD: The maximum effort or intensity an individual can maintain for an extended time with minimal effect on blood lactate levels.

The measure of the lactate threshold measures the maximum effort or intensity a person can maintain for an extended time with minimal effect on blood lactate levels. This requires a blood draw to measure blood lactate levels, which makes it accurate but not necessarily practical in a fitness setting. Lactate threshold is often expressed as approximately 75 percent of VO_2 max or 85 percent of the maximum heart rate for the average person and can vary based on fitness level.

VENTILATORY THRESHOLD

Closely related to the lactate threshold is the **ventilatory threshold (VT)**. This measure tracks changes in carbon dioxide extraction, oxygen consumption, and breathing rate and volume. Ventilatory threshold represents the lactate threshold—the level of intensity where blood lactate accumulates faster than it can be cleared from the body—and it causes a person to breathe faster (increase their breathing rate) to consume more oxygen and expel more carbon

VENTILATORY THRESHOLD (VT): The threshold where ventilation increases faster than the volume of oxygen.

dioxide. It is measured with a breathing mask or based on observable breathing rates as opposed to the blood draw needed to accurately measure lactate thresholds.

For the average adult, the ventilatory threshold is at exercise intensities between 50 and 75 percent of maximum. An unconditioned client will reach their ventilatory thresholds at lower physical intensities than a trained one. For example, walking may elevate an unconditioned client's breathing rate, while someone who has been training for a while may need to be running at a seven-mile-per-hour pace to elevate their breathing rate.

It is also related to VO_2 max in that ventilatory thresholds occur before maximum oxygen uptake. Ventilatory threshold 1 (VT1) occurs when the breathing rate begins to increase during activity, and ventilatory threshold 2 (VT2) is at a relatively high-intensity effort when the person is out of breath. When someone achieves their VO_2 max, they will no longer be able to continue their exercise or activity.

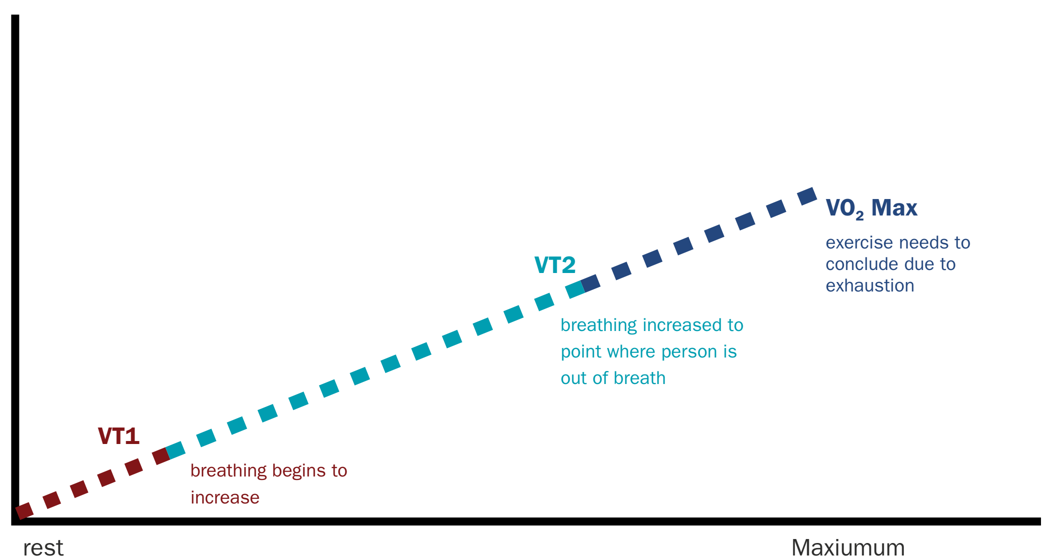


Figure 11.2 Ventilatory Thresholds and VO_2 Max

MAXIMUM HEART RATE

Maximum heart rate is the maximum beats per minute someone's heart can achieve during activity, and it is a measure that is estimated to help determine exercise intensity for cardiorespiratory training. Testing to determine a client's actual maximum heart rate requires the client to work at maximum capacity, which is not practical for a fitness setting. However, an estimation of maximum heart rate is commonly found using the following formula:

Maximum heart rate (HRmax) = 220 – age

where age is in whole years. While commonly used to estimate maximum heart rate, this formula has a margin of error of +/– 10 to 15 beats.

There is great variability by client and age on actual heart rate maximums. For example, a well-conditioned client will likely have a higher maximum heart rate and a lower resting heart rate because their cardiorespiratory system is more conditioned and efficient and can handle more work than an unconditioned client. With that in mind, a fitness professional can estimate a client's heart rate and corresponding heart rate zones, but this formula should not be used as an absolute.

HEART RATE ZONES

The heart rate is a key indicator for exercise intensity and is used by fitness professionals to prescribe intensity and evaluate fitness levels. There are five heart rate zones that generally correspond with exercise intensities. Each zone represents a range of the percentage of maximum heart rate and an RPE. As with the maximum heart rate estimation, heart rate zones are also estimations and can vary based on the training status, health condition, age, and body size of the client.

Zone 1 is a very light intensity and equates to 50 to 60 percent of maximum heart rate and an RPE of 1 to 2. Examples of zone 1 activities include a warm-up, a cooldown, and a slow walking pace. This zone can be used to slightly elevate the heart rate, promote physical recovery, and promote optimal metabolism. Activities in zone 1 can be sustained for extended periods.

Zone 2 is a light intensity and equates to 61 to 70 percent of maximum heart rate and an RPE of 3 to 4 (easy). Lightweight resistance training, a light jog, or walking up a flight of stairs would fall into zone 2 cardiorespiratory intensity. Breathing at this intensity is light, and the client may begin to sweat. Training in this zone can improve both muscular and cardiorespiratory endurance and can be sustained for extended periods.

Zone 3 is a moderate training intensity and equates to 71 to 80 percent of maximum heart rate and an RPE of 5 to 6 (moderate). Breathing may begin to deepen with moderate sweating in this zone. Based on the percentage of maximum heart rate, training in zone 3 is generally still aerobic, and aerobic fitness can be improved. Hiking, a moderate jog, and moderate-paced resistance training are generally zone 3 activities that can elicit this level of heart rate response.

ANAEROBIC EXERCISE: Short-duration muscle contractions that break down glucose without using oxygen.

Zone 4 is generally moving into **anaerobic exercise** and is a challenging intensity. Training in this zone equates to 81 to 90 percent of maximum heart rate and an RPE of 7 to 8 (hard). Training in zone 4 can only persist for moderate amounts of time and elicits feelings of physical fatigue and heavy breathing to the point that the client cannot carry on a conversation. For example, running at a five-kilometer run pace, cardiorespiratory interval training, or resistance training intervals would fall into zone 4. Training in this heart rate zone can promote anaerobic fitness improvements and improve performance capacity.

The final heart rate zone is zone 5. Zone 5 is maximum effort and equates to 91 to 100 percent of maximum heart rate with an RPE of 9 to 10 (very hard). This intensity can only be maintained for short durations, and it will feel like an all-out effort. Training in this zone can improve athletic performance, fast-twitch muscle fiber development, and sprint speeds. Not all clients will need to reach this heart rate zone. However, unconditioned clients may reach this zone and RPE at lower heart rates than estimated, while more conditioned clients will see the opposite effect.

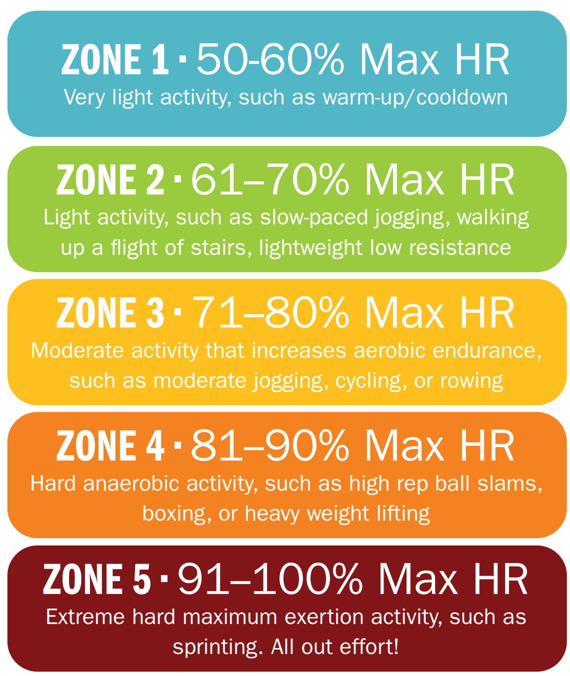


Figure 11.3 Heart Rate Zones

To calculate the beats per minute that equate to each heart rate zone during cardiorespiratory fitness prescription, a client's maximum heart rate will be multiplied by the high and low ranges of each zone. For example, consider a 35-year-old client.

$$HR_{max} = 220 - 35 = 185 \text{ beats per minute}$$

Zone 1: 185 bpm × 0.50 = 92 bpm

185 bpm × 0.60 = 111 bpm

Zone 1 = 92 to 111 beats per minute

Zone 2: 185 bpm × 0.61 = 113 bpm

185 bpm × 0.70 = 129 bpm

Zone 2 = 113 to 129 beats per minute

Zone 3: 185 bpm × 0.71 = 131 bpm

185 bpm × 0.80 = 148 bpm

Zone 3 = 131 to 148 beats per minute

Zone 4: 185 bpm × 0.81 = 149 bpm

185 bpm × 0.90 = 166 bpm

Zone 4 = 149 to 166 beats per minute

Zone 5: 185 bpm × 0.91 = 168 bpm

185 bpm × 1.0 = 185 bpm

Zone 5 = 168 to 185 beats per minute

Again, these heart rate beats per minute are not absolute but can provide general guidance as to where the client's heart rate needs to be to achieve the desired cardiorespiratory training effect.

HEART RATE RESERVE AND TARGET HEART RATE (THR)

Heart rate reserve (HRR) calculates the difference between a person's estimated maximum heart rate and their resting heart rate. It is a metric that can be tracked and improved as the resting heart rate decreases with cardiorespiratory conditioning. A fitness professional can use this formula to calculate HRR:

HEART RATE RESERVE (HRR):
Maximum heart rate minus resting heart rate.

$$HRR = HR_{max} - HR_{rest}$$

HRR can also be used to calculate a client's THR. THR is the desired heart rate to be achieved based on the desired exercise intensity, and this measure also considers the person's maximum and resting heart rates. THR can be calculated with the **Karvonen formula** as follows:

KARVONEN FORMULA:
The formula to estimate a target heart rate with consideration of heart rate reserve and resting heart rate.

$$\textbf{THR} = ([\textbf{HR}_{max} - \textbf{HR}_{rest}] \times \textbf{desired intensity}) + \textbf{HR}_{rest}$$

Consider the 35-year-old client again with a resting heart rate of 55 beats per minute. If the trainer would like them to work at 80 percent training intensity, their THR would be calculated as follows:

$$HR_{max} = 220 - 35 \text{ (age)} = 185 \text{ bpm}$$

$$HRR = 185 \text{ bpm} - 55 \text{ bpm (resting)} = 130$$

$$THR = ([HRR] \times 0.80 \text{ [intensity]}) + 55 \text{ (resting)}$$

$$= (130 \times 0.80) + 55$$

$$= 104 + 55$$

$$THR = 159 \text{ bpm for 80 percent exercise intensity}$$

WEARABLE FITNESS TECHNOLOGIES

Wearable fitness technologies track physical activity, such as heart rate, steps taken, and Calories burned. Most come with a three-axis accelerometer to track movement in every direction. Physical activity has numerous benefits to health, wellness, and fitness. Tracking physical activity is an effective way to monitor activity. Most people tend to overestimate time spent in vigorous intensities and underestimate sitting and low-intensity activities unless they have objective data. Wearables are a great way for clients to get a feel for how hard or long they are working and how active they are. Objective data can help a fitness professional set and monitor realistic goals for clients.

WARM-UP AND COOLDOWN

A general warm-up should be conducted before a cardiorespiratory training bout to increase heart rate, breathing, and body temperature and to psychologically prepare the client for exercise. A general warm-up should include 5–10 minutes of low- to moderate-intensity activity. Examples of general warm-up exercises include walking, jogging in place, walking lunges, jumping jacks, or a few slow laps in the pool.

Self-myofascial release and targeted stretching for movement preparation should also be conducted during the warm-up period. This is especially true for clients with a history of injury, muscle imbalance, or tightness in certain muscles.

Specific warm-ups are done to further enhance performance of the exercise activity to follow and should come after the general warm-up. A specific warm-up should include dynamic movements that mimic the exercises that follow. Warm-up exercises should target the joints and muscles that will be used in the workout. This may include lower-intensity intervals of the activity such as leg swings before running stadium stairs or high-knee marching before sprint intervals.

A fitness professional should allow at least 30 seconds to 3 minutes of rest before beginning the training session.

After the exercise bout, a client should perform a cooldown. A proper cooldown routine will allow the heart rate and body temperature to return to normal. The cooldown period may last from 5 to 10 minutes but should ideally last until the heart rate is back to normal. Elements of flexibility may be added to the cooldown after heart rate has returned to resting.

During exercise, the heart must pump a greater volume of blood to support working muscles. The muscles aid in this process by contracting with more force against the blood vessels. With this force helping the blood resist gravity, it quickly returns to the heart to be reoxygenated and sent back out to the body. If intense exercise is stopped abruptly without allowing the body to cool down, blood may pool in the lower extremities and cause dizziness or loss of consciousness.

PHYSIOLOGICAL ADAPTATIONS TO AEROBIC EXERCISE

Aerobic exercise burns stored fat from adipose tissue, improves cardiovascular health and fitness, and improves the body's ability to recover after intense exercise. Aerobic exercise is typically longer duration and relies on slow-twitch muscle fibers, which contract slower and at a lower intensity. One major training adaptation of aerobic exercises is the increase in the size and number of type I muscle fibers to improve endurance performance.

Aerobic exercise cannot change type II muscle fibers into type I fibers contrary to popular belief. These fiber types are too inherently different. However, some muscle fibers can begin to favor and take on similar characteristics as another type of fiber based on the activity of the person. This can occur, for example, if a sedentary person becomes more active and begins to train for an athletic event such as powerlifting. While the adaptations surely do not come overnight, this person, with proper training, will start to generate larger type II muscle fibers and train a relatively low number of type I fibers to support their activity.

ATROPHY:
The wasting away or loss of muscle tissue.

In the same respect, type II fibers are more prone to **atrophy** with nonuse. This means there are physiological mechanisms in the fast-twitch fibers that make them more likely to degenerate than the more readily activated type I fibers.

ANGIOGENESIS:
The development of new blood vessels.

Aerobic training also increases the number and size of blood vessels because of the need for higher levels of oxygen. Capillary networks surround the muscle fibers in a process called **angiogenesis**. Increased amounts of nutrients and oxygen supply the muscles with fuel, and waste is removed faster. This, in turn, supports muscular endurance, resistance to fatigue, and recovery.

MYOGLOBIN:
A protein in muscle cells that carries and stores oxygen.

AEROBIC CAPACITY:
A measure of the ability of the heart and lungs to get oxygen to the muscles.

Aerobic exercise also triggers important metabolic changes in muscle tissue, including an increase in mitochondria and myoglobin. Mitochondria are necessary for energy production, and **myoglobin** stores the oxygen needed for that process. These changes improve **aerobic capacity**, a measure of the ability of the heart and lungs to get oxygen to the muscles. Many of these adaptations contribute to the body's increased ability to store muscle glycogen and use fat for energy with aerobic training as well. Since fatty acids are a more efficient source of ATP, assuming adequate nutrition, the body will increase its ability to release fatty acids into the bloodstream during aerobic exercise.

CARDIAC MUSCLE ADAPTATIONS

Aerobic exercise is ideal for strengthening the heart muscle, lungs, and blood vessels. A strong, healthy heart efficiently supplies working muscles, organs, and tissues with oxygenated, nutrient-rich blood and removes metabolic waste.

As the body is conditioned through aerobic exercise, the cardiac muscle strengthens, delivery of blood and oxygen to the heart itself is improved, and the heart chambers empty and fill more efficiently. All these adaptations improve the pumping capacity of the heart. The heart can then pump more blood with fewer heartbeats, reducing the resting and maximum heart rates of trained people.

MODES OF CARDIOVASCULAR EXERCISE

Along with the various cardiovascular machines available, there are several basic modes of cardiovascular exercise. Walking and running serve as the foundation for most cardiovascular training sessions. Proper form, movement mechanics, and ranges of motion contribute to the efficacy of any cardiovascular activity and will prevent overuse injuries. Choosing an appropriate mode of exercise for clients involves client goals, convenience, preference, and client ability. The mode a client will consistently use may be the best option, at least initially.

WALKING

Walking is a low-impact workout suitable for most clients. A fitness professional should coach clients on posture, foot motion, stride, and arm swing to get the most from this exercise.

Posture

- Stand straight with feet about hip width apart, toes pointed forward, shoulders relaxed and pulled back, and chin parallel to the ground.
- Engage the core muscles by pulling the belly button back toward the spine.
- Do not lean forward or arch the back.

Foot Motion

- Follow a heel-toe motion with the heel striking the ground first.
- Roll through the step from heel to toes, and push off with the toes.

Stride

- Keep a natural stride distance; do not overextend the front leg. The heel should strike the ground close to the front of the body.
- The back leg is what propels the body forward. Keep the rear foot on the ground for as long as possible, then push off with the toes as the hip and knee reach full extension.
- Hips should move front to back, not side to side.

Arm Swing

- Close the hands into loose fists, but do not clench the fists because this can raise blood pressure.
- The arms should swing naturally from relaxed shoulders. The forward hand should not cross the midline of the body.
- Keep the elbows close to the body.

RUNNING

The basic mechanics of running are similar to those of walking. However, the foot strike differs. Here are some additional tips a fitness professional should share to cue proper running form:

- Shoulders should trace an “X” pattern. As the right foot comes forward, the left shoulder moves forward. While the left foot is back, the right shoulder should be forward. Shoulders should stay relaxed and over the hips.
- Lean slightly into the run by hinging at the hips and bracing the core. This helps engage the gluteus maximus for more power through the stride as the hip and knee extend.
- Knees should fall in line with hips and midfoot. Measure by imagining a line from the front of the hip joint through the knee joint and through roughly the second and third toe.
- The most efficient running stride is one in which the shin is perpendicular to the

ground, directly underneath the hips, torso, and head when the foot strikes the ground and is bearing the weight of the body. However, for running fast, an anterior or positive shin angle means increased force application in the direction desired.

- The ideal foot strike when running occurs at the forefoot versus the heel (when walking).

TREADMILL

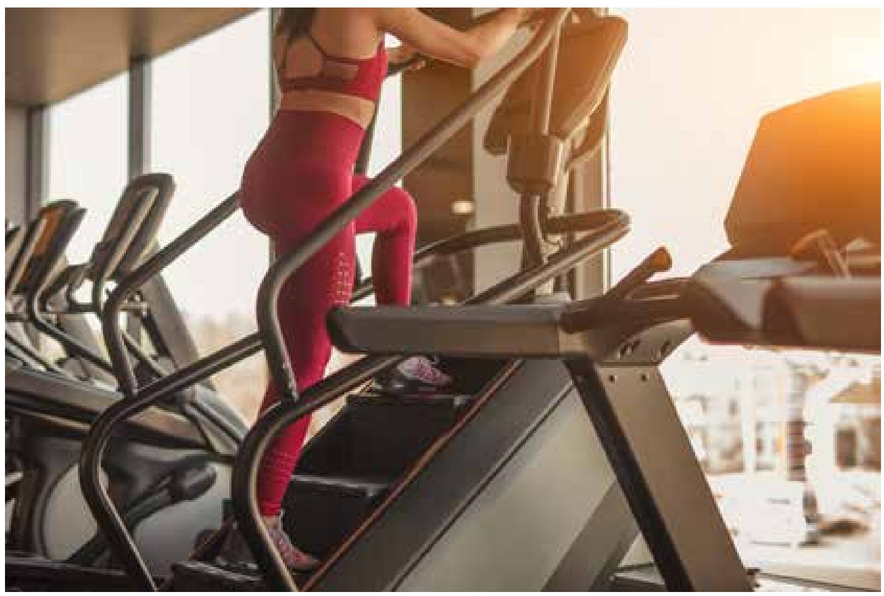
Treadmills are commonly used for walking or running, as part of a warm-up or cooldown, or for cardiovascular endurance assessments. Here is how a client can safely use a treadmill:

- With the treadmill off, grab the handrails and place feet on the sides of the belt. Attach the safety clip to the clothing, and press the “Start” button.
- The belt will move slowly. Place one foot at a time onto the moving belt. Start walking.
- Remove hands from the handrails.
- Walk or run with proper form without holding on to the handrails.
- To get off the treadmill, allow the belt to stop completely. Place feet on the sides of the belt. Hold on to the handrails. Remove the safety clip. Step off, one foot at a time.

STAIR-CLIMBER AND STEP MILL

A stair-climber has pedals that move up and down to mimic walking up steps. A step mill is a revolving staircase that simulates walking or running up a flight of stairs. Here is how a client can safely mount and dismount these machines:

- With the machine off, grasp the handrails. Step up, one foot at a time, and place feet on the pedals or step. If on a step mill, climb to the highest step.
- Attach the safety clip to the clothing. Press the “Start” button.
- To dismount, make sure the pedals are immobile or the steps have come to a complete stop. Grasp the handrails. Unclip the safety clip from the clothing. Step off, one foot at a time.



Form and Posture on a Stair-Climber

The handrails on the stair-climber should only be used for getting onto and off the machine or for balance as necessary.

- Stand upright. Hinge slightly forward from the hips.
- Keep the entire foot on the pedal.
- Steps should be moderately deep, not short or choppy.

Form and Posture on a Step Mill

- Use the handrails for getting onto and off the step mill or for balance as necessary.
- Stand upright. Keep a neutral spine. Relax the shoulders and look straight ahead.
- Do not hunch over or lean on the handrails.

SWIMMING

Swimming is a very low-impact aerobic activity and is often used as a recovery technique because of its minimal impact on the body. In addition to the benefits realized by aerobic exercise, swimming offers the following:

- Reduced exercise-induced asthma symptoms from exercise in moist air
- Increased lung volume, which helps further reduce asthma symptoms
- Improved bone strength, especially in postmenopausal women
- Relief from arthritis symptoms such as joint stiffness and pain

To safely coach clients in the pool, it is best for a fitness professional to become a certified swim instructor or water safety instructor through the Red Cross or to refer a client to one.

CYCLING

Cycling is a versatile, low-impact sport that can be done outdoors or indoors, in urban or rural areas. Variables in cycling that affect intensity include the following:

- **Tires:** Road bikes have thinner tires that reduce resistance on the street, while mountain bikes have thicker, rugged tires to grip the terrain for better traction.
- **Cycle frame:** In outdoor cycling, the lighter the frame, the lower the resistance.
- **Cadence:** The rhythm at which pedals affect muscle activation. One study showed that higher speeds increased hamstring activation, while slower speeds engaged the quadriceps.
- **Environment:** Weather affects cycling performance in outdoor cycling.
- **Terrain:** The condition of streets or trails affects overall performance as do incline and decline (hills).

The muscles engaged in cycling include the gluteus maximus, semitendinosus, semimembranosus, biceps femoris, adductor magnus, vastus lateralis (externus), vastus intermedius, vastus medialis (internus), gastrocnemius, soleus, plantaris, tibialis posterior, flexor hallucis, and flexor digitorum longus.

Here's how a fitness professional can properly adjust a cycle for comfort, ergonomics, and performance:

Table 11.8 Upright and Recumbent Bike Setup Procedures

UPRIGHT CYCLES	RECUMBENT CYCLES
Adjust the saddle (seat) to hip height. Lift the knee to a 90-degree angle from the hip, and adjust the saddle to the height of the thigh.	Adjust the seat so that the extended leg has a slight bend in the knee.
When seated, the extended leg—with the pedal at the bottom of its rotation—should have a slight bend in the knee.	Clients with lower back issues may benefit from riding a recumbent rather than an upright cycle. However, clients with knee pain or injury may benefit more from upright cycles because recumbent cycles put much more strain on the legs and knees.
With the pedals parallel to the floor, the knee of the forward leg should be over the ball of the foot.	
Handlebars should be far enough away to allow a slight bend in the elbows. For clients with lower back issues, raise the handlebars until they are comfortable.	

ROWING

Rowing is a low-impact aerobic activity that engages the legs, core, back, and arms. It is ideal for including in cross-training. To mount the rowing machine, a client should sit on the seat and bring the seat to the front of the machine, nearest the flywheel. Then the client should place feet into the stirrups and secure the straps across the toes at the base of the great toe joint. Grasping the oar with the thumbs under the handle, the client should maintain a light grip.

Each rowing movement has four parts:

- **The catch:** This is the starting position. The shins should be vertical, lats engaged, shoulders relaxed, and core engaged. The client should lean slightly forward with shoulders just in front of hips. A fitness professional should coach the client to not allow the shoulders to round forward. Some of the muscles engaged in this position are the deltoids, triceps, trapezius, serratus anterior, erector spinae, rectus abdominus, hamstrings, tibialis anterior, and gastrocnemius.
- **The drive:** With back straight, core tight, and feet secured, the client should push back with the lower body. Some of the muscles engaged in this position are the biceps, brachialis, brachioradialis, erector spinae, hamstrings, gastrocnemius, soleus, quadriceps, and gluteus maximus.

- **The finish:** When the legs are almost fully extended, the client should hinge backward at the hips and use the upper back to pull the oar toward the chest. The oar should touch just below the chest. A fitness professional should cue the client to engage the lats, not the shoulders or biceps. The drive and finish should be one continuous movement. Some of the muscles engaged in this position are the biceps, brachialis, brachioradialis, forearm extensors, latissimus dorsi, trapezius, quadriceps, posterior deltoid, and gluteus maximus.
- **The recovery:** This is the return to the catch. The client should extend the arms before leaning forward at the hips. Once the hands pass over the knees, the client should allow the knees to bend. Then the client should slide the seat forward and assume the catch position. Some of the muscles engaged in this position are the trapezius, rectus abdominus, hamstrings, anterior deltoid, triceps, wrist extensors, and gastrocnemius.

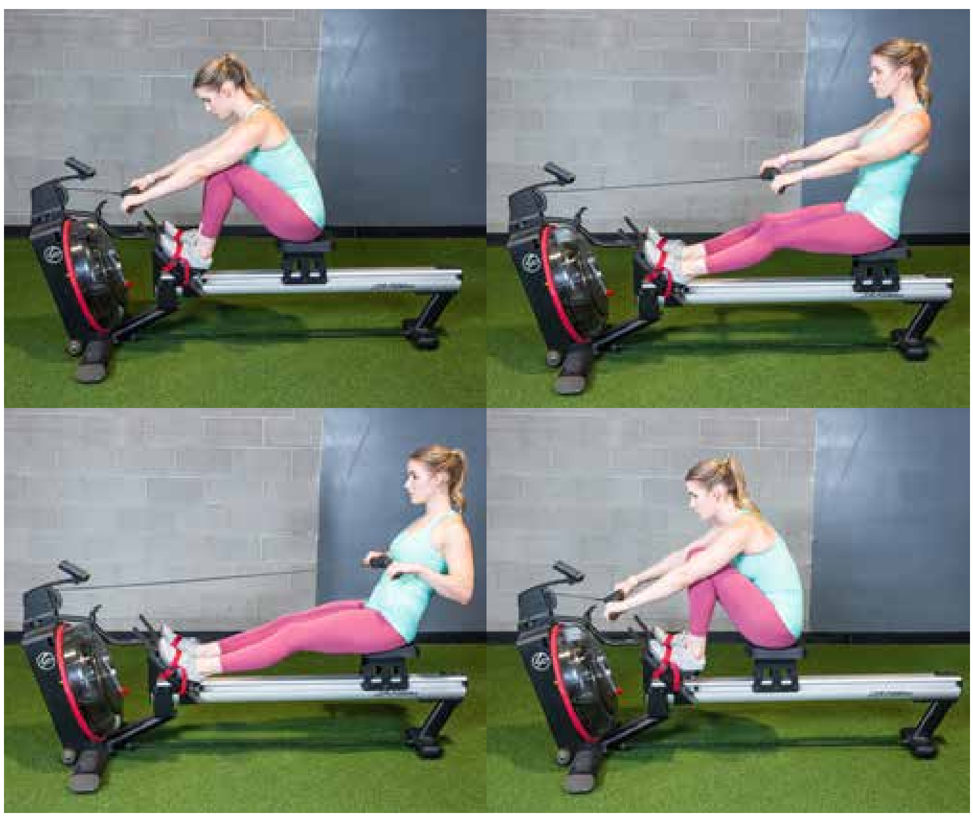


Figure 11.1 Rowing Movement Pattern

JUMP ROPE

Skipping rope offers an intense aerobic workout and may improve balance, coordination, and motor control. In addition, studies have shown that regular rope skipping can increase bone density for young females.

Beginners and novices may find it easier to jump with a beaded rope rather than a cloth or vinyl rope. To find the right length rope, a client should grasp the handles and step on the middle of the rope. The handles should reach the armpits.

A fitness professional should find an area at least four-by-six feet large with enough overhead clearance for the rope to pass. The jumping surface should be a wood floor, a plywood floor, or an impact mat. Fitness professionals should be cautious of having clients jumping on hard or uneven surfaces such as concrete or grass. If a client is not conditioned for jumping, a high volume of jumping is not warranted and does not follow the principles of progression.

A client should practice upper and lower body movements separately. Fitness professionals should coach clients to stay on the forefoot to better absorb impact.

BATTLE ROPES

A battle rope is a heavy rope used for intense metabolic conditioning. Some research suggests that a 10-minute workout with battle ropes meets heart rate and energy expenditure thresholds to increase cardiorespiratory fitness. HIIT with battle ropes may improve aerobic and anaerobic capacity after just one month.

Battle ropes vary by length, thickness, and material.

Table 11.9 Battle Rope Variants

LENGTH	THICKNESS	MATERIAL
From 30 feet to 100 feet	1.0 inches to 2.0 inches	Natural fibers: manila Synthetic fibers: polypropylene, Dacron, or nylon

A large space with a solid anchor on which to affix the rope is needed for battle rope workouts. The most popular use of battle ropes is wave exercises. Pulling exercises are done by wrapping the rope around the anchor.

Here are some guidelines for varying muscle activation and intensity:

- **Thickness:** Thicker ropes increase intensity by activating the forearm and hand muscles to challenge (and develop) grip strength. They also add resistance to the workout because they are heavier.
- **Length:** Longer ropes require more space than shorter ropes but provide more challenge while doing wave exercises.
- **Distance from the anchor:** Waves should reach all the way to the anchor. The further a client stands from the anchor, the more challenging the workout.

- **Wave size/pace:** Wave size is subjective, but the larger the upper body motion, the larger the wave and the greater the intensity. Likewise, pace can increase or decrease intensity. The faster the pace (the smaller the wave), the more intense the workout.
- **Body position:** To vary muscle activation, vary body position. A client should try kneeling, squatting, lunging, sitting, and doing a plank position to target different muscle groups.
- **Wraps:** To perform pulling exercises, a fitness professional can wrap the rope around an anchor, and the client can pull the rope through the anchor, hand over hand, and repeat. Intensity can be added by increasing the number of wraps around the anchor.

KETTLEBELLS

Kettlebells were originally used for recreation and competitive strength athletics. They continue to be used as such and have added functionality in circuit training as a cardiovascular challenge. The benefits of kettlebell training include reduced pain in the neck, shoulders, and low back and stronger overall musculature. Some studies report increased aerobic conditioning for intercollegiate athletes, while other studies report no change in aerobic capacity for sedentary adults. Kettlebell swings are complex movements that should be progressively trained using first no or little weight and then increasing weight as form and fitness improve.

Common kettlebell exercises include the following:

- Deadlift
- Halo
- Lunge
- Overhead press
- Row
- Goblet squat
- Swing
- Turkish getup

HALO

OVERHEAD PRESS

GOBLET SQUAT

Figure 11.2 Kettlebell Exercises: Halo, Overhead Press, and Goblet Squat

CIRCUIT TRAINING

CIRCUIT TRAINING:
Body training that combines endurance, resistance, high-intensity interval, and aerobic training.

Circuit training includes strength training and cardiovascular training. A circuit is a group of exercises performed in succession. Each exercise is done for a predetermined number of repetitions or amount of time before moving on to the next exercise with little to no rest between exercises.

The benefits of circuit training are constant among many populations, including healthy adults, youth, seniors, obese adults, and adults with cardiometabolic syndrome and risk factors for cardiovascular disease. Some proven benefits are as follows:

- Improved body composition
- Increased strength
- Improved cardiovascular performance
- High adherence rate to training

Even the following greater results are realized when circuit training is manipulated to create HIIT:

- Improved peak oxygen uptake
- Increased perception of general health
- Decreased RPEs
- Improved quality of life
- Decreased systolic and diastolic blood pressures
- Increased stroke volume
- Improved emotional well-being

To implement circuit training, a fitness professional should measure the one-repetition maximum (1RM) for each exercise to be performed and determine the training intensity for each. Between 40 and 70 percent of 1RM is recommended. Since measuring 1RM can be problematic, the use of a time frame, such as "should reach fatigue in 30 seconds" or "completes 15 to 20 reps in 30 seconds," is recommended. This will at least provide the fitness professional with a rough guideline concerning what weight to use depending on what the circuit training is targeting.

CROSS-TRAINING

Cross-training is a method of training outside one's chosen sport. For athletes, it helps avoid overuse injuries and can help maintain training adaptations during seasonal training cycles. For general fitness clients, it is a way to improve and maintain overall fitness while increasing engagement and exercise compliance.

CROSS-TRAINING:
The action of training or practice in two or more sports or types of exercise to improve fitness or performance in one's main sport.

Research has shown that cross-training:

- improves muscular endurance better than weight training alone,
- produces similar cardiovascular endurance benefits to running alone, and
- reduces the risk of injury from lifting heavy objects compared with weight training alone.

For strength-based athletes, cross-training should include cardiovascular endurance training. For aerobic endurance athletes, cross-training should include lower-impact aerobic activities and resistance training. Flexibility training is also a sound addition to any cross-training program.

Too much cross-training violates the fitness principle of specificity. Therefore, if a client has sport-specific goals, a fitness professional should include cross-training in the off-season or during a taper.

OTHER SPORTS APPLICATIONS

Sports that require constant movement are considered aerobic. These include basketball, cross-country skiing, dancing, fencing, gymnastics, hiking, hockey, ice-skating, kayaking, lacrosse, martial arts, racquetball, in-line skating, skateboarding, snowboarding, soccer, and tennis—to name a few. Many of these are **cyclic activities** in which the same movement is repeated, but some are considered **acyclic activities** in which different movements are involved. Nearly every sport's performance can be improved with the use of intervals, but the dominating energy system should be the focus of an effective cardiovascular training program.

CYCLIC ACTIVITIES: Activities that use the same movement in repetition.

ACYCLIC ACTIVITIES: Activities that incorporate different movement patterns throughout.

Table 11.10 Energy System Guidelines

ENERGY SYSTEM	WHEN SYSTEM IS DOMINANT	TYPICAL ACTIVITIES	TIME REQUIRED FOR FULL RECOVERY
ATP/CP	0-10 seconds	Resistance training <200 Msprints Plyometrics and ballistics	3–5 min.
Glycolytic	10-120 seconds	Badminton Soccer Gymnastics Hockey 100–400 M sprints	20–60 min.
Aerobic	2 min. and longer	Long-distance running Swimming Rowing Cycling	24–72 hr.

ENVIRONMENTAL INFLUENCES ON ACTIVITY

Many sports have seasons that endure extreme weather conditions. Exercise in extreme heat or extreme cold places additional stress on the body beyond exercise-induced stress. A fitness professional is responsible for making choices about training variables, and environment, including how long and how often a client can train in a given location safely and effectively, is one of those variables.

EXTREME HEAT

Each person's acclimatization state, fitness level, and hydration status affect the body's ability to dissipate heat to the environment. When temperatures are high, the body depends on **evaporative heat loss**—perspiration or sweating—to maintain body temperature.

EVAPORATIVE HEAT LOSS:
Cooling the body and releasing heat via evaporation of water and electrolytes from the skin.

Scientific studies regarding skeletal muscle metabolism during exercise in the heat versus cold have shown the following in heated conditions:

- Increased plasma lactate levels
    - Lactic acid levels rise when oxygen levels decrease.
- Increased muscle glycogen use
    - Depletion of glycogen will reduce muscle endurance.
- Increased serum glucose concentration
    - Body's response to energy demand. Depletion of liver glycogen storage will lead to the onset of fatigue.
- Decreased serum triglyceride concentration
    - There is less fat in the bloodstream, likely due to both less triglyceride manufacture and more muscle use during exercise.
- Increased anaerobic metabolism during submaximal exercise
    - The body expends energy faster than blood can supply the muscles with oxygen. To keep muscles fueled in this oxygen-deprived state, the body increases anaerobic metabolism using glucose.

The causes of these conditions may include reduced muscle blood flow and a redistribution of blood flow away from internal organs in favor of skeletal muscle.

When body temperature rises, the body produces sweat to release excess heat. Sweating rates of one liter per hour may result in dehydration, increasing the thickness of blood and decreasing total blood volume. Both conditions can reduce the amount of heat lost and result in an elevated core temperature, which can be detrimental to health.

EXTREME COLD

During cold exposure, the body reduces heat loss with **peripheral vasoconstriction** and **shivering**. Peripheral vasoconstriction during exercise constricts smaller arterioles near the skin to keep blood closer to the core of the body. This protective response also limits blood flow to the muscles and has been found to contribute to a decrease in muscle function and exercise capacity. Shivering is a generally involuntary contraction or twitching of muscle tissue as a physiological means of heat production, and it is only observed in humans and other mammals. Vasoconstriction occurs first, then shivering if body temperature continues to drop below a set point.

PERIPHERAL VASOCONSTRICTION: Constriction of smaller arterioles near the skin to keep blood closer to the core of the body and preserve heat.

SHIVERING: Involuntary contraction or twitching of muscle tissue as a physiological means of heat production.

Temperature balance within the body in extreme cold and the necessity for shivering are dependent on a few factors:

- Severity of environmental stress
- Effectiveness of peripheral vasoconstriction
- Intensity and mode of exercise

A person's sex, age, and acclimatization state affect the body's thermoregulatory responses to cold. However, the most important factor affecting thermoregulatory tolerance in cold environments is body composition. Bodyfat provides insulation for the body, so those with higher body fat mass will have a less severe reaction to extreme cold than those with less body fat mass.

ALTITUDE TRAINING: Training at altitudes greater than 2,500 meters above sea level with the goal of increasing the blood's oxygen carrying capacity.

ALTITUDE

Altitude training includes training at altitudes greater than 2,500 meters above sea level with the goal of increasing the blood's oxygen-carrying capacity. Specifically, there is an increase in **erythropoietin (EPO)** in the event of chronic **hypoxia** or lack of oxygen, over a period of weeks. EPO is a hormone produced by the kidneys and liver that plays a large role in the production of red blood cells. The resulting training adaptation subsequently improves sea level endurance performance by increasing lung capacity, increasing the lactic acid threshold, and positively influencing red blood cell volume and hemoglobin mass.

ERYTHROPOIETIN (EPO): A hormone with a role in the proliferation of red blood cells.

HYPOXIA: Lack of oxygen.

Acclimatization to altitude occurs between 12 and 14 days at moderate altitudes, up to 2,300 meters, but can take up to several months.

AIR QUALITY AND POLLUTION

Acute exposure to air pollution, including car emissions, ozone, dust, pollen, and mold, has been found to significantly reduce exercise performance. However, the benefits of habitual exercise, even in polluted conditions, seem to win out. In a large-scale study, the Danish Diet, Cancer, and Health study, researchers found that long-term exposure to air pollution while exercising did not reduce the benefits of physical activity on overall health. Furthermore, evidence suggested that exercise reduced the risk of overall mortality by 25 percent.

Even though habitual exercise in polluted areas still has positive effects on health, scientists suggest finding areas with less pollution in which to exercise. There is no sense in taking two steps forward and one step back. Thinking through the best options possible in a creative way will only enhance a fitness professional's value to their clients.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CHAPTER 12

CONCEPTS OF RESISTANCE TRAINING

LEARNING OBJECTIVES

1 | List the benefits of strength training for general health and fitness.

2 | Describe applying strength training principles to achieve specific adaptations.

3 | Explain the manipulation of acute training variables to drive strength training adaptations.

4 | Describe the common types of resistance training equipment.

RELATIVE STRENGTH: The individual's body weight in relation to the amount of resistance they can overcome and found with the following calculation: 1RM / body weight = force per unit of body weight.

MAXIMUM STRENGTH: The ability for a muscle (or muscle group) to recruit and engage as many muscle fibers as possible.

STARTING STRENGTH: The ability to recruit as many motor units as possible instantaneously at the start of a movement.

POWER: The combination of strength and speed—the ability for a muscle to generate maximal tension as quickly as possible.

SPEED STRENGTH: The ability of a muscle or muscle group to absorb and transmit forces quickly.

There are five categories of strength, and each plays a role in programming and acute variable selection and manipulation in fitness. They range from general fitness to sports performance applications. **Relative strength** and **maximum strength** explain the way strength is measured, while **starting strength**, explosive **power**, and **speed strength** are all components of strength. All can be trained and improved with the correct acute variables.

Table 12.1 Strength Categories

STRENGTH CATEGORY	DEFINITION
Starting strength	The ability to recruit as many motor units as possible instantaneously at the start of a movement.
Relative strength	Determined by considering the individual's body weight in relation to the amount of resistance they can overcome and found with the following calculation: 1RM / body weight = force per unit of body weight
Maximum strength	The ability for a muscle (or muscle group) to recruit and engage as many muscle fibers as possible
Power	The combination of strength and speed—the ability for a muscle to generate maximal tension as quickly as possible
Speed strength	The ability of a muscle or muscle group to absorb and transmit forces quickly

TRAINER TIP!

Power is a function of strength.

Power is defined by the equation:

$$\frac{\textbf{force x distance}}{\textbf{time}}$$

Force is mass times acceleration: **F = M x A**

The more strength an individual or athlete has, the more muscular power they are capable of producing. Training for explosive power couples that strength with the speed of muscle contraction with the aim to produce maximal force as fast as possible.

BENEFITS OF STRENGTH TRAINING

The multitude of benefits from strength and resistance training fall into one or more of these categories: body composition, metabolic health, physical capacity, quality of life, and longevity. As little as 10 weeks of resistance training has been proven beneficial to increasing lean body mass, increasing metabolic rate, reducing fat mass, helping manage or prevent diabetes, enhancing cardiovascular health, and promoting bone health.

INCREASING LEAN BODY MASS

Completing just 12–20 exercise sets, two to three nonconsecutive days per week, can increase muscle mass in youth, adults, and the elderly. This increase in muscle mass, known as **hypertrophy**, is due to the increase in the size of muscle cells.

HYPERTROPHY:
An increase in muscular size as an adaptation to exercise.

INCREASING RESTING METABOLIC RATE

Resistance training stimulates muscle protein turnover, requiring up to 100 Calories (Cals) per day or more in additional energy. Chronic strength training increases lean muscle mass, which, in turn, requires more energy at rest, raising the resting metabolic rate (RMR) by about 20 Cals per day per pound of muscle added. Acutely, microtrauma caused to muscle tissue during a training session increases the body's energy needs by 5–9 percent for up to 72 hours following exercise.

REDUCING FAT MASS

A 20-minute circuit training workout burns roughly 200 Cals during exercise and another 50 Cals during the first hour after the workout. Following a routine of just two circuit training sessions per week would burn about 5,000 additional Cals over the course of 30 days. With proper nutrition intervention, this calorie deficit can help reduce body fat overall.

TYPE 2 DIABETES PREVENTION AND MANAGEMENT

Resistance training programs of higher volume and higher intensity have been found to improve insulin resistance and glucose tolerance. The American Diabetes Association recommends that individuals exercise all the major muscle groups three days per week, gradually progressing to three sets of 8 to 10 repetitions at high intensity. This kind of exercise decreases **visceral fat** and has been proven to reduce **hemoglobin A1c (HbA1c)** —a type of hemoglobin linked to sugar. Resistance training is especially helpful for middle- and older-aged adults to counteract the age-related declines in insulin sensitivity.

VISCERAL FAT:
Fat accumulated within the abdomen and around internal organs. It has potentially negative effects on arteries, the liver, and the breakdown of sugars and fats.

HEMOGLOBIN A1C (HBA1C):
A minor component of hemoglobin to which glucose is bound.

ENHANCING CARDIOVASCULAR HEALTH

Strength training helps reduce resting blood pressure. Twenty minutes of resistance training paired with 20 minutes of aerobic activity, done two to three days per week for at least 10 weeks, is proven to reduce blood pressure for adults from 21 to 80 years old. Further, resistance training may increase **high-density lipoprotein (HDL)** cholesterol by 8–21 percent, decrease **low-density lipoprotein (LDL)** cholesterol by 13–23 percent, and reduce **triglycerides** by 11–18 percent.

HIGH-DENSITY LIPOPROTEIN (HDL): A lipoprotein that removes cholesterol from the blood. It is sometimes considered the “good cholesterol.”

LOW-DENSITY LIPOPROTEIN (LDL): The form of lipoprotein in which cholesterol is transported in the blood. It is sometimes considered the “bad cholesterol.”

TRIGLYCERIDES: A chemical compund formed when three fatty acids combine with glycerol. The most abundant fat in the body.

TEST TIP!

Did you know that HDL is known as the “good” kind and LDL is known as the ”bad” kind of lipoprotein?

The body produces and has a use for both, but not all cholesterol is bad!

HDL carries cholesterol from the bloodstream to the liver, so it does not cause arterial blockages. LDL, on the other hand, keeps cholesterol in the arteries, where it can build up and cause plaque, which is known as atherosclerosis.

PROMOTING BONE DEVELOPMENT

Every year, bone mineral density declines by 1 to 3 percent for adults who do not participate in resistance training. For women, resistance training has been shown to increase bone mineral density by over 3 percent. However, if resistance training is stopped, then bone density gains are reversed. Young men also build bone mass, by 2.7–7.7 percent, by resistance training.

REVERSING AGING IN SKELETAL MUSCLE

There is scientific evidence that suggests exercise is able to slow and reduce the effects of aging. In one study, circuit training was found to increase the number of mitochondria and oxidative capacity of muscle tissue. The study looked at the muscle tissue of adults in their late 60s after participating in circuit training. They found healthy mitochondria similar to those of a 23-year-old.

Strength or resistance training has also been proven to improve physical performance, movement control, balance, posture, walking speed, functional independence, cognitive abilities, and self-esteem. Affected participants report reduced low back pain and discomfort from arthritis and fibromyalgia.

Multiple studies have demonstrated the mental health benefits of not just cardio but also resistance training for adults. These include improving symptoms for those suffering from fatigue, anxiety, and depression.

CLASSIFYING STRENGTH

Strength can be further classified by determining whether it is anaerobic, aerobic, linear, or nonlinear. By definition, anaerobic means without oxygen, while aerobic means in the presence of oxygen. **Linear strength** means there is a correlating relationship between two variables—when one variable changes, so does the other in the same way and vice versa. **Nonlinear strength** has variables that are not directly correlated. For example, as strength increases (or decreases), so does muscular power in the same muscle group(s). Though the relationship may not be balanced as a 1:1 ratio, this is a linear strength relationship. The relationship of flexibility and maximal strength, on the other hand, is a nonlinear relationship as one is not directly related to the other. Greater strength does not mean someone is more flexible, nor does improving one's flexibility mean they will get stronger.

LINEAR STRENGTH: Two or more strength variables that are directly correlated to one another.

NONLINEAR STRENGTH: Two or more strength variables that are not directly correlated to one another.

ANAEROBIC AND AEROBIC STRENGTH

Anaerobic strength activities derive energy from the ATP/CP energy pathway and anaerobic glycolysis. An anaerobic strength activity can only be sustained for up to 60 seconds before stored energy is used up. Activities include

- shot put,
- powerlifting,
- high jump,
- golf swing,
- 200- to 400-meter sprint, and
- high-intensity interval training (HIIT).

It takes roughly three to five minutes for the body to restock the cells with **adenosine triphosphate (ATP)** or **creatine phosphate (CP)** after this kind of all-out effort.

Aerobic strength is also known as **endurance strength**. It is the ability to sustain a submaximal activity for a longer duration. Aerobic strength requires oxygen for energy and is fueled by aerobic glycolysis, the oxidative pathway, or gluconeogenesis.

ADENOSINE TRIPHOSPHATE (ATP): An energy-carrying molecule used to fuel body processes.

CREATINE PHOSPHATE (CP): A high-energy molecule stored in skeletal muscle, the myocardium, and the brain.

ENDURANCE STRENGTH: The ability to sustain a submaximal activity for a longer duration.

Table 12.2 Energy System Basics

ENERGY SYSTEM	WHEN THE SYSTEM IS DOMINANT	TYPICAL ACTIVITIES	TIME REQUIRED FOR FULL RECOVERY
ATP/CP	0-10 seconds	Resistance training Short sprints Plyometrics Ballistics	3–5 min.
Glycolysis	10-120 seconds	Badminton Soccer Gymnastics Hockey Short to intermediate sprints	20–60 min.
Aerobic	2 min. and longer	Long-distance running Swimming Rowing Cycling	24–72 hr.

LINEAR AND NONLINEAR STRENGTH ENDURANCE

Any activity that requires a sustained effort for an extended period is a **linear strength endurance activity**. For example, a marathon requires a sustained effort for several hours. Strength and endurance are directly correlated. Another example of a linear activity is an 800-meter or longer swimming event. These events are cardiovascular in nature—requiring aerobic energy—but cannot be completed without adequate strength endurance.

LINEAR STRENGTH ENDURANCE ACTIVITY: Activity that requires a sustained, all-out maximum effort for an extended period.

A **nonlinear strength endurance activity** can be anaerobic or aerobic. Examples include basketball or soccer, in which players use intermittent bursts of agility, speed, and power for a long duration. Another example is a competitive powerlifter. The athlete must complete nine maximum lifts to be scored and as many as 20 near-maximum warm-up lifts during the three- or four-hour competition. Because the event has intermittent rest periods and the activities are not sustained, the activity is nonlinear.

NONLINEAR STRENGTH ENDURANCE ACTIVITY: An activity with intermittent activity and rest periods.

STRENGTH CURVE

The strength curve is a visual representation of the amount of force produced over a range of motion (ROM). Strength curves differ for exercises and individuals and are important to understand regarding exercise selection, equipment used, and even when considering tempo and time under tension during movement execution.

ASCENDING STRENGTH CURVE

In an ascending strength curve, more force is applied toward the end range of motion than during the beginning or middle phase. For example, during the squat, it is possible to lift more weight from above parallel to the top of the movement. This means that much lighter loads would be necessary if starting from below parallel.

DESCENDING STRENGTH CURVE

A descending strength curve is opposite the ascending strength curve. Loads are easier to leverage at the beginning ranges of motion than in the latter. A rowing exercise uses less strength at the beginning of the movement than at the end, when the elbows are pulled back. Exercises with a descending strength curve get more difficult toward the end range of motion.

BELL-SHAPED STRENGTH CURVE

In a bell-shaped strength curve, the beginning and ending phases of movement are more difficult than the middle. An example is the biceps curl. The biceps muscle is at a mechanical disadvantage at the bottom of the curl. Between 60 and 110 degrees of flexion, the biceps muscle gains leverage and produces more force. At the end range of motion, the biceps muscle is at a mechanical disadvantage again and therefore has less potential force production.

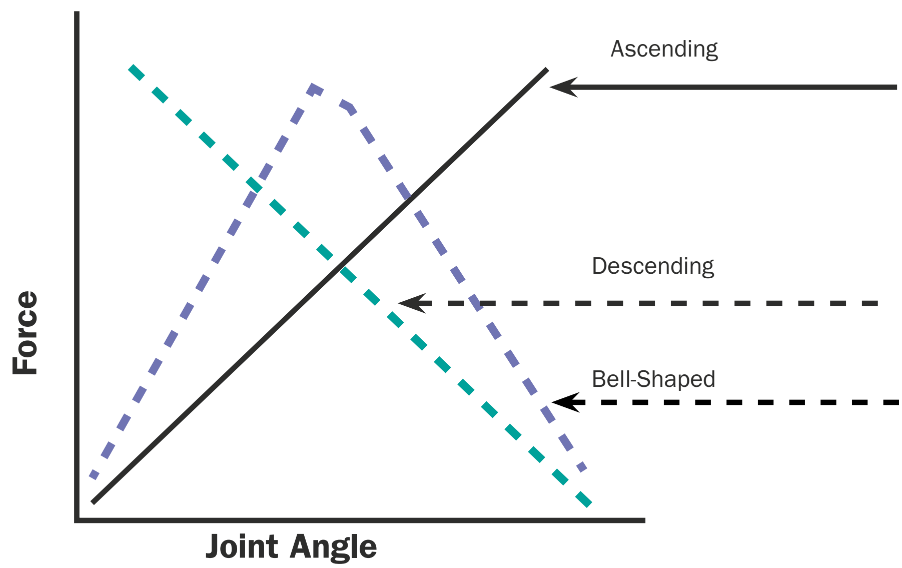


Figure 12.1 Strength Curves

STRENGTH TRAINING AND TRAINING PRINCIPLES

While there are many general fitness principles and training variables, there are some that are specific to strength and resistance training - load, intensity, time under tension, and exercise selection, to name a few variables. It is through proper application of these variables, and the way that resistance training can create overload, that adaptations such as maximizing strength, power, and hypertrophy can be achieved efficiently.

Muscle fiber type also plays a role in the adaptations of an individual. Those with a higher amount of type II fibers will have greater success in building muscle size, strength, and power relative to those with predominantly type I muscle fibers. Those with mostly type I fibers are physiologically predisposed to have greater success with endurance gains.

PRINCIPLE OF SPECIFICITY

Exercises typically progress from a general type (simple) to a more sport-specific or goal-oriented type (complex) as training continues. Assessments allow a trainer to uncover a client's starting point and plan the appropriate progression for their goals and abilities.

To improve general health, fitness, and functional capacity, a balance of several kinds of exercise should be included in the training program. The training goal helps determine the ideal balance of general and specific exercises.

> **TEST TIP!**
>
> A client's goal should determine the specific types of training modalities chosen. For example, to become better at throwing, the muscles involved in throwing, like the pectoralis major, must be trained. How they are trained is the question. The mechanics (the throwing motion) of throwing must be trained and not just the individual muscle as in a chest press.

General Exercises

General exercises can also be considered foundational exercises. In other words, movements can produce overall strength and efficiency gains but do not necessarily transfer to performance of specific skills. Isolation and compound movements using free weights, cables, or machines fall into this category. General exercises include the bench press, cable row, plank, squat, and leg press.

GENERAL EXERCISES: Foundational exercises that train overall strength.

Benefits of including general exercises include a reduced injury risk and an increase in the following:

- Muscle hypertrophy
- Motor unit recruitment
- Bone density
- Connective tissue strength
- Increased cardiovascular capacity

ISOLATION EXERCISES

Isolation exercises are single-joint movements that primarily activate individual muscles or smaller muscle groups. The biceps curl, triceps extension, leg curl, and leg extension are examples. Isolation exercises improve muscle control, strength, and hypertrophy while also

ISOLATION EXERCISES: Single-joint exercises that primarily activate an individual muscle or muscle group.

working to balance musculature—as long as both agonist and antagonist muscles are worked—and enhance the physique and strengthen connective tissue.

Isolation exercises also help target muscles that are not fully activated during compound movements. For example, research has found that hamstring activation is inherently low during exercises such as the leg press and squat. To help strengthen the hamstrings, one can perform isolation movements.

COMPOUND EXERCISES

COMPOUND EXERCISES:
Multi-joint movement exercises that require the use of multiple muscles or muscle groups.

Compound exercises engage multiple joints and many muscle groups throughout a range of motion. Compound exercises increase muscle hypertrophy and bone density and strengthen connective tissues. Examples include

- squats,
- lunges,
- deadlifts,
- bench press, and
- chin-ups.

Applying specificity to exercise selection means training the musculature as well as the neuromuscular connections that innervate the movement. Select exercises use the same movement pattern that a client wants to improve. For example, to increase strength through the squat movement, a client will train primarily with the squat, not the leg press. This ensures the prime movers, synergists, and stabilizers for a squat are all addressed and strengthened appropriately and in proportion. This also facilitates improvements in coordination of the musculature involved in an exercise such as the squat as opposed to the leg press.

TEST TIP!

Most major movement patterns in everyday life and in sports are multi-joint movements that can be trained with compound exercises. This means not only are they a good choice to train multiple muscle groups at once, but they have direct translation to function.

Specific Exercises

Exercises that directly improve performance and are predominantly skill-based are **specific exercises**. The best specific exercises target a particular skill set and, when performed properly, enhance that ability. A baseball pitcher improves pitching skills and speed by practicing pitching. Lacrosse athletes responsible for scoring, called "attackers," need to practice shooting to improve shooting skills. Therefore, sport-specific practice should never be disregarded for strength and conditioning.

SPECIFIC EXERCISES: Exercises that directly improve performance and functional capacity.

Specific exercises must be like the target activity and mimic specific:

- joint movements,
- movement direction,
- range of motion, and
- speed of movement.

Examples of specific exercises include the standing single-arm chest press, which is transferrable to the sports of football, rugby, and ice hockey, as well as any other sport where the athlete must push away an opponent.

CROSS-BODY EXERCISES

Cross-body exercises more closely mimic the natural movement of the body in space. Considering how humans walk, the arm and shoulder on one side "link" diagonally to the hip and leg on the other side so that:

- the left arm and shoulder are forward,
- the left hip and leg are back,
- the right arm and shoulder are back, and
- the right hip and leg are forward.

The terms "x-factor" and "serape effect" were coined to refer to the interaction between various muscles causing the body to move in a crisscross manner, primarily referring to trunk rotation. These muscles—ipsilateral rhomboids, serratus anterior, external abdominal obliques, contralateral internal abdominal obliques, and adductors—attach via fascia in a crisscross manner around the body.

Although research is being done regarding the x-factor, there are no proven training methods. However, because cross-body action is a natural human movement, it should be included in a well-balanced strength training program. Many recent studies have tried to quantify the x-factor to determine how best to train for more power in, say, a golf or baseball swing. Like plyometric exercises, the x-factor muscles use the stretch-shortening cycle. Researchers suggest that flexibility and efficient interaction of x-factor muscles may increase performance.

For example, a 2016 study on badminton technique suggests that training focused on increasing the efficiency of cross-body movement should focus specifically on how the x-factor is incorporated into the kinematic chain of the arm and the racket. A more recent study found that although skilled golfers had greater rotational flexibility, they did not use that flexibility to increase x-factor efficiency to improve clubhead speed.

To load x-factor muscles, clients can use single-arm or offset loading (uneven weights) and vary the stance. Examples of exercises include single-arm standing cable press, high-to-low cable chop, and suitcase carry.

EXPLOSIVE EXERCISES

Exercises that engage many muscles in a sequential, powerful, quick movement are explosive exercises. Soccer, tennis, boxing, shot put, Olympic lifting, sprinting, and many other sports require explosive movements. Explosive movements follow a triphasic pattern of alternating bursts of agonist and antagonist muscle activation.

Phase 1—eccentric: the loading phase of the movement

Phase 2—amortization: the transition time between phase 1 and phase 3

Phase 3—concentric: agonist taking advantage of the stored energy from the eccentric action and firing explosively

Choosing the right explosive movements is key to program success. Since most sports are explosive or ballistic in nature, adding fast, ballistic movements into the training program improves neuromuscular coordination and control and prevents injury. Movements should be trained in various directions as power is direction-specific.

Finally, when considering specificity, the following should be noted:

A recent study measured electrical activity of the upper and lower lateral hamstrings and the upper and lower medial hamstrings during the stiff-legged deadlift and lying leg curl exercises. When compared with the stiff-legged deadlift, the lying leg curl caused significantly greater activation of the lower lateral and lower medial hamstrings. Since each movement offers unique but complementary benefits, it is recommended to include at least one movement focused at the hip joint (deadlift) and one focused at the knee joint (leg curl) to properly train the hamstrings.

No single type of resistance exercise can address the various needs of the human body. Rather than using just one type of resistance, the client should vary the resistance throughout the training cycles based on the physical qualities that are most desired.

PRINCIPLE OF PROGRESSIVE OVERLOAD

For fitness to progress, the body must be forced to adapt to or overcome a stress greater than what is normally encountered. Range of motion, volume, intensity, density, and frequency can all be progressively overloaded to influence adaptations. For the trainer, it is important to understand which acute training variable to overload for the desired result.

PRINCIPLE OF REVERSIBILITY

The idea of "use it or lose it" applies to all aspects of fitness. For example, researchers followed an Olympic rower who took eight weeks off from training after hitting peak fitness during the Olympic games. It took 20 weeks of training to return to their previous fitness level after a two-month hiatus. Several observations have been made regarding detraining and resistance training:

- Detraining happens about three to four weeks after training stops.
- Muscle **atrophy** may occur as soon as two weeks after training stops.
- Endurance performance declines by 4–25 percent after just three to four weeks of no exercise.
- VO_2 max goes down by 6–20 percent at around four weeks of detraining.
- Flexibility declines by 7–30 percent after four weeks of detraining.
- Bed rest or immobilization increases the rate of muscle atrophy.

ATROPHY:
The wasting away or loss of muscle tissue.

TAPERING

Tapering is a planned reduction in training to avoid detraining and increase gains prior to competition. Tapering should meet three objectives:

1. To reduce fatigue as much as possible
2. To increase or maintain fitness at competition levels
3. To enhance specificity

TAPERING:
A decrease in training volume or frequency to allow the body adequate rest and recovery.

Recent research has found that tapering strength training can lead to performance gains from 0.5–6 percent, the average being 3 percent. This can be significant. For example, if a powerlifting athlete peaks at 2,000 pounds, then a taper could increase their maximal lift by 60 pounds.

During a taper, intensity must remain at or slightly above competition levels. Volume (reps x sets x weight) and frequency then should be reduced.

Some studies suggest that volume be reduced by 30–70 percent to improve maximal strength. However, the principle of individual differences comes into play here as well as the fitness-fatigue paradigm:

- Individual A has been following an intense training program for 10 weeks and has a competition in two weeks. This person may benefit from a 70 percent drop in training volume.
- Individual B has been training intensely for four weeks and has a competition in two weeks. This person may benefit more from a one-week taper at 35–40 percent reduced volume.

Tapering is not only for elite athletes. Before moving from one training cycle to another, general fitness program participants also benefit from a taper period.

PHYSIOLOGICAL ADAPTATIONS TO ANAEROBIC EXERCISE

ANAEROBIC EXERCISE: Short-duration muscle contractions that break down glucose without using oxygen.

Anaerobic exercise uses glycolysis without the presence of oxygen. In practical terms, it is harder and shorter movement and can increase the size and quantity of fast-twitch fibers. More fast-twitch muscle fibers means greater strength, power, and larger muscle size. Anaerobic exercise includes short-duration activities such as weightlifting (resistance training), powerlifting, sprints, and high-intensity intervals.

Anaerobic activity cannot last as long as aerobic activity. The lack of oxygen triggers a buildup of lactic acid and excess protons (H+), causing pain and muscle fatigue. However, individuals who engage in anaerobic activity more frequently develop a higher threshold to lactate and proton buildup.

In addition, anaerobic exercise increases glycolysis—the breakdown of glucose for energy. This further increases levels of ATP and creatine phosphate (CP), which can be quickly changed to ATP and used for energy. Intramuscular **creatine** levels also increase, helping supply energy for muscle contraction.

CREATINE:
An organic compound that aids in the recycling of ATP in the energy systems.

Muscle hypertrophy occurs with an increase in mitochondria, myoglobin, extracellular and intracellular fluid, capillarization, and fusion of muscle fibers to surrounding satellite cells. In addition, resistance exercise generates thicker myofibrils, or contractile tissue, increasing the size of individual muscle fibers.

Except for muscular hypertrophy, the cellular changes found in endurance training do not usually happen with resistance training. However, resistance training increases the development of connective tissue. The epimysium and tendons become stronger to support more powerful muscular contractions and prevent injury.

MODIFYING THE ACUTE TRAINING VARIABLES

As with cardiovascular training, commonly manipulated acute training variables for resistance training include the following:

- Frequency
- Intensity
- Time/duration
- Type
- Tempo
- Range of motion
- Repetitions
- Sets
- Rest

FREQUENCY

The client's overall level of fitness, as determined by assessments, is the most important factor to consider when prescribing exercise frequency. In addition, daily workload from exercise or on-the-job tasks must be considered as well as the ultimate training goal. For example, warehouse or construction workers perform many lifts throughout the workday. They may not be able to do more than two or three days per week of strength training without reaching a state of overtraining.

Beginner and Novice Training Status

New trainees should train no more than two to three nonconsecutive days per week when training the entire body. Generally, one to three days of rest should be scheduled between sessions to promote recovery.

Table 12.3 Example Beginner Training Prescription

TRAINING DAYS	EXERCISE PRESCRIPTION	REST PRESCRIPTION
Monday and Thursday	Whole-body exercises	Two days of rest
Tuesday, Thursday, and Saturday or Monday, Wednesday, and Friday	Whole-body exercises	One day of rest between sessions

Intermediate Training Status

SPLIT-ROUTINE: The division of training sessions by body part or body region.

Training frequency may increase to three or four days per week for slightly more experienced clients. Intermediate clients more often follow a **split-routine** when training frequency is increased. A training split allows the client to recover while keeping training volume high.

Table 12.4 Example Intermediate Training Prescription

TRAINING DAYS	EXERCISE PRESCRIPTION	REST PRESCRIPTION
Monday, Tuesday, Thursday, and Friday	Monday and Thursday: upper body Tuesday and Friday: lower body	Two days of rest per major muscle group
Monday, Tuesday, Thursday, and Friday	Monday: chest Tuesday: back Thursday: legs Friday: core	Three days of rest per week; one week of rest per major muscle group

Advanced Training Status

Most clients won't progress to the advanced level of training. However, clients who have reached intermediate training status and want to continue to build strength should consider increasing training frequency to increase training volume—a key factor in developing lean mass and strength. The split training for an advanced client will also be more detailed.

Table 12.5 Example Advanced Training Prescription

TRAINING DAYS	EXERCISE PRESCRIPTION	REST PRESCRIPTION
Monday, Tuesday, Thursday, and Friday	Double split routine Two sessions per day Alternating: Upper-body push exercises; lower-body, upper-body pull exercises; core	Three days of rest per week
Week 1: Thursday rest day Week 2: Friday rest day Week 3: Saturday rest day Week 4: Sunday rest day	Alternating: upper-body push exercises; lower-body, upper-body pull exercises	Three days of training, one day of rest Workouts on unspecified days; rest day is not the same each week

The latest research shows that muscle groups can fully recover and be ready for more training within three days after a hard training session. Therefore, when muscle hypertrophy is the goal, total volume is a determining factor.

Total training volume = sets x weight x reps

ONE-REPETITION MAX (1RM):
A single maximum-strength repetition with maximum load.

Training at a significant intensity, 65–85 percent of **one-repetition max (1RM)**, results in more and faster muscle growth. A recent meta-analysis observed that participants who performed two training sessions per week for each muscle group increased hypertrophy by 6.8 percent over 6 to 12 weeks. Those who trained each muscle group once per week experienced only a 3.7 percent increase in muscle growth over the same period. The net result is 48 percent more growth for the biweekly training group.

INTENSITY

Training intensity is the amount of effort being put forth and is expressed as a percentage of one-repetition maximum for resistance training activities. Intensity can also be measured in relation to 10 repetitions. For instance, if a client lifts 150 pounds for 10 repetitions and cannot complete another lift, that is their 10-repetition maximum.

The rate of perceived exertion (RPE) is another way to measure exercise intensity. This subjective scale is moderately accurate but allows the exercise participant to offer insight into what they are feeling and their level of effort.

Table 12.6 Resistance Training Intensity Protocol for a Training Goal

TRAINING GOAL	INTENSITY (PERCENTAGE 1RM)
Muscular endurance	67 percent or less
Hypertrophy	67 percent–85 percent
Maximum strength	85 percent or greater
Power • Single-repetition event • Multiple-repetition event	80 percent–90 percent 75 percent–85 percent

The table below can be used to determine how much weight to use in a given exercise based on the approximate 1RM of a client. For example, if a client had a 1RM of 150lbs for the barbell bench press and their goal was to gain strength, then a training program would require working at 85 percent or greater of their 1RM for that exercise. The 1RM (150lbs) intersects with 85 percent of 1RM at 127.5lbs, which would be the correct weight to use.

Table 12.7 Percentage of 1RM Chart

1RM (LBS)	PERCENTAGE OF 1RM									
	95%	90%	85%	80%	75%	70%	65%	60%	55%	50%
10	9.5	9	8.5	8	7.5	7	6.5	6	5.5	5
20	19	18	17	16	15	14	13	12	11	10
30	28.5	27	25.5	24	22.5	21	19.5	18	16.5	15
40	38	36	34	32	30	28	26	24	22	20
50	47.5	45	42.5	40	37.5	35	32.5	30	27.5	25
60	57	54	51	48	45	42	39	36	33	30
70	66.5	63	59.5	56	52.5	49	45.5	42	38.5	35
80	76	72	68	64	60	56	52	48	44	40
90	85.5	81	76.5	72	67.5	63	58.5	54	49.5	45
100	95	90	85	80	75	70	65	60	55	50
110	104.5	99	93.5	88	82.5	77	71.5	66	60.5	55
120	114	108	102	96	90	84	78	72	66	60
130	123.5	117	110.5	104	97.5	91	84.5	78	71.5	65
140	133	126	119	112	105	98	91	84	77	70
150	142.5	135	127.5	120	112.5	105	97.5	90	82.5	75
160	152	144	136	128	120	112	104	96	88	80
170	161.5	153	144.5	136	127.5	119	110.5	102	93.5	85
180	171	162	153	144	135	126	117	108	99	90
190	180.5	171	161.5	152	142.5	133	123.5	114	104.5	95
200	190	180	170	160	150	140	130	120	110	100
210	199.5	189	178.5	168	157.5	147	136.5	126	115.5	105
220	209	198	187	176	165	154	143	132	121	110

Table 12.7 Percentage of 1RM Chart (CONT)

1RM (LBS)	PERCENTAGE OF 1RM									
	95%	90%	85%	80%	75%	70%	65%	60%	55%	50%
230	218.5	207	195.5	184	172.5	161	149.5	138	126.5	115
240	228	216	204	192	180	168	156	144	132	120
250	237.5	225	212.5	200	187.5	175	162.5	150	137.5	125
260	247	234	221	208	195	182	169	156	143	130
270	256.5	243	229.5	216	202.5	189	175.5	162	148.5	135
280	266	252	238	224	210	196	182	168	154	140
290	275.5	261	246.5	232	217.5	203	188.5	174	159.5	145
300	285	270	255	240	225	210	195	180	165	150
310	294.5	279	263.5	248	232.5	217	201.5	186	170.5	155
320	304	288	272	256	240	224	208	192	176	160
330	313.5	297	280.5	264	247.5	231	214.5	198	181.5	165
340	323	306	289	272	255	238	221	204	187	170
350	332.5	315	297.5	280	262.5	245	227.5	210	192.5	175
360	342	324	306	288	270	252	234	216	198	180
370	351.5	333	314.5	296	277.5	259	240.5	222	203.5	185
380	361	342	323	304	285	266	247	228	209	190
390	370.5	351	331.5	312	292.5	273	253.5	234	214.5	195
400	380	360	340	320	300	280	260	240	220	200

TIME/DURATION

Time refers to the total amount of time an activity or exercise session lasts. Accumulating time doing general physical activity can account for long-term health benefits. According to the 2018 *Physical Activity Guidelines for Americans, 2nd Edition*, 150 minutes of moderate-intensity aerobic exercise is the recommended amount for adults on a weekly basis. Time is also used to measure the duration of planned bouts of exercise. It is common for cardiovascular exercise to have a planned amount of time associated with each session.

TYPE

The type of exercise selected is determined by training goals. With resistance training, there are several possible exercise types with a combined multitude of individual exercises to choose from, such as barbell, cable, kettlebell, dumbbell, etc. Each has its benefits and drawbacks, depending on the desired training outcome. Within each type are two important sub-variables: **grip**, or hand placement, and breath control throughout a range of motion.

GRIP:
Hand placement.

Grip

Grip describes the way the hands are spaced and positioned on the implement being used. There are seven different grip types that can be modified for greater specificity or enhanced overload:

1. Supinated: the palm faces up toward the ceiling.
2. Pronated: the hand or forearm is rotated, and the palm faces down or back.
3. Neutral: the palms face each other (facing the body's midline).
4. Alternated: one hand grasps the bar in a supinated position, while the other grasps the bar in a pronated position.
5. **Hook**: the barbell is held by gripping the thumb between the barbell and fingers.
6. Open: the thumb does not wrap around the bar.
7. Closed: the hand wraps fully around the bar.

HOOK:
Gripping the thumb between the barbell and fingers.

A 1996 study found that supine grips were the strongest, followed by grips in the neutral position due to their activation of the biceps. Pronated grips were the weakest due to their involvement of the triceps as synergists. While the triceps are a larger grouping of muscles than the biceps, it has been demonstrated that the biceps generate more force and are, therefore, stronger. This is an important consideration before increasing loads. The fitness professional should ensure that the client's **grip strength**—the force applied by the hand to pull or suspend a load—is strong enough to handle the load.

GRIP STRENGTH:
The force applied by the hand to pull or suspend a load.

Breath Control

How one breathes during exercise is important. In most cases, trainees should exhale with exertion—the concentric action—and inhale during the eccentric action. The bench press is an example. The client inhales during the eccentric lowering of the bar to the chest and exhales at the bottom and through the concentric movement to elevate the bar. The exhale during the exertion not only focuses the exerciser on the hardest part of the movement but also serves as an unconscious initiation of abdominal bracing to protect the spinal column.

Clients will often hold their breath during exercise movements when they are not conscious of it. The fitness professional should cue them throughout the range of motion to promote optimal breath control. If they don't breathe throughout the range of motion, they may experience symptoms of dizziness, seeing stars, or **syncope** due to a lack of oxygen. Clients with hypertension or heart problems should be especially mindful of their breathing to avoid complications.

SYNCOPE:
Temporary loss of consciousness related to insufficient blood flow to the brain.

TRAINER TIP!

An advanced breathing technique includes deliberately taking a deep breath to help stabilize muscles of the abdomen, back, and core muscles and protect the spine during exertion. Experienced and well-trained athletes performing structural exercises (exercises that load the vertebral column) with heavy loads often use this technique, known as the **Valsalva maneuver**.

The Valsalva maneuver involves expiring against a closed glottis (part of the larynx). When this is combined with contracting muscles of the abdomen and rib cage, it creates rigidity in the entire torso via increasing intraabdominal pressure. Inhaling and holding the breath on exertion, as opposed to exhaling with exertion, provides up to 20 percent greater force, stabilizes the spine, and helps prevent low back injuries.

VALSALVA MANEUVER:
The act of forcibly exhaling with a closed windpipe, where there is no air that is exiting via the nose or mouth.

TEMPO

The tempo used during exercises in part determines the amount of time muscle tissues will be under tension and how fast those muscle tissues will be contracting. Total tempo accounts for the eccentric, isometric, and concentric muscle actions of an exercise.

Tempo is written as follows:

eccentric count : isometric hold count : concentric count : isometric hold count

Table 12.8 Tempo By Training Goal

TRAINING GOAL	TEMPO (EXAMPLE IN SECONDS)
Muscular endurance	4:0:6:0
Hypertrophy	3:1:3:1
Maximum Strength	3:0:1:0
Power	Fastest controllable tempo

RANGE OF MOTION

Range of motion can be manipulated to meet many objectives. For example, if a client's goal is to perform 10 pull-ups, then beginning with a small range of motion, such as a straight-arm hang, will increase grip strength and be a good initial step for beginners. From there, the client can use assistance (a step, rubber resistance loop, or machine) to perform a bent-arm hang. The next step would be to perform eccentric lowering from the bent-arm position to improve muscular strength (also known as negative pull-ups). Finally, the client would practice a full range of motion pull-up with or without assistance from a loop or machine.

Complex Olympic lifts and variations—hang clean, power clean, push press, clean and press, deadlift, and snatch—should be trained by first isolating and training each range of motion, then combining the movements to perform the exercise through the full range of motion. Little or no resistance should be used to begin. The client can progressively overload the movement as form improves and strength increases.

Partial repetitions—exercise movements performed through a limited range of motion—are a popular resistance training technique. Trainers and athletes use partial repetitions for increasing volume and time under tension, working around injuries in the upper or lower extremities, and overcoming "sticking points"- the weakest point in a range of motion for an exercise.

PARTIAL REPETITIONS:
Repetitions of an exercise intentionally done with a reduced ROM.

The science suggests that partial ROM repetitions could be used as supplemental exercises when added to a balanced training program. Research has compared full and partial range of motion repetitions on the bench press with regard to strength adaptations. There were three groups within this research: a partial ROM, a full ROM, and a combination group. After 10 weeks of training, all groups had nearly identical strength improvements. However, the full ROM group experienced greater levels of strength, cross-sectional areas, fascicle length, and subcutaneous fat loss.

REPETITIONS

One repetition is one completion of a single range of motion for an exercise. Modifying the number of repetitions completed affects exercise outcomes. A range, for example 6–12, means that the individual should be able to complete at least 6 but no more than 12 repetitions. If the individual can continue past 12 repetitions without fatiguing, then the resistance is inadequate to promote adaptation and must be increased.

The ideal repetition count will be based on the desired training outcome as well as, like most variables, the exerciser's strength level and abilities. Repetition ranges and the associated resistance used to challenge the muscles are closely correlated to exercise intensity.

Table 12.9 Repetition Protocol for a Training Goal

TRAINING GOAL	REPETITIONS
Muscular endurance	15 or more repetitions
Hypertrophy	6–12 repetitions
Maximum strength	1–6 repetitions
Power	1–5 repetitions

SETS

A set is the number of times an exercise or group of repetitions is completed. The desired training outcome is part of what dictates the number of sets within a program. Each training outcome has an ideal range of sets for each exercise.

Table 12.10 Set Protocol for a Training Goal

TRAINING GOAL	SETS
Muscular endurance	1–3 sets
Hypertrophy	3–4 sets
Maximum Strength	3–5 sets
Power	3–5 sets

REST

Rest is as important as the other variables for achieving fitness goals. Rest can occur between repetitions, between sets, and between training sessions. For the purposes of resistance and strength training, rest is most often considered as the time allowed between sets for the metabolic recovery of the trained muscles before attempting subsequent sets of work.

TRAINER TIP!

It is important to consider the general adaptation syndrome (GAS) when prescribing rest between sessions, between specific muscle group training, and between training cycles. The fitness professional should conduct assessments and monitor the client for symptoms of overtraining.

Table 12.11 Rest Protocol for a Training Goal

TRAINING GOAL	REST BETWEEN SETS
Muscular endurance	30–60 seconds
Hypertrophy	30–60 seconds
Maximum strength	2–5 minutes
Power	1–2 minutes

WARM-UP AND COOLDOWN

Before resistance training, moderate-intensity general warms-ups and specific warm-ups are recommended. Specific warm-ups, beyond warming the muscles and ligaments, increase muscle force production via neuromuscular facilitation. Self-myofascial release (SMR) should also be conducted during the warm-up to promote optimal muscle length-tension relationships.

After a training session, the cooldown should be sufficient to allow the heart rate and body temperature to return to baseline. Completing SMR after the exercise bout may acutely reduce muscle soreness, improve arterial function, improve vascular endothelial function, and increase parasympathetic nervous system activity. All these benefits can work to enhance recovery from training.

RESISTANCE EQUIPMENT

The fitness industry is well known for its ingenuity in creating new exercise equipment. Some equipment serves to train a single movement pattern or muscle group, while others are multifunctional. No matter what is trained, each piece of resistance training equipment will fall into one of the four categories of resistance: constant, variable, accommodating, or static.

CONSTANT RESISTANCE

Barbells, dumbbells, kettlebells, and medicine balls are categorized as constant resistance equipment. The weight of the dumbbell does not change throughout the range of motion. Although it may feel heavier at some points in a lift—the bottom or top of a biceps curl—due to gravity and the angle at which it is moved, the weight of the equipment is constant.

VARIABLE RESISTANCE

Variable resistance equipment changes the resistance throughout the range of motion to match the various exercise strength curves. This includes rubber-based resistance such as loops, tubes, and bands, as well as chains.

Research has compared traditional resistance training to variable resistance training. A study group added 30 percent of their 1RM as band tension to one weight training session, one time per week. Results found that adding variable resistance to one training session per week enhanced athletic performance over traditional resistance training. This included increased squat and bench press 1RM values and vertical jump height.

ACCOMMODATING RESISTANCE

Accommodating resistance machines control the resistance throughout the full range of motion. Some machines were built to create constant speed or resistance. However, resistance bands are also commonly used as accommodating resistance equipment. For example, using a resistance band at the knees during a squat creates greater tension in the glutes during the range of motion as the femur is externally rotated (the knees pressed laterally) to create tension in the band.

Research shows that this type of training is useful for increasing sprint speed—when used as part of the warm-up for muscle activation—peak power output and jump height due to increased neuromuscular control and activation in the affected muscles.

STATIC RESISTANCE

Static resistance is also known as an isometric contraction. With static resistance, the muscle develops tension but does not contract nor relax—the muscle fiber length remains constant. Examples include planks and bent-arm hangs. In most cases, isometrics is not considered functional. Holding a dumbbell in a fixed position only strengthens the muscle in that position and at that length. However, in some sports, isometrics translates into athletic skills. Examples of sports that use isometrics include the following:

- Alpine skiing
- Climbing
- Gymnastics
- Horseback riding
- Judo
- Motocross
- Mountain biking
- Shooting
- Wrestling

Advanced-strength athletes use a training method called **functional isometrics**. Functional isometrics combines partial reps with isometric holds. This technique is used to overcome sticking points in movements. For example, to overcome the sticking point in a bench press,

FUNCTIONAL ISOMETRICS:
The combination of partial repetition training and isometric holds.

pins can be placed in the rack near the top of the trainee's sticking point. The client can push the bar (unweighted) up into the pins with maximal force and then hold the contraction by pushing the bar firmly against the pins for five to six seconds.

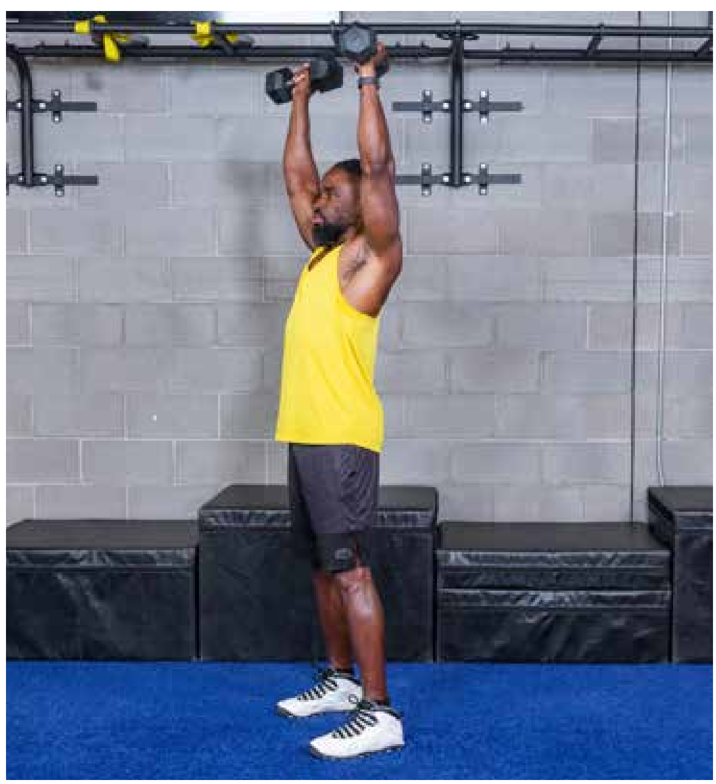
Research suggests that 15 percent more force is created in an isometric versus concentric contraction. Strength gained from functional isometrics only transfers 15 degrees to the joint angle being worked. The localized strengthening effect does not have a huge transference to the overall ROM but can help trainees overcome weak points within a ROM.

COMPARING FREE WEIGHTS AND WEIGHT MACHINES

FREE WEIGHTS: Loads that are not attached to an apparatus.

WEIGHT MACHINES: Pieces of equipment with fixed or a variable range of motion that uses gravity and a load to generate resistance.

Two common modalities of resistance training are **free weights** and **weight machines**. Free weights are loads that are not attached to an apparatus, such as barbells and dumbbells. Weight machines are pieces of equipment with a fixed or a variable range of motion that uses gravity and a load to generate resistance. Each has benefits and drawbacks, and the ideal modality will be based on the client's desired training goal or goals. In many cases, both modalities are programmed throughout a periodized program to introduce training variability, promote progressive overload, vary intensity, and prevent boredom.



BENEFITS OF FREE WEIGHTS

Benefits of free weights include the following:

- Free weights are less expensive and take up less storage space. They may be more practical in a home gym.
- They are more versatile. Exercise can target any muscle group with this simple equipment.
- Free weights help develop greater power, as compared to machines.
- Working out with free weights is a more efficient way to reach most fitness goals, including increasing strength and muscle size, changing body composition, and weight loss.
- Exercises done with free weights better mimic neurological patterns of actual fitness and sports skills than those done on a machine or with a fixed ROM.
- Free weights recruit more of the smaller synergist and stabilizer muscles.

DRAWBACKS OF FREE WEIGHTS

Drawbacks of free weights include the following:

- Changing weights on barbells and dumbbells is time-consuming and poses a hazard if they are not secure and slide off during an exercise.
- Using free weights requires more physical space. This is a safety issue if several people are using free weights in a small space.
- It is not always possible to completely isolate an individual muscle with free weight exercises.

BENEFITS OF WEIGHT MACHINES

Benefits of weight machines include the following:

- Certain machines are much better at isolating a single muscle or group of muscles for the purpose of generating progressive overload.
- Machines make more efficient use of space in a gym where there are many people working out at the same time.
- Working with machines may be faster. Changing the resistance is more efficient and quicker.
- With a proper introduction and guidelines, novice resistance training clients may find machines to be safer.

DRAWBACKS OF WEIGHT MACHINES

Drawbacks of weight machines include the following:

- The movements done on a machine are not as natural as those done with free weights.
- It's more difficult to recruit stabilizer and helper muscles with machines, especially when seated.
- Many machines have limited positional adjustments and do a poor job of accommodating people who are shorter or taller than average.
- The repetitive motions used when working out with a machine can lead to overuse injuries.
- Most weight machines are specialized, which means multiple machines are needed to get a full-body workout.
- Weight machines can be cost-prohibitive, even for many gyms.
- High-speed weight training for power is far more difficult to do with a machine.

BODY WEIGHT EXERCISE

BODY WEIGHT EXERCISES: Movements performed with no additional load other than what the exerciser's body provides.

Body weight exercises are essentially calisthenics—movements performed with no additional load other than what the exerciser's body provides. While body weight training has many benefits, one drawback to this variation of training is that there is no way to add resistance. In terms of the principles of fitness, body weight training cannot adhere to the principle of progressive overload as it has its limits.

One of the most effective uses for body weight training is with clients who are new to strength training. It's a safe way to ease into lifting and gives the fitness professional a chance to teach clients proper movement mechanics. When clients get stronger and have mastered the movement patterns, then resistance can be added. Some other important benefits of body weight exercises include:

- Body weight training is accessible and inexpensive. Everyone can do it.
- The intensity of the body weight exercises can be manipulated by varying tempo, speed, time under tension (TUT), and adding plyometric moves.
- Body weight exercises are largely functional movements and can improve core strength.
- Body weight movement improves balance and stability.

REP AND SET SCHEMES

The use of different rep and set schemes can help determine the amount of work done in a given workout. They are a way to either cluster or spread out the work depending on the goal of the day and the overall goal of the client. Some of the common rep or set schemes include the following:

- **Single set** training: the use of one set per exercise or muscle group.
- **Multiset**: adds volume by performing multiple sets per exercise or muscle group.
- **Straight sets**: done by using the same weight for every set.
- **Supersets**: done by performing two exercises back-to-back followed by a short rest. Typically, the two exercises are opposing muscle groups, such as a pull followed by a push.

SINGLE SET:
The use of one set per exercise or muscle group.

MULTISET:
Multiple sets per exercise or muscle group.

STRAIGHT SETS:
The use of the same weight for every set.

SUPERSETS:
Two exercises, typically opposing muscle groups, performed back-to-back followed by a short rest.

DROP SET:
Technique in which a set is done until failure or fatigue, the weight is "dropped" or lowered, and the exerciser continues until another failure; can continue for several rounds.

ASCENDING PYRAMIDS:
Lighter weights are used to start the workout, and they get progressively higher with subsequent sets.

GERMAN VOLUME TRAINING:
A method in which 10 sets of 10 repetitions are done of an exercise with one minute of rest between sets.

- **Drop set**: an advanced training technique where a set is done until failure or fatigue, the weight is "dropped" or lowered, and the exerciser continues until another failure. This can continue for several rounds.
- **Ascending pyramids**: a set scheme that uses a light to heavy approach, meaning lighter weights are used to start the workout and they get progressively higher. This style may sacrifice total volume but may allow for quicker recovery and turnaround between workouts.
- **German volume training**: a method in which 10 sets of 10 repetitions are done of an exercise with one minute of rest between sets.

SAMPLE STRENGTH TRAINING WORKOUTS

The adaptation of the muscular system to an exercise program will rely heavily on how the workouts are structured and progressed over time. Structuring the acute variables correctly and understanding which variables need to be progressed are at the heart of goal-specific exercise programming. The following sample workouts highlight the resistance training portion of a workout (proper warm-up and cooldown are still recommended) and how to structure the acute variables for the different goals.

MAXIMIZING STRENGTH

Maximizing strength as a primary fitness goal focuses on progressively increasing the load used during workouts. This style of training can result in greater motor unit recruitment and greater overall force production. Force equals mass multiplied by acceleration (F = M x A). With this type of training, force (F) production is increased by emphasizing the mass (M) part of the equation. In other words, intensity (load) will be the primary variable that will need to be progressed throughout the program to achieve this result. Special attention should be given to rest period length as well to ensure that proper recovery of ATP stores allows for subsequent maximal efforts.

Table 12.12 Sample workout for maximizing strength

EXERCISE	LOAD/ INTENSITY	SETS	REPS	TEMPO	REST
Barbell chest press	85 percent or greater	3–5 sets	1–6	3:0:1:0	2–5 minutes
Dumbbell incline press	85 percent or greater	3–5 sets	1–6	3:0:1:0	2–5 minutes
Barbell row	85 percent or greater	3–5 sets	1–6	3:0:1:0	2–5 minutes
Seated cable row	85 percent or greater	3–5 sets	1–6	3:0:1:0	2–5 minutes

MAXIMIZING HYPERTROPHY

Increasing muscular size (hypertrophy) is a common fitness goal. This style of training requires relatively high levels of volume along with short rest periods. As volume is the primary acute variable that would need to be progressed during a hypertrophy program, there would eventually be a need to create a split training routine. An example of this would be splitting upper-body pushing, upper-body pulling, and lower body into three separate workouts.

Table 12.13 Sample workout for maximizing hypertrophy

EXERCISE	LOAD/ INTENSITY	SETS	REPS	TEMPO	REST
Dumbbell chest press	67–85 percent	3–5 sets	6–12	3:1:3:1	30–60 seconds
Dumbbell chest fly	67–85 percent	3–5 sets	6–12	3:1:3:1	30–60 seconds
Chest press machine	67–85 percent	3–5 sets	6–12	3:1:3:1	30–60 seconds
Triceps extension pushdown	67–85 percent	3–5 sets	6–12	3:1:3:1	30–60 seconds

MAXIMIZING POWER

The goal of increasing power focuses on force production with greater velocity. This should result in muscle contraction happening at a faster rate. Keeping in mind that power equals force multiplied by velocity (P = F x V), this style of training will emphasize the velocity (V) part of the equation. The tempo used for maximizing power should be fast while under control. Moving as fast as possible with loss of control will not serve the participant in terms of maximizing power or minimizing potential injury. As the client progresses and they have maximized movement velocity, increases in intensity will become necessary.

Table 12.14 Sample workout for maximizing power

EXERCISE	LOAD/ INTENSITY	SETS	REPS	TEMPO	REST
Jump squats	75–85 percent	3–5 sets	1–5	Fastest controllable tempo	1–2 minutes
Plyometric push-ups	75–85 percent	3–5 sets	1–5	Fastest controllable tempo	1–2 minutes
Overhead medicine ball throw	75–85 percent	3–5 sets	1–5	Fastest controllable tempo	1–2 minutes
Medicine ball soccer throw	75–85 percent	3–5 sets	1–5	Fastest controllable tempo	1–2 minutes

MAXIMIZING MUSCULAR ENDURANCE

Maximizing muscular endurance focuses on increasing the ability to continuously perform a movement (contract muscles) against resistance. Higher volume through increased sets and reps is the primary way to progress with this goal in mind. The higher volume of this style of training may also lend itself to those looking to reduce body fat because of the relatively high workload, which can result in relatively higher calorie burn.

Table 12.15 Sample workout for maximizing muscular endurance

EXERCISE	LOAD/ INTENSITY	SETS	REPS	TEMPO	REST
Push-ups	67 percent or less	1–3 sets	15 or more	4:0:6:0	30–60 seconds
Assisted pull-ups	67 percent or less	1–3 sets	15 or more	4:0:6:0	30–60 seconds
Goblet squats	67 percent or less	1–3 sets	15 or more	4:0:6:0	30–60 seconds
Dumbbell Romanian Deadlift (RDL)	67 percent or less	1–3 sets	15 or more	4:0:6:0	30–60 seconds

CHAPTER 13

EXERCISE SELECTION AND TECHNIQUE

LEARNING OBJECTIVES

1 | Describe the three different learning styles.

2 | Define verbal and nonverbal communication and how a fitness professional uses both.

3 | Explain exercise cueing and its importance in exercise and fitness.

4 | Identify the fundamental movement categories that classify human movements.

5 | List exercises applicable to each fundamental movement category.

6 | Identify the prime mover(s) for each exercise presented.

Exercise selection is one of the primary acute training variables the personal trainer will consider when building exercise programming. Exercise selection can determine factors such as the potential intensity of the exercise, training outcome, or even enjoyment of the program by the client. When considering which exercises to select for a program, the trainer must consider the following:

- The target muscle groups or movement patterns
- Muscle groups or movement patterns to avoid that will prevent injury or overuse
- Skill or comfort level of the client with specific movements
- Available tools, space, or exercise equipment

For most training programs, there's an excess of different exercises a trainer can select. Most exercises can be divided into how they are performed and the fundamental human movements they incorporate. A well-rounded exercise program should incorporate exercises from each category of movement to promote optimal health, **mobility**, strength, and musculoskeletal function. For the most part, the variety of exercise choices come from the many variations of each foundational movement pattern including the use of different equipment, starting positions, exercise machines, surfaces, or grips.

MOBILITY:
The ability of a joint to move freely through a given range of motion.

COMMON EXERCISE INJURIES AND INJURY PREVENTION

Before learning about movement categories and exercise technique, it is important for a fitness professional to understand why proper exercise technique is important. "Ideal" form will vary by client since factors such as flexibility, joint mobility, strength, and body size can impact the range of motion a client will have. However, proper form and technique can prevent injury and encourage optimal muscular recruitment during a movement pattern. When ideal muscular recruitment occurs, movement and muscular compensation can be avoided.

There are many common reasons a client may have an injury during exercise:

- **Misuse of the acute training variables**: when load, speed, rest, and so forth are not implemented in a way the body can handle. For example, performing a back squat too quickly or with too much weight.
- **Improper training progression**: when the acute training variables are implemented out of order. For example, a beginning client performing jump squats without properly training and progressing their ability to squat with both feet flat on the floor.
- **Poor mobility or flexibility**: Both mobility and flexibility impact every movement pattern. Whether the client has stiff joints, poor range of motion at a joint or joints,

or low muscle pliability, they may see what is known as **altered arthrokinematics**, or the altered movement of joint surfaces, or movement dysfunctions including **synergistic dominance** when a synergist (helper) muscle takes over a movement pattern when the prime mover fails.

- **Poor exercise form or technique**: A client may experience movement dysfunctions that lead to injury when they perform an exercise incorrectly. This can include moving without proper stabilization such as abdominal bracing or making compensations where other muscles take over for the action of the prime mover (synergistic dominance or inhibited musculature). For example, having weak or inhibited glutes for many movement patterns including walking can cause low-back pain, hip or knee pain, and overactive hip flexors.
- **Poor preparation for movement**: When a warm-up is skipped (general or specific), the body may not be prepared to execute the necessary movement patterns.
- **Insufficient energy or exhaustion**: When the body is fatigued, under recovered, or exhausted, movement will suffer, and injury can result. This can apply both within an exercise session, from one session to the next, or over time with overtraining.

ALTERED ARTHROKINEMATICS: Altered movement of joint surfaces.

SYNERGISTIC DOMINANCE: When a synergist (helper) muscle takes over a movement pattern when the prime mover fails or is too weak to control the movement.

EXERCISE PROGRESSION AND REGRESSION

Most exercises have a standard technique for proper execution that may vary by person. Exercises can have **progressions** that increase the challenge of the movement and **regressions** that decrease the challenge of the movement. For example, adding weight to a movement to progress it or removing weight from the exercise to regress it. Variables that can be manipulated to create a progression or regression include load (weight), tempo (speed), range of motion, movement complexity, or novelty.

PROGRESSIONS: Modifications to acute training variables that increase the challenge of a movement pattern.

REGRESSIONS: Modifications to acute training variables that decrease the challenge of a movement pattern.

Increasing tempo adds the challenge of generating speed and controlling the body when moving at greater speed through a movement. For example, progressing from a body weight squat to a squat jump. Decreasing tempo can be used as a regression to allow someone to master technique, but it can also be a progression if time under tension becomes the emphasis, as with a very slow push-up.

Increasing the range of motion of an exercise can increase the challenge since a load is traveling for a greater distance, which will require more work and higher levels of control. A decrease in range of motion may allow for the client to work in a range that they can better control and move through without pain. Trainers should consider a lunge for this concept. Lunging forward and moving all the way to the ground may be too great of a range of motion for some people. Their maximum range of motion should be determined by the distance they can travel in the movement with coordination and without pain.

An increase in movement complexity can increase the challenge, such as pairing two movements together in the reverse lunge with rotation. This exercise combines two different movement patterns with several joints moving, which increases the necessary coordination and stability to complete the exercise. Keeping movements simple (fewer movement patterns and joint movements) can act as a regression and teach individual aspects of a complex movement pattern before combining them.

Movement novelty simply refers to movements that are new or highly untrained. Breaking down a more complex movement pattern into simple components is a way to regress a novel movement and strengthen the individual aspects before combining them and increasing the speed at which they are executed.

KEY COMMUNICATION PRINCIPLES

Just as there are many ways to effectively design a workout, there are many different ways to teach and communicate with clients. When teaching clients exercise and progressing them through a training session, clear communication is required to prevent injury and ensure optimal form and movement execution. While some personal trainers may have the ability to easily communicate clearly and directly, most trainers need to work at it.

NONVERBAL: Not involving words or speech.

BODY LANGUAGE: Communication of a nonverbal form with gestures or body movement.

SPATIAL RELATIONS: How objects are located relative to one another in space.

PARALANGUAGE: Components of speech like tone, pitch, facial expressions, cadence, and hesitation noises.

Communication encompasses much more than just spoken words. The quality of interactions with clients is reflected in how trainers greet their clients, teach them movement patterns, and answer their questions along the way. An effective first step to successful teaching is gaining the clients' trust, and to do this, trainers must understand that some valuable communication techniques are **nonverbal**.

NONVERBAL COMMUNICATION

Nonverbal communication has three components

- **body language**,
- **spatial relations**, and
- **paralanguage**.

Body language incorporates communication through physical appearance, posture, gestures, touch, and changes in facial and eye movements. The face is the most expressive part of the body, and facial expressions are an important part of communication and developing impressions of other people. Smiling transcends cultural and language barriers and can be an effective way to offer positive encouragement and understanding.

Posture is another key element of body language and is an indicator of self-esteem, openness, and kinesthetic awareness (an individual's sense of their body and how it moves). Clients will look to personal trainers to set an example, so it is important for trainers to maintain good posture both inside and outside the gym.

Proxemics is the study of what is communicated by the way a person uses personal space. Edward T. Hall, an anthropologist and considered the father of proxemics, described four distinct zones used when interacting with others: intimate distance (0–18 inches), personal distance (1.5–4 feet), social distance (4–12 feet), and public distance (12–20 feet). A personal trainer's interactions with clients will primarily fall in the personal and social distances, although it is possible that they may enter the intimate distance. Asking for permission to come into this zone is recommended, always with new clients and frequently with regular clients, to determine their comfort level with the trainer's presence in such close proximity.

PROXEMICS:
The study of what is communicated by the way a person uses personal space.

There are many elements to delivering a message to clients; what a personal trainer does and how they do it speaks more loudly than what they say. Personal trainers should practice their own nonverbal messages and strive for congruence among the various forms of verbal and nonverbal delivery.

The Importance of Listening

One of the greatest communication skills a personal trainer can acquire is the ability to listen. As a personal trainer, it is important to foster trust and build rapport with clients and support their growth.

- **Active listening** is the act of paraphrasing or stating in one's own words what someone has just said. Personal trainers can use lead-ins such as "I hear you saying…" and "Do you mean…?" Paraphrasing keeps the trainer more involved in the conversation, helps them to remember what was said, eliminates miscommunication, and makes clients feel that they are being heard. Asking more questions for clarification may be necessary, especially if the client is discussing a complex issue they are working through.

ACTIVE LISTENING:
Paraphrasing or stating in one's own words what someone has just said.

EMPATHIC LISTENING:
The ability to understand how the clients feel and empathize with them.

- **Empathic listening** is another useful listening skill. The ability to understand how the clients feel, whether they are new to exercise, working with an injury or condition, or working through something else, establishes a foundation of trust. As a personal trainer, it is important to practice humility, and empathetic listening is an excellent way to better relate to clients and resist being placed on a pedestal.

VERBAL COMMUNICATION

The introduction of language to communication is not a requirement, but a luxury. So much goes into overall communication and the addition of speech can cause confusion or miscommunications. Attention to detail is necessary with language to ensure the intended message is conveyed.

Paralanguage

ARTICULATION:
The ability to pronounce distinctly—to enunciate.

Paralanguage comprises the vocal components of speech considered separate from the actual meaning of the words. It includes things like pitch, **articulation**, tempo, and volume. These elements make a huge impression on clients, so it is worth refining them.

Pitch occurs by tightening or loosening the vocal cords. Intense feelings of joy, fear, or anger cause the voice's pitch to rise. When a person is depressed, tired, or calm, the voice relaxes and the pitch decreases. The most dramatic pitch change should occur when saying the most important words of the message.

Articulation is the ability to pronounce distinctly—to enunciate—which is an extremely valuable tool. Clients should be able to hear and clearly understand a trainer's cues.

Tempo, or the speed at which words are spoken, is also important. If words are spoken too slowly, a client's attention may wander. On the other hand, if words are spoken too rapidly, some clients may find it difficult to follow the instructions.

The volume of a personal trainer's voice can vary depending on the workout, and it can convey different emotions and energy levels. Finding the right volume comes with experience and an awareness of one's own voice. If unsure of how well clients can hear instruction, the trainer should not hesitate to ask.

A vital part of becoming a successful personal trainer is the ability to instruct effectively in each of the three forms - visual, auditory, and kinesthetic. Each form corresponds with the way people communicate and the way they learn.

- **Visual learners** tend to process information quickly, use descriptive language, and are prone to using hand gestures. They learn best through seeing the information being taught. This could include reading text, looking at pictures or diagrams, or watching someone demonstrate a movement.
- **Auditory learners** prefer to learn by hearing instructions. They do best by listening and rely on both speaking and hearing to process information. Auditory learners often like to repeat information back to ensure their understanding of a concept or movement.
- **Kinesthetic learners** learn best through movement and hands-on activities. They can be slower to process information and respond better to physical touch than verbal instruction. They prefer being active when learning and rely on the senses of touch, smell, and taste in the learning experience.

VISUAL LEARNERS:
People who learn by seeing information.

AUDITORY LEARNERS:
People who learn by hearing information.

KINESTHETIC LEARNERS:
People who learn by physical touch.

Effective trainers remain aware of all three types of learners. This includes learning different types of instruction to better relate to clients in their "language."

Language Choices

Personal trainers should be selective with the words they choose and consciously construct the phrasing of their instructions, keeping in mind that literal and implied meanings are not always the same. For example, the instruction "straighten your spine" is ambiguous and can be frustrating for clients because it is not physically possible to straighten the spine due to its natural curves. A clearer cue would be "lengthen your spine" or "elongate your spine" to indicate increasing the space between each vertebra and the sensation of growing taller.

Using clear, active language rather than passive or overly descriptive language is essential for personal trainers. An instruction such as "straighten your arms" is much clearer and action-oriented than "your arms are straightening," which implies that clients are already doing what is asked of them. Using excessive or complex jargon, such as "dorsiflex your ankle" or "flex through the hip," should be avoided because these instructions are ambiguous and difficult for clients to understand in many cases. Keeping language clear and simple will ensure that the greatest number of clients can benefit from the trainer's knowledge and guidance.

CUEING

Cueing is an important part of personal training. The ability to cue with clarity and precision plays a huge role in each client's movements and overall success. Every client has a different learning style, so effective cueing involves both good communication skills and an ability to

CUEING:
To give a reminder or a direction.

adapt based on clients' individual needs. Most individuals will have a dominant learning preference, whether visual, auditory, or kinesthetic, but it will not be exclusive. As cues are refined, it is important to cultivate a greater understanding of the cues that might work best for each learning preference.

VISUAL CUEING

Visual learners tend to learn best by seeing what is being taught through physical demonstration. To best serve those who learn visually, movements must be clear and concise. Any unnecessary movements or transitions should be avoided, and (if relevant) a movement can be broken down to ensure that clients can understand the proper execution. Particularly with advanced or more complex movements, trainers should consider offering a step-by-step demonstration. For example, when teaching a deadlift, the trainer may individually break down the start, stand, hinge, and knee flexion components so the client can understand the full movement and see it in action.

VERBAL CUEING

Auditory learners learn best by listening to verbal cues. Much of the cueing a personal trainer will deliver will be verbal. The ability to succinctly provide verbal feedback to clients and reinforce correct movement patterns is a vital skill and takes practice. Here are a few things to consider while refining verbal cues:

1. Trainers should avoid over-instructing or feeling the need to narrate every moment. Clients can only take in so much information at once, and the level of the client should be considered. Newer clients may need more guidance while more advanced clients likely have a better understanding of how to execute certain movements.
2. Trainers should avoid using overly technical language. Although it is important to have a solid understanding of the biomechanics of each exercise, trainers should stick to simple language so clients have a clear understanding of what they are being asked to do.
3. Trainers should watch to see if clients are responding to verbal cues. If not, it may be that the concept was not explained clearly, or repeating the same cue using a different language is necessary. It could also be that the action being taught is too complex for the level of the client, which may call for a different form of instruction, such as a physical demonstration or a regressed form of the movement first.

KINESTHETIC CUEING

Kinesthetic learners absorb instruction best through hands-on learning. Physical cueing can be effective, particularly for new clients as it helps them develop kinesthetic awareness. While hands-on learning can be useful, any kind of physical touch between a personal trainer and client must be appropriate. It is important to ensure that clients feel comfortable with the use of touch and that it has been approved by the client.

MOVEMENT CATEGORIES

There are six fundamental **movement categories**. They can help to ensure that exercise selections are being made to accommodate a specific fitness goal and meet the basic criteria of maintaining general movement skills and capacity. They are not an absolute description of an exercise but are used as organizational categories. With this in mind, it's important for fitness professionals to note that there are exercises that can overlap more than one movement category.

MOVEMENT CATEGORIES: The six fundamental movements that are the basis for most exercise selections in exercise programming.

The movement categories (in no particular order) are

- Hinge
- Push
- Pull
- Squat
- Lunge
- Locomotion

In addition to the movement categories, the following exercise categories are also applied:

- Core
- Isolation and activation

HINGE

The **hip hinge** is a forward and backward movement of the upper body (spine remains neutral) while the hips remain at the same height and move back rather than downward to counterweight the movement of the head and rib cage. The primary joint involved is the acetabulofemoral joint (hip joint).

HIP HINGE: A forward and backward movement of the upper body while the hips remain at the same height and move back.

During a hip hinge, the prime mover creating hip extension is the gluteus maximus, with some strong help from the hamstring group. Hinges can also be used to strengthen the erector spinae along the spine as they will be isometrically acting to maintain the neutral spine position. This position is a foundational movement for many exercises and should be mastered early in an exercise program.

Barbell Deadlift

Prime movers: Hamstrings, Quadriceps, Glutes

Begin by stepping up to the barbell with the shins to the bar and with the feet just outside hip width. Next, hinge to the bar, and place the hands just outside the shins with an overhand grip. The back should remain flat with the shoulders down and away from the ears. Press through the midfoot to come to a standing position with the barbell in hand, while avoiding *pulling* to stand up by using the arms to lift the weight before extending the legs. The glutes are engaged while standing with a slight posterior pelvic tilt. The knees should remain stacked over the ankles (pressing out) to engage the glutes. To return to the starting position, a hip hinge is initiated until the barbell reaches the knees. Then, keeping the knees over the ankles, begin to bend the knees while maintaining a flat back and pushing the hips back with the goal of maintaining a close-to-vertical shin angle.

TRAINING TIP:

For clients with limited mobility or strength, fitness professionals should elevate the starting position of the bar using plates or boxes. Also, they must watch for jerking at the start of the movement or bouncing consecutive reps off the ground.

Dumbbell Romanian Deadlift (RDL)

Prime movers: Hamstrings, Glutes

To begin the exercise, pick up the dumbbells and stand tall. Keep the shoulders down, brace the abdominals, and initiate a hip hinge. Keeping a slight bend in the knees, hinge until a stretch in the hamstrings is felt. Typically, the weight will be between the knee and mid shin. To return to the standing position, squeeze the glutes and hamstrings with bodyweight in the midfoot. Do not allow the upper body to *pull* the weight up and extend the hips, placing all the effort into the lower back as opposed to the glutes and hamstrings. Glutes are engaged with a slight posterior pelvic tilt at the top of the movement pattern.

TRAINING TIP:

Trainers should coach clients to drive the knees out during the descent of this exercise to keep the glutes engaged and protect the low back. The shoulders should remain relaxed and the cervical spine neutral (chin down as if holding an orange between the chin and the chest) to avoid spinal extension throughout the range of motion.

Kettlebell Swing

Prime movers: Hamstrings, Glutes

Begin standing with the feet just outside the hips with the kettlebell in hand. Hinging from the hips and keeping the back flat, bring the kettlebell between the knees. The arms and shoulders remain relaxed through the swing. Resist the urge to force the weight through the range of motion and instead focus on the hip thrust. Next, quickly extend the knees and hips to full extension (standing position), driving the head straight up. Hyperextension of the spine should be avoided. The glutes are squeezed, and the core is braced for stability. The kettlebell will follow an arc in front of the body and should swing naturally, no higher than the shoulders. Remain in the upright and engaged position as the kettlebell follows its natural arc back toward the hips. Just as the weight reaches the front of the pelvis, hinge quickly, allowing the weight to finish just behind (and between) the knees, and immediately begin the next repetition, starting with a powerful knee and hip extension.

TRAINING TIP:

Trainers should coach the client to look for a standing plank position at the top of each rep. They should also ensure the client doesn't force the kettlebell to move with the arms. Instead, the weight should "swing" as the hips control the movement.

Dumbbell Single-Leg RDL

Prime movers: Hamstrings, Glutes

Begin in a standing position with the desired weight in the hands and with the arms fully extended at the sides (or slightly in front of the thighs). With the feet set about hip width apart and a soft bend in the knees, hinge from the hips while elevating one leg, keeping the back flat, the shoulder blades in place, and the abdominals braced. The leg being elevated should have a flexed foot and remain level (even) with the back. Hinge until a stretch is felt in the hamstring of the stationary leg—typically the hands or load will be between the knee and mid shin. Next, squeeze the glutes and hamstring on the stationary leg to return to a standing position while keeping the elevated leg in alignment with the flat back. The glutes are engaged with a slight posterior pelvic tilt before beginning the next repetition.

> **TRAINING TIP:**
>
> The hip on the elevated side should not be allowed to rotate open, and the hips and chest should remain square to the floor during the range of motion. If the client has issues with balance, instead of elevating one leg, coaches should encourage them to adopt a staggered stance with the front foot flat on the ground and the back foot elevated to the toes for stability.

PUSH

Pushing movements are categorized as upper body exercises in which the arms themselves, or the arms and a tool directed by the arms, move away from the body. This can happen vertically (overhead) or horizontally (anteriorly) and everything in between. The primary joints involved in these movements will be the glenohumeral joint (shoulder) and the elbow joint.

The direction of the push will directly affect the prime mover of the shoulder joint. In a vertical push, the deltoids will be the primary mover at the shoulders, with the triceps being the primary mover at the elbows. In a horizontal push, the pectoralis major will be the primary mover at the shoulders, with the triceps again being the primary mover at the elbows.

Push-Up

Prime mover: Pectoralis Major

Begin in a high plank position with the body in a straight line from the head to the feet. The hands are placed just outside of shoulder width and even with the middle of the chest. Maintain the plank position, and bend the elbows to lower the body toward the floor. The bottom of the push-up is reached when the elbows are bent to a 90-degree angle. Press through the hands to engage the chest and extend the elbows back to the starting position.

TRAINING TIP:

A modified push-up can be executed from the knees with the body in a straight line from the knees to the head. Also, the range of motion at the elbows will vary based on a client's strength, flexibility, and body size. For example, someone with a larger chest may not achieve a 90-degree elbow bend before their chest contacts the floor.

Standing Cable Chest Press

Prime mover: Pectoralis Major

For this exercise, the handles on the cable cross should be set at approximately chest height. Begin standing in front of a cable cross, facing away from the machine. The feet can be parallel or in a staggered stance for balance, but in either position, the feet should be about hip width apart. Grab the handles of the cable cross with one in each hand, and bend the elbows to approximately 90 degrees. The arms will be parallel to the floor in the start position with the shoulders relaxed and away from the ears. Press the hands forward to fully extend (but not lock) the elbows. Slowly flex the elbows and return to the starting position.

TRAINING TIP:

This variation of a chest press challenges the core and the stability of the shoulder joint when cables are used. The body should not shift forward, nor should the shoulders elevate or the head move forward, during this exercise. Trainers should coach clients to brace the core and maintain the height of the arms throughout the range of motion. If additional stability is necessary, trainers should have the client execute this exercise from a seated position (with or without a backrest).

Barbell Bench Press

Prime mover: Pectoralis Major

Lie supine on a flat bench with the feet on the floor and the head, shoulders, and glutes in contact with the bench. Grasp the barbell just outside of shoulder width, and with a pronated grip (palms facing the feet), lift the barbell off the rack. Keep the shoulders down and away from the ears, and begin to flex the elbows to lower the barbell. Lower the bar until it touches the chest (or just above the chest) before extending the elbows back to the starting position.

TRAINING TIP:

The shoulders, head, and glutes should stay in contact with the bench throughout the range of motion, and the wrists should remain rigid. Trainers should coach clients to brace their abdominals during the concentric press to stabilize and support the spine.

Dumbbell Chest Press

Prime mover: Pectoralis Major

With dumbbells in hand, lie supine on a flat bench with the feet on the floor and the head, shoulders, and glutes in contact with the bench. Extend the arms over the chest for the starting position. Slowly flex the elbows to lower the dumbbells toward the lateral aspect of the chest, keeping the wrists over the elbows until the upper arm is parallel to the floor. In a controlled manner, press the dumbbells back to the starting position by extending the elbows and engaging the pectorals.

TRAINING TIP:

There are several possible grips for this exercise, including palms toward the midline (neutral) or palms pronated (facing the feet). Regardless of grip, the wrists should remain stacked over the elbows to control the weight and engage the pectoral muscles.

Dumbbell Seated Overhead Press

Prime mover: Deltoid

Begin seated on a flat bench (no back) or an upright bench (with a back) and feet flat on the floor with the knees bent at 90 degrees. Bring the dumbbells to the shoulders with the palms facing the midline (neutral grip) and the elbows flexed and near the abdomen. Brace the abdominals, press the weight overhead, and extend the elbows while keeping the shoulders down and away from the ears. Avoid arching the back (spinal extension) when pressing the weight overhead. Slowly flex the elbows and return to the starting position.

TRAINING TIP:

The grip for the overhead press can also be pronated (palms facing away) or supinated (palms facing the body).

Machine Chest Press

Prime mover: Pectoralis Major

Sit in the machine with the glutes, upper back, and head in contact with the seat. Grip the handles of choice (neutral or wide grip). Brace the abdominals, press the arms of the machine overhead, and extend the elbows while keeping the shoulders down and away from the ears. Avoid arching the back (spinal extension) when pressing the weight overhead. Slowly flex the elbows and return to the starting position.

> **TRAINING TIP:**
>
> When using exercise machines that have adjustable seat heights or other settings, trainers should be sure to record the seat and handle settings for future reference.

Machine Assisted Dips

Prime mover: Triceps Brachii

Adjust the weight pin for the desired amount of assistance (may require trial and error to find the right assistance). Step into the assisted-dip machine, and place the feet on the foot bar (or kneel on the knee pad if appropriate). Place the hands on the dip bars with the elbows fully extended and the shoulders relaxed and away from the ears. Shift the weight into the arms, and slowly flex the elbows to approximately 90 degrees to lower the body down. Avoid elevating the shoulders. Press through the hands to extend the elbows back to the starting position.

TRAINING TIP:

Trainers should coach clients to keep their elbows in toward the midline during the eccentric lowering. It is also important that trainers tell clients to always keep their shoulders down during this movement pattern. If the shoulders elevate, trainers should increase the assistance until proper form can be maintained.

PULL

Pulling movements are upper body exercises in which the arms, or the arms and a tool directed by the arms, are moved closer to the body. Much like pushing, this can happen vertically (from overhead) and horizontally (posteriorly) with additional angles in between. The primary joints involved in these movements will be the shoulders and the elbows.

In a vertical pull, the prime mover at the shoulder will be the latissimus dorsi, with the biceps being the prime mover creating flexion at the elbow. In a horizontal pull, where the joint action is a shoulder extension, the prime mover at the shoulder again is the latissimus dorsi with the biceps moving the elbows. In a horizontal pull where the joint action is a horizontal abduction, the prime mover at the shoulder will be the posterior deltoids, with the biceps again moving the elbow.

Barbell Bent-Over Row

Prime mover: Latissimus Dorsi

Begin with the shins behind a barbell loaded with the appropriate weight. Hinge from the hips, and grip the bar just outside of shoulder width. Come to a standing position with the barbell. Again, hinge from the hips, keep a soft bend in the knees, and keep the back flat with the arms fully extended to find the starting position. Hold the hinged position, and pull the barbell toward the belly button by flexing the elbows. The elbows should move straight back, not out and away from the torso. Slowly extend the elbows and lower the barbell back to the starting position.

TRAINING TIP:

Clients should master the hip hinge before attempting an unsupported bent-over row (any variation) to protect the low back and avoid injury. Also, avoid bouncing during the concentric action (the pull) when possible to prevent synergistic dominance or "cheating."

Standing Single-Arm Cable Row

Prime mover: Latissimus Dorsi

Begin standing under a cable cross machine with a single handle set at a height between the belly button and chest. Grip the handle, and step back from the pulley to engage the weight. Set the feet at hip width with a soft bend in the knees (or stagger the stance if additional stability is necessary). Brace the core, and keep the shoulders down and away from the ears during elbow flexion and shoulder extension to pull the handle toward the torso. Slowly extend the elbow and flex the shoulder to guide the handle back to the starting position.

TRAINING TIP:

The grip may vary for this exercise—pronated (palm down), supinated (palm up), neutral (palm toward the midline), or rotating (from pronated to neutral or supinated) based on the client's mobility. Trainers should cue clients to brace the core when standing or if additional stability is needed, have the client execute the movement from a seated position, for example, on a flat bench, an upright bench, or a stability ball.

Seated Cable Row

Prime mover: Latissimus Dorsi

Set the appropriate weight on the weight stack, and sit on the extended bench. Reach forward, grab the handle(s) of the machine, and place the feet on the foot platforms. Relax the shoulders, and sit tall with the arms starting fully extended. Flex the elbows, brace the core, and pull the handle(s) in toward the mid abdomen. Slowly extend the elbows and release the handle(s) back to the starting position.

TRAINING TIP:

Trainers should coach clients to minimize the forward and backward shifting of the torso during the concentric and eccentric action with this exercise to avoid straining the back. The shoulders should stay down and away from the ears throughout the range of motion.

Lat Pulldown

Prime mover: Latissimus Dorsi

Sit in the lat pulldown machine, and adjust the leg roller pads to secure the upper thigh in place with the knees bent at 90 degrees. Grip the pull bar with the desired grip just outside of shoulder width, and begin with the arms fully extended. Relax the shoulders down, and pull the pull bar down toward the upper chest while maintaining an upright posture. Avoid an excessive lean back or swinging the torso during the concentric pulling phase. Extend the elbows back to the starting position in a controlled manner.

TRAINING TIP:

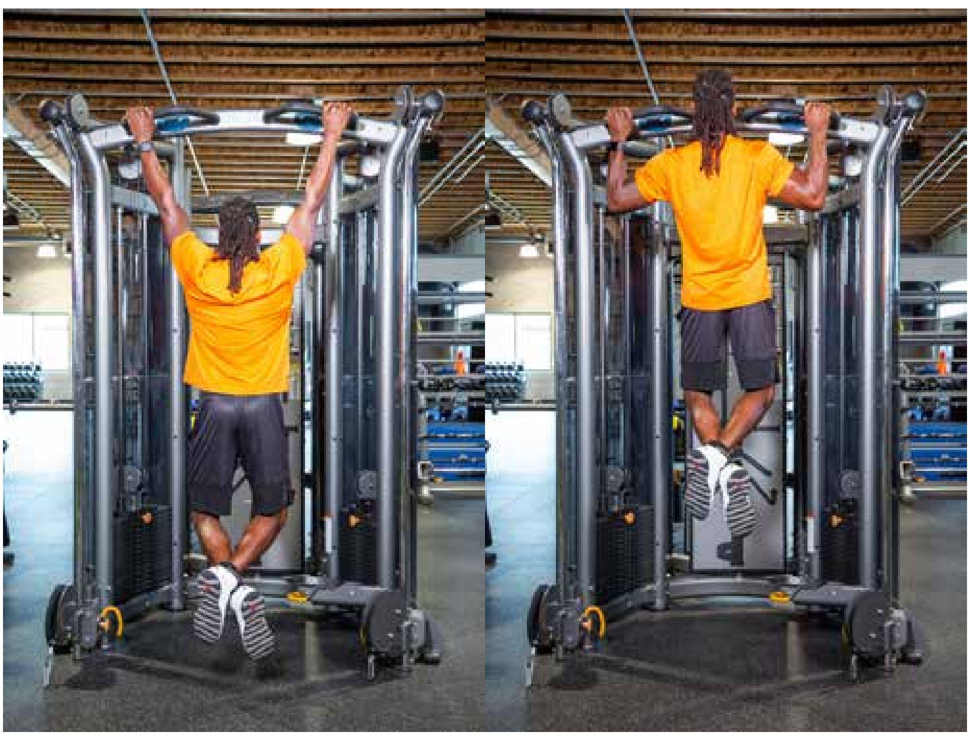
The grip and hand placement for this exercise may also vary—pronated, supinated, or, with the appropriate machine handle, neutral (wide or narrow). As the client sets up in the machine, trainers should coach them to keep their knees at a 90-degree angle or greater (feet in front of them) as opposed to behind them. Placing the feet behind or under the seat promotes lumbar extension, which is undesirable.

Pull-Up

Prime mover: Latissimus Dorsi

Begin standing under the pull-up bar. Reach up, and grip the bars with the desired grip (wide, neutral, underhand, or overhand). Relax the shoulders, and brace the core. Pull the body up toward the bar, and bring the eyes to the level of the hands (or slightly higher). Slowly lower the body back to the starting position in a controlled manner.

> **TRAINING TIP:**
>
> Trainers should coach the client to think of the pull-up as if it is a hanging plank to stabilize the core and prevent swinging. The shoulders should remain as relaxed as possible and down and away from the ears throughout the range of motion.



Machine Assisted Pull-Up

Prime mover: Latissimus Dorsi

Adjust the weight pin for the desired amount of assistance (may require trial and error to find the right assistance). Step into the assisted-pull-up machine, and place the feet on the foot bar (or kneel on the knee pad if appropriate). Reach up, and grip the bars with the desired grip (wide, neutral, underhand, or overhand). Relax the shoulders, and brace the core. Pull the body up toward the bar, and bring the eyes to the level of the hands (or slightly higher). Slowly lower the body back to the starting position in a controlled manner.

TRAINING TIP:

Trainers should ensure the client keeps their shoulders down and away from their ears throughout the range of motion. Clients should also maintain a kneeling plank position with the core braced and the hips tucked to stabilize the spine.

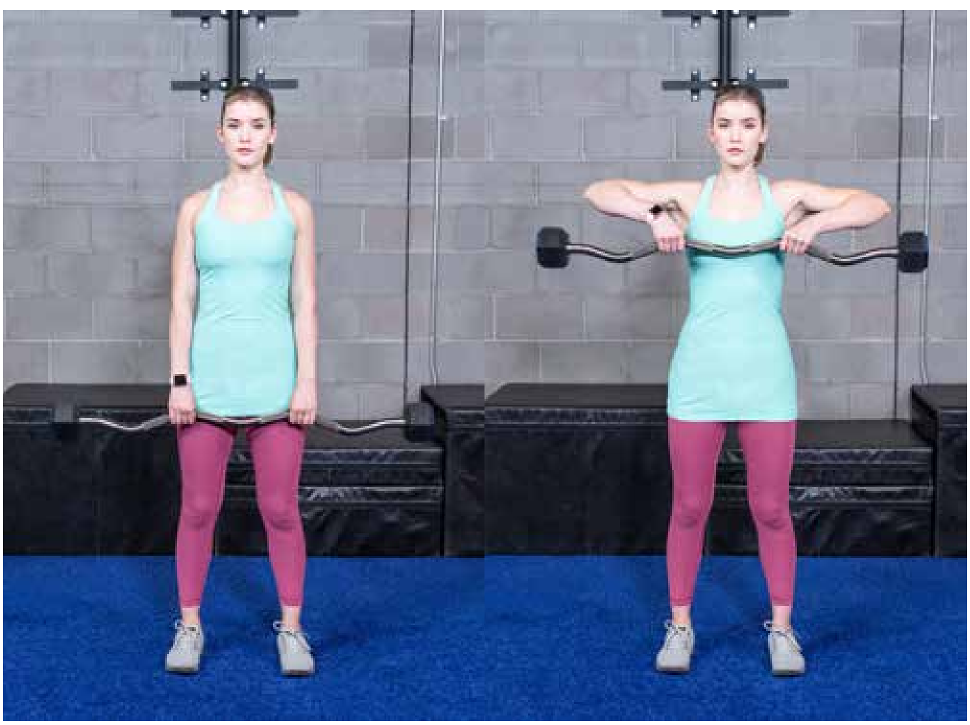
Upright Row

Prime mover: Deltoids

Begin standing with the barbell (straight or EZ bar) in hand with the desired hand placement. The arms start fully extended, with the weight resting in front of the upper thighs. Roll the shoulders back and down, and brace the core. Remain upright, and pull the barbell up the front of the body, leading with the elbows. Avoid elevating the shoulders during the pull. Slowly lower the barbell back to the starting position with the arms fully extended.

TRAINING TIP:

Trainers should coach clients to guide the bar up the front of the body to minimize strain on the shoulder joint. Hand placement can also be varied—wide, neutral, or close grip—based on the client's shoulder mobility. Trainers should also keep in mind that a full range of motion may vary as the shoulder abducts during the pull. This exercise may not be ideal for clients with shoulder impingements or injuries, and another exercise that targets the deltoids should be selected.



SQUAT

The squat is level-change movement in which a person goes from a standing position to a lower position by bending at the hips, knees, and ankles. The primary joints involved will be the hip joint, the tibiofemoral joint (knee joint), and the talocrural joint (ankle joint).

During a squat, the prime mover at the hips will be the gluteus maximus, at the knees it will be the quadriceps, and at the ankles it will be the calf muscles (soleus and gastrocnemius). Squat-like movements can also be performed with various machines. These machines allow for varying loads to be applied to the movement pattern at the hips, knees, and ankles without necessarily involving a level change.

With any squat movement, mobility and muscle flexibility in the calves, adductors, glutes, and hip flexors is imperative. For clients with poor mobility or muscular imbalances, these body regions may need to be addressed with myofascial release, stretching, or an effective warm-up to prevent injury. A fitness professional may use squat or overhead squat assessments to identify potential areas of concern.

Goblet Squat

Prime movers: Quadriceps, Glutes

This exercise begins with the elbows flexed to hold the load at chest height against the body. The feet are set just outside the hips, with a soft bend in the knees. Keeping the neck neutral, hinge from the hips, bend the knees, and then drive the knees out to engage the glutes. The ideal end of range puts the glutes just below the crease of the hips and the elbows on the inside of the knees. Press through the midfoot to extend the knees and hips and return to the starting position.

TRAINING TIP:

The load can be held at the chest or with the arms extended down in front of the body. A slight lean forward is acceptable and expected with a goblet squat. Excessive lumbar extension should be avoided, and there is no need for a posterior pelvic tilt (called a butt wink) at the bottom of a squat.

Barbell Back Squat

Prime movers: Quadriceps, Glutes

Standing in front of a racked barbell, step under the bar, and place it either on the trapezius and shoulder (high bar) or just above the spine of the scapula (low bar). With the feet set just outside the hips and a soft bend in the knees, lift the barbell, and take a step back. Keeping the abdominals braced and the neck neutral, hinge from the hips while bending the knees. Ideally, the thighs will go just below parallel to the ground. Press through the midfoot, keeping the hips back, and extend the knees and hips to come back to the starting position. The glutes are engaged with a slight posterior pelvic tilt before beginning the next repetition.

TRAINING TIP:

Trainers can use a depth marker (block, bench, or step) if necessary to mark an appropriate stopping point for the client. They should ensure the client's knees track in the same direction as the big toe for proper muscle activation.

Dumbbell Split Squat

Prime movers: Quadriceps, Glutes

Starting from a standing position with the dumbbells in hand and the arms fully extended and relaxed, take a large step forward with one foot while maintaining a hip-width stance and keeping a soft bend in both knees. Bend the *back* knee toward the floor, keeping each knee in alignment with its respective ankle, and bend until the front knee reaches a 90-degree angle. Press through the toes of the back foot and the midfoot on the forward foot to extend both knees and return to the starting position.

TRAINING TIP:

The split squat can be loaded in a multitude of ways, including with a barbell, a dumbbell, a kettlebell, and resistance bands. This vertical loading variation can be executed bilaterally or unilaterally. There is also the option for unilateral **contralateral loading**—the opposite side of the forward leg—or **ipsilateral loading**—the same side as the forward leg. A slight lean forward is acceptable in a split squat (any variation) or a lunge. This will reduce low-back activation and focus the effort on the hamstrings and glutes primarily while minimizing knee pain or malalignment.

CONTRALATERAL LOADING: Loading the body on the opposite side of the work being executed.

IPSILATERAL LOADING: Loading the body on the same side as the work being executed.

Seated Leg Press

Prime movers: Quadriceps, Glutes

Adjust the weight stack to the desired load, and sit into the machine. Place the feet just outside of hip width on the foot platform, and lower the seat carriage to the lowest position. Press through the feet to extend the legs and push the seat back to the starting position. Keeping the back and head rested on the seat, bend the knees to lower the seat and raise the weight stack. When the knees reach approximately 90 degrees, press through the midfoot to extend the legs back to the starting position.

> **TRAINING TIP:**
>
> Trainers should take the time to adjust the machine for the height of the client and note the settings for future use. Clients should avoid locking the knees at the top of the range of motion. Also, foot placement may be varied on this machine—wide, sumo (wide with feet pointing outward), or close. Regardless of the foot position, clients should ensure the knees track over the respective ankle..

Angled Leg Press

Prime movers: Quadriceps, Glutes

Add the desired load, and sit into the leg press. Place the feet just outside of hip width on the foot platform. Press through the feet to extend the knees and reach the starting position. Keeping the back and head rested on the seat, bend the knees to lower the carriage toward the torso. When the knees reach approximately 90 degrees, press through the midfoot to extend the legs back to the starting position.

TRAINING TIP:

Trainers should coach clients to keep their hips and glutes against the seat at the bottom of the range of motion to avoid stressing the spine. They should also avoid locking the knees at the top of the range of motion. Foot placement may be varied on this machine—wide, sumo, or close. Regardless of the foot position, clients should ensure the knees track over the respective ankle.

LUNGE

The lunge is a step and return movement. In other words, from a stationary position, a person steps (in any direction) with one leg while the other remains stationary and then returns to the starting position. Like the squat, it typically also has an element of level change. The primary joints involved will be the hip, knee, and ankle joints.

During a lunge in the sagittal plane, the prime mover at the hips will be the gluteus maximus, at the knees it will be the quadriceps, and at the ankles it will be the calf muscles. As the lunge becomes more of a diagonal or frontal plane movement, the prime movers remain the same, but there will be an added element with musculature along the lateral side of the hips, knees, and ankles providing synergistic support.

Dumbbell Forward Lunge

Prime movers: Quadriceps, Glutes

Starting from a standing position with the feet hip width apart, take a large step forward, maintaining the hip-width foot placement. Bend the back knee toward the floor until the forward knee reaches approximately 90 degrees of flexion. Next, press through the midfoot of the forward foot and the toe of the back foot, engage the hamstring, and push with the glute to extend both legs and return to the standing starting position. The glutes are engaged with a slight posterior pelvic tilt before beginning the next repetition on the same leg (or switching legs).

TRAINING TIP:

The step for a lunge in any direction is relatively large, but clients should not overreach. If there is pulling or pain in the adductors or groin, shorten the step taken. Ideally, both knees should reach approximately 90 degrees of flexion without bumping the back knee on the floor.

Reverse Lunge

Prime movers: Quadriceps, Glutes

Starting from a standing position with the feet hip width apart, take a large step back, maintaining the hip-width foot placement. Bend the back knee toward the floor until the forward knee reaches approximately 90 degrees of flexion. Next, press through the midfoot of the forward foot and the toe of the back foot, engage the hamstring, and push with the glute to extend both legs and return to the standing starting position. The glutes are engaged with a slight posterior pelvic tilt before beginning the next repetition on the same leg (or switching legs).

TRAINING TIP:

A slight hinge forward can help a client with balance during lunging movements, but the hips should be shifted posteriorly and the weight distributed evenly over both feet (in the toes of the rear foot and the midfoot of the forward foot).

Step-Up

Prime movers: Quadriceps, Hamstrings, Glutes

Starting by standing in front of a platform of the desired height, lift one leg with the knee flexed, and place the *entire* foot onto the platform. Hinging from the hips will shift bodyweight into the elevated foot. Pressing through the midfoot, squeeze the glutes, and extend the knee and hip on the elevated leg until the entire body comes to a standing position atop the platform. The glutes are engaged with a slight posterior pelvic tilt before beginning the descent to the starting position. The last leg onto the platform is the first one off. Lifting the foot and stepping down from the platform slowly, work to keep the elevated knee in alignment with the same side's ankle to keep the glutes engaged, and always brace the core.

TRAINING TIP:

There is no ideal height for a step-up, so trainers should adjust the height to that which their client can lower from under control. Trainers should watch for a hard landing of the trailing or down leg because this demonstrates a lack of control during the lowering process. Also, the elevated foot can remain elevated between repetitions, or it can be brought down to the floor. If alternating legs, the client can bring both feet back to the floor before the next repetition.

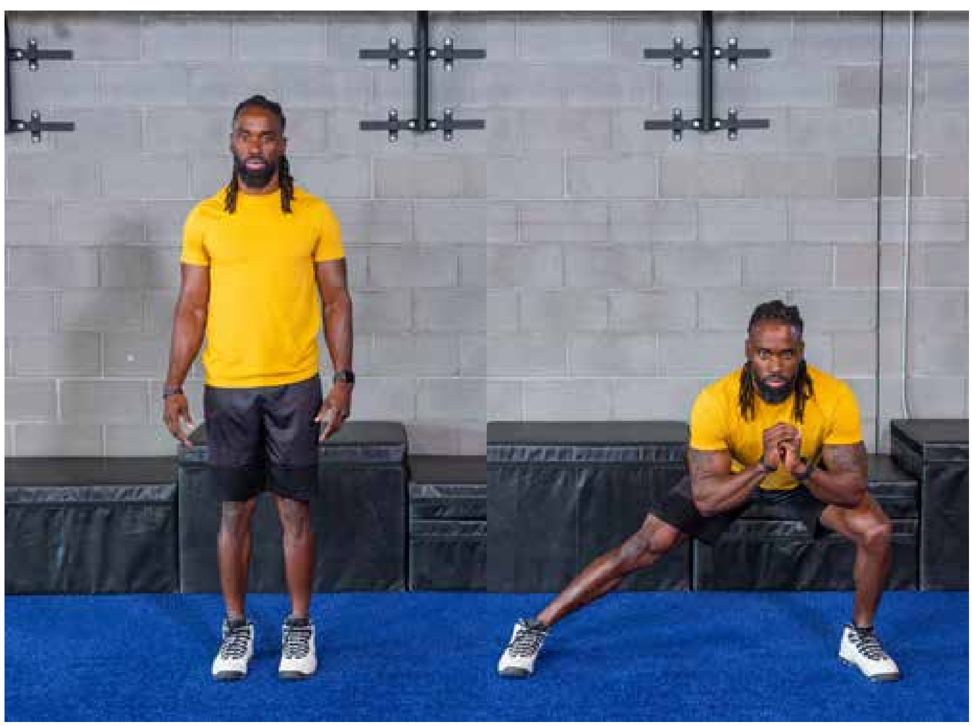
Lateral Lunge

Prime movers: Quadriceps, Glutes

Starting from a standing position with the feet straight and hip width apart, take a large step to the side. The stationary foot remains straight, and the same side knee will remain extended. On the side of the body that the step was taken, hinge at the hips, and flex the knee as in a single-leg squat. The ankle, knee, and hip should be aligned at the bottom of the range of motion. Press through the foot, extend the bent knee, and return to the starting standing position.

TRAINING TIP:

Trainers can use a line on the floor to guide the position of the stepping foot. A hinge is necessary for proper hip and knee flexion during the descent. At the bottom of the range of motion, if the knee is inside the ankle, coaches should cue the client to either press the knee out to engage the glutes or take a smaller step to the side when initiating the repetitions.



Reverse Lunge with Rotation

Prime movers: Quadriceps, Glutes, Core

Hold a weight or weighted implement (such as a medicine ball) in front of the chest with the elbows tight to the body and shoulders relaxed and away from the ears. Starting from a standing position with the feet hip width apart, take a large step back, maintaining the hip-width foot placement. Bend the back knee toward the floor until the forward knee reaches approximately 90 degrees of flexion. As the knee is flexing to the end of range, rotate the torso and weight in hand as far as possible in the direction of the *forward* leg. Rotate back to a neutral spine in a controlled manner. Next, press through the midfoot of the forward foot and the toe of the back foot, engage the hamstring, and push with the glute to extend both legs and return to the standing starting position. The glutes are engaged with a slight posterior pelvic tilt before beginning the next repetition on the same leg (or switching legs).

TRAINING TIP:

The load can be held at the chest as described or with extended arms in front of the body to challenge shoulder strength and stability for more advanced clients. Trainers should watch for undesirable shifting at the feet, knees, or hips during the rotation.

LOCOMOTION:
Movement from one place to another.

BIPEDAL LOCOMOTION:
A form of locomotion in which a person moves from one place to another using the legs.

LOCOMOTION

Locomotion, as a human movement category, is a broad term referring to the ability to move from one place to another using the limbs. This can include walking, running, skipping, swimming, and crawling. For the purposes of this course, the focus is on **bipedal locomotion**, or movement done on two feet. During bipedal locomotion, the primary joints involved will be the hips, knees, and ankles.

Farmer Carry

Prime movers: Quadriceps, Core, Hamstrings, and Glutes

Start in a standing position with the feet at hip width and the desired weight next to the feet. Hinge to reach down and grasp the weight, and return to a standing position. With the weight in hand, walk forward, one foot at a time, with a slow, steady pace. Walk for the desired distance or number of steps before stopping with parallel feet. Hinge to place the weight back onto the floor.

TRAINING TIP:

The client should easily be able to deadlift a farmer's carry load, which makes it safe to pick up or put down at any time. The shoulders should remain relaxed and away from the ears throughout the movement, and trainers should cue clients to keep the torso and core as steady as possible. If the client begins to shift side to side dramatically, the trainer should cue them to brace the core and consider reducing the carry load until proper core stabilization can be achieved.

Suitcase Carry

Prime movers: Quadriceps, Core, Hamstrings, and Glutes

Start in a standing position with the feet at hip width and the desired single weight next to the feet. Hinge to reach down and grasp the weight in one hand, and return to a standing position. With the weight in hand, walk forward, one foot at a time, with a slow, steady pace. Avoid leaning to the side of the load being carried. Walk for the desired distance or number of steps before stopping with parallel feet. Hinge to place the weight back onto the floor.

> **TRAINING TIP:**
>
> A client should learn the unilateral (single leg) deadlift before performing the suitcase carry to ensure adequate core strength. This makes it safe to put it down at any time. If the client begins to shift side to side dramatically, the trainer should cue them to brace the core and consider reducing the carry load until proper core stabilization can be achieved.

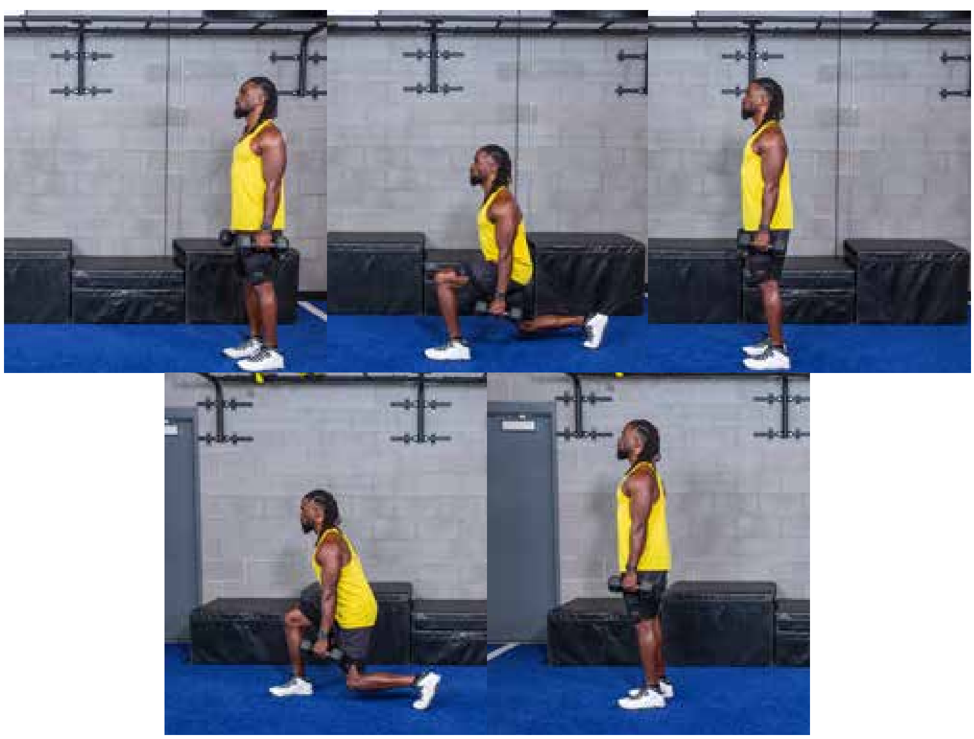
Dumbbell Walking Lunge

Prime movers: Quadriceps, Glutes

Starting from a standing position with the feet hip width apart, take a large step forward, maintaining the hip-width foot placement. The back knee is bent toward the floor until the forward knee reaches approximately 90 degrees of flexion. Press through the midfoot of the forward foot and the toe of the back foot, engage the hamstring, and push with the glute to extend both legs, bringing the back foot forward to be even with the forward foot. The glutes are engaged with a slight posterior pelvic tilt before beginning the next repetition and switching legs.

TRAINING TIP:

Lines on the floor are helpful to guide proper foot alignment during this exercise. Trainers should avoid excessively long steps that may overextend the adductors and groin, where the front foot lands hard on the heel and the back foot gets dragged forward.

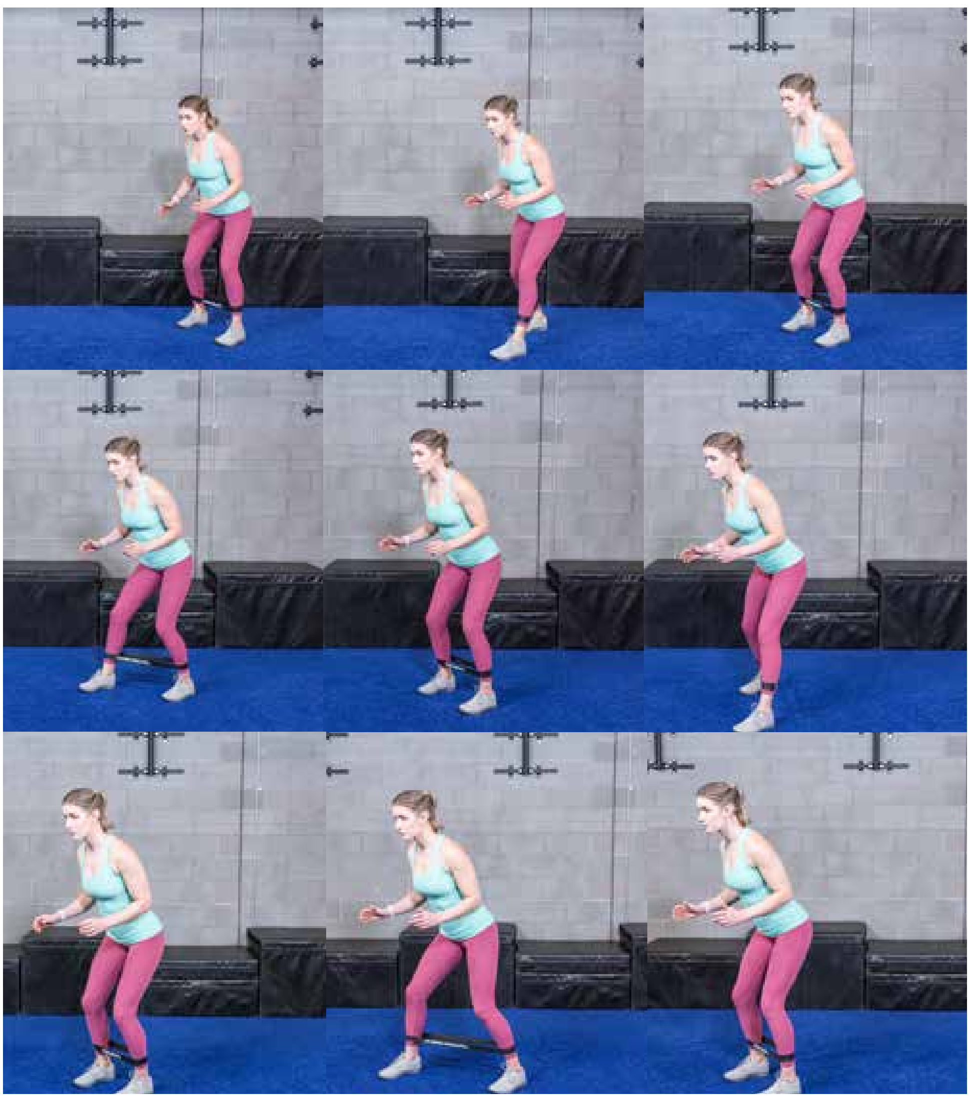


Monster Band Walk

Prime movers: Tensor Fasciae Latae, Glutes

From a standing position, place a mini band around both legs at the knees or the ankles. Slightly flex the knees and hips with a partial hinge, then proceed by walking in a diagonal pattern forward, stepping laterally.

> **TRAINING TIP:**
>
> Clients should use the arm movement to drive a contralateral gait pattern if that is desired. They should avoid excessive lateral shifting with each forward step.



Lateral Band Walk

Prime movers: Glutes

From a standing position, place a mini band around both legs at the knees or the ankles. In a partial hinge with the feet about hip width apart, step laterally with the right foot first, ensuring the knee remains above the ankle, then move the left foot in the same direction until the feet are again hip width and parallel. Continue in one direction until the desired number of steps are taken, and then reverse direction.

TRAINING TIP:

Trainers can use lines on the floor to guide the position of the stepping foot. If the trailing foot is dragged into external rotation or eversion (the toes turn out), clients should shorten the step. Trainers should coach clients to avoid excessive lateral shifting with each lateral step and cue clients to brace the core.

EXERCISE CATEGORIES

The following exercise categories address two common classifications: core, as well as isolation and activation. Many exercises in these categories can fit within the movement categories, but the exercises may not fit into them as easily. Additionally, some of these exercises do not fit within the movement categories but are deserving of attention because of their value in exercise programming. In any case, core exercises along with isolation and activation exercises are an important and common component of many exercise routines.

CORE

Core exercises specifically help to train the muscles of the pelvis, lower back, hips, and abdomen. When there is weakness or dysfunction in any of these areas, postural and stability issues are likely. The importance of training the core very much has to do with overall function as opposed to the widely accepted thought that training the core leads to a lean midsection. A strong core contributes to overall strength, power production, balance, and stability, as well as lowering the incidence of low-back pain.

Forearm Plank

Prime mover: Core

Begin in a kneeling position. Come to a prone lying position with the forearms on the floor and the elbows directly under the shoulders. Extend both legs and dorsiflex the feet. Shift the body weight to the forearms (relaxed hands) and the toes, and lift the hips off the floor. The body should maintain a straight line from the heels to the back of the head. Tuck the hips (posterior pelvic tilt) by squeezing the glutes, and engage the shoulders by pressing the forearms into the floor and lifting the chest away from the floor. The neck is neutral, and the eyes are fixed on a spot between the forearms on the floor. Hold for the desired duration.

TRAINING TIP:

Trainers should coach the client to hold themselves up with both their arms and feet to ensure the entire body remains engaged. They should cue clients to breathe normally during the isometric hold.

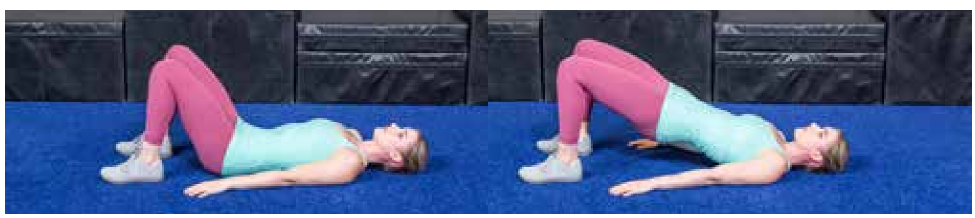
Glute Bridge

Prime movers: Core, Glutes

Lie flat on the back (supine) with the knees flexed and the feet flat on the floor. Initiate the movement by raising the pelvis off the ground. Keeping the hips raised toward the ceiling, press through the heels to perform hip extension and squeeze the glutes at the top or end range of motion. Slowly lower the hips back down to the floor before beginning the next repetition.

TRAINING TIP:

Trainers should coach clients to perform abdominal bracing throughout the range of motion to engage the abdominals and support the spine. Additional resistance can be added to progress this exercise in the form of resistance bands at the knees or weight added at the hip.



Abdominal Crunch

Prime mover: Rectus Abdominus, External Oblique

Begin lying supine (face up) on the floor. Keep the shoulders relaxed and away from the ears, and bring both hands up behind the head or in front of the chest. Gently tuck the chin toward the chest, and flex the spine to bring the lower ribs closer to the pubic bone. Lift until the shoulder blades lift off the floor while keeping the lumbar spine securely on the floor. Slowly lower back down to the mat to the starting position.

TRAINING TIP:

Trainers should cue clients to breathe normally and perform a posterior pelvic tilt before beginning this exercise. This will flatten the lumbar spine to the floor and engage the abdominals effectively. Clients should not pull on the cervical spine with their hands. Instead, trainers should cue them to focus on engaging the abdominals to lift the shoulders off the floor.

Abdominal Double Crunch

Prime mover: Rectus Abdominus, Rectus Femoris, External Oblique

Begin lying supine (face up) on the floor. Keep the shoulders relaxed and away from the ears, and bring both hands up behind the head. Gently tuck the chin toward the chest, and flex the spine to bring the lower ribs closer to the pubic bone. At the same time, flex the hips, lift the feet off the floor, and bring the knees up over the hips. Lift until the shoulder blades lift off the floor while keeping the lumbar spine securely on the ground. The elbows will meet the knees (or get close) over the torso. Slowly lower back down to the mat to the starting position.

TRAINING TIP:

Trainers should cue clients to breathe normally and perform a posterior pelvic tilt before beginning this exercise. Clients should not pull on the cervical spine with their hands. Instead, trainers should cue them to focus on engaging the abdominals and hip flexors to lift the shoulders and feet off the floor. Trainers should also coach clients to pull the belly button in toward the floor for abdominal bracing.

Back Extension

Prime mover: Erector Spinae

Set the back extension apparatus to the desired height. Step into the apparatus, support the bodyweight by using the handles, and secure the feet. Release the handles, and flex the hips to allow the torso to move toward the floor for the starting position. Keeping the chin and spine in a neutral position, squeeze the glutes, and slowly lift the torso until the body is in a straight line from head to heels. Release back down to the starting position in a controlled manner.

TRAINING TIP:

The appropriate height for this apparatus places the thigh pads just below the crease of the hips to allow for adequate hip flexion. Clients should avoid spinal hyperextension at the top of the range of motion. This exercise may be loaded but should be progressed slowly to ensure adequate core strength.

ISOLATION AND ACTIVATION

Isolation exercises and **activation exercises** contribute greatly to exercise programming. Isolation exercises are typically single-joint movements and can be used to add stress to specific areas of the body to promote hypertrophy (muscle growth). Activation exercises are typically low-intensity exercises and can be used as part of a specific warm-up or as a part of a **corrective exercise** program used to improve muscular imbalances.

Seated Calf Raise

Prime mover: Gastrocnemius, Soleus

Load the machine with the appropriate weight, and sit on the seat with the ball of each foot on the foot platforms. Adjust the knee pad if necessary to secure the lower legs in place. Raise onto the toes to release the load lever before relaxing the feet and pressing the heels down toward the floor (dorsiflexion) as far as possible at the starting position. Raise up onto the toes (plantarflexion) as far as possible, then release back to the starting position.

TRAINING TIP:

Clients should avoid excessive forward and backward weight shifting during the range of motion to avoid synergistic dominance when moving the load. The range of motion at the ankle will vary by client based on flexibility, ankle mobility, and strength.

ISOLATION EXERCISES: Single-joint exercises that primarily activate an individual muscle or muscle group.

ACTIVATION EXERCISES: Low-intensity exercises that bring on additional blood flow and activate the nervous control of a muscle. Often used as part of a specific warm-up or as part of corrective exercise programming.

CORRECTIVE EXERCISE: Exercise programming used to improve function through assessing and improving muscle imbalances.

Incline Bench Fly

Prime mover: Pectoralis Major, Anterior Deltoid

Begin lying supine (face up) on an incline bench with dumbbells in hand. Ensure the head, shoulders, and low back are supported on the bench and the feet are flat on the floor. Extend the arms with the weights up over the chest with the palms facing the midline of the body. With a soft bend in the elbows and relaxed shoulders, slowly open the arms (horizontal abduction of the shoulder) until a stretch is felt in the pectorals. Avoid hyperextending (arching) the spine during the eccentric lowering of the weight. Engage the pectorals, and slowly bring the arms back to the starting position above the chest.

TRAINING TIP:

The ideal bench angle for incline upper body movements is between 15 and 30 degrees. Trainers should ensure clients keep the weights over the chest as opposed to over the chin or face to protect the shoulder joint and engage the chest muscle. Trainers should cue clients to brace the core throughout the range of motion to support the spine.

Dumbbell Bent-Over Reverse Fly

Prime movers: Rhomboids, Rear Deltoid

Begin in a standing position with the appropriate weights in hand. With the feet hip width apart, hinge at the hips, and maintain a flat back until the back is approximately 45 degrees in relation to the floor. Allow the arms to hang toward the floor, and put a soft bend in the elbows. Minimize torso movement, and slowly raise each arm laterally (horizontal abduction of the shoulder) until they reach the level of the back. In a controlled manner, release the arms back down to the starting position.

> **TRAINING TIP:**
>
> Trainers should coach clients to master the deadlift and hip hinge before teaching the bent-over reverse fly since they serve as the foundation of the setup. Throughout the range of motion, the body should not bounce, the spine should remain neutral, and the shoulders should remain relaxed and away from the ears.

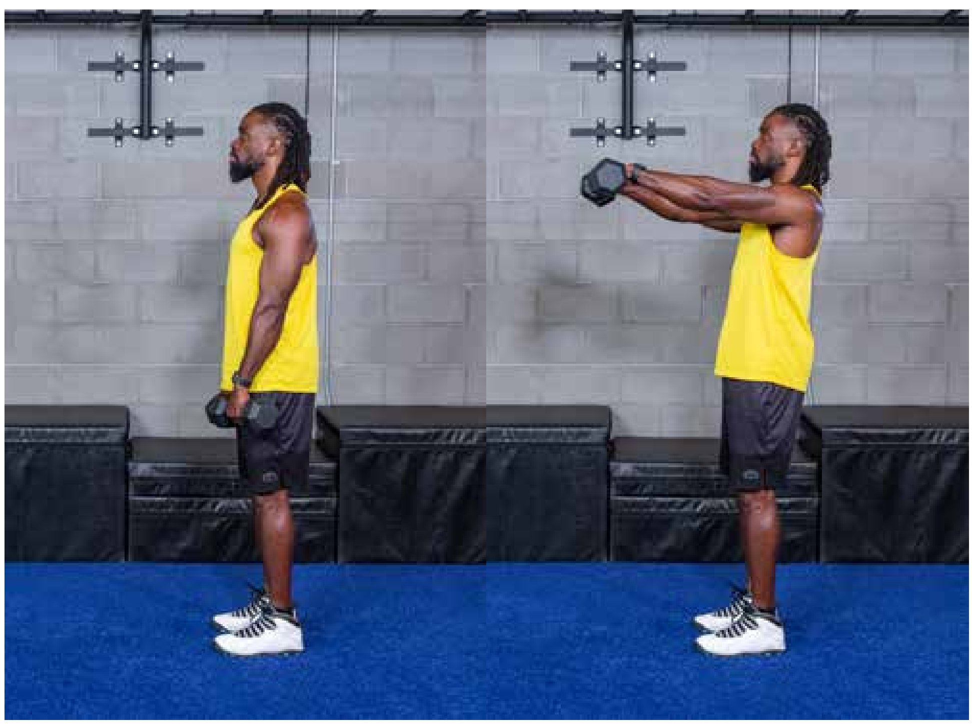
Dumbbell Front Raise

Prime mover: Anterior Deltoid

Begin in a standing position with the feet at hip width and the dumbbells in hand. Keep a soft bend in the knees, and bring the dumbbells to the front of the thighs with the arms fully extended. Keep the shoulders relaxed and away from the ears. Both elbows remain extended as the weight is raised to approximately chest height. Slowly lower the weight back down to the thighs in a controlled manner.

TRAINING TIP:

Trainers should teach this movement as a standing plank to encourage core bracing and isolate the shoulder activation. Trainers should also cue clients to avoid forward and backward swinging of the torso, bouncing, or swinging during the range of motion.



Leg Extension

Prime mover: Quadriceps

Set the leg extension machine to the appropriate seat position. The knees should be aligned with the mark on the lever arm of the leg pad (located on most leg extension machines). Sit into the machine, and place both feet behind the ankle pad. Sit back and keep the shoulders, glutes, and low back on the seat. Dorsiflex the ankles, and extend the knees until the legs are as straight as possible. Slowly flex the knees and lower the machine lever arm back to the starting position.

TRAINING TIP:

Trainers should cue clients to relax their upper body during the leg extension exercise and breathe normally. The entire range of motion should be smooth, and clients should avoid allowing the weight to slam back to the starting position. The orientation of the feet may be varied—neutral (straight), eversion (turned out), or inversion (turned in)—for different quadriceps activation.

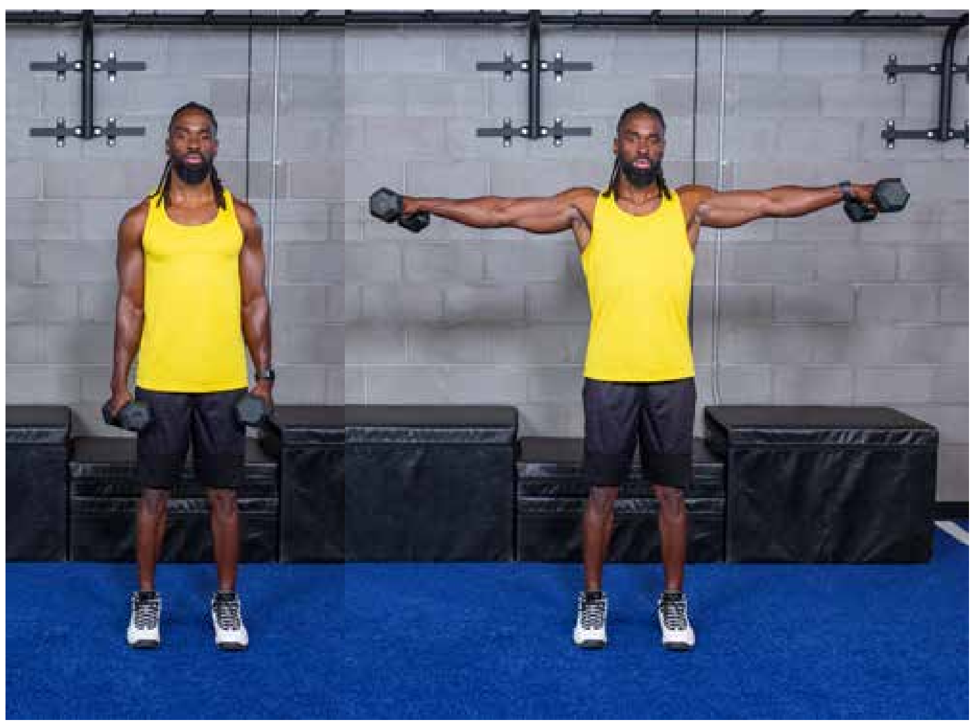
Dumbbell Lateral Raise

Prime mover: Deltoid

Begin in a standing position with the feet at hip width and the dumbbells in hand. Keep a soft bend in the knees, and bring the dumbbells at the side of the body up with the arms fully extended. Keep the shoulders relaxed and away from the ears. Both elbows remain extended as the weight is raised approximately parallel to the floor. Slowly lower the weight back down to the lateral aspect of the thighs in a controlled manner.

TRAINING TIP:

Trainers should cue clients to brace the core throughout the range of motion, as well as to avoid swinging, bouncing, or excessively abducting the shoulders (higher than shoulder height). Clients can execute this exercise from a seated position (on a flat bench or upright bench) to reduce the demand on the core musculature.



Prone Leg Curl

Prime movers: Hamstrings

Lay face down on the pads for the body and grasp the handles to stabilize the upper body. The knees should be aligned with the pivot point of the machine. Place the lower legs under the ankle pads so the undersides of the pads touch the calves just above the ankles. Without moving your upper body, curl your lower legs until the ankle pads are almost touching your gluteus maximus. Lower the weight back down until just prior to full extension and repeat.

> **TRAINING TIP:**
>
> Trainers should coach clients to brace the core and avoid shifting their weight in the leg-curl machine. The weight should be controlled both eccentrically and concentrically, and if this is not possible, the weight should be reduced.

Hip Adduction Machine

Prime movers: Adductor Group

Sit in the adductor machine with one foot in each foothold. Use the lever on the side to open the footholds as wide as possible for a starting position. Sit back and keep the glutes, low back, and shoulders on the seat. Squeeze the legs toward the midline of the body, keeping the core braced and the ankles in dorsiflexion. Then release the legs back to the start position in a controlled manner.

TRAINING TIP:

The only joint that should be moving in this exercise is the hips. Trainers should cue clients to control the weight in both directions to prevent injury from excessive or fast movement.

Hip Abduction Machine

Prime mover: Gluteus Medius, Gluteus Minimus, Piriformis

Sit in the abduction machine with feet in the footholds. If necessary, use the lever on the side to bring the feet and knees together. Sit back and keep the glutes, low back, and shoulders on the seat. Press the knees into the pad to abduct the legs from the midline. At the end of range, slowly release back to the starting position in a controlled manner.

TRAINING TIP:

The only joint that should be moving in this exercise is the hips. Trainers should cue clients to control the weight in both directions to prevent the weight stack from slamming down.

Cable Triceps Pushdown

Prime mover: Triceps Brachii

Begin standing in front of a cable machine with the rope attachment set at the top. Grip the rope handles with a neutral grip (palms toward the midline) and the elbows flexed and at the sides of the body. Roll the shoulders down and back, keep a soft bend in the knees, and press the rope down toward the feet by extending the elbows as far as possible. Slowly flex the elbows to return to the starting position.

TRAINING TIP:

Trainers should cue clients to brace the core and keep the shoulder blades on the back of the body to prevent the shoulders from rolling forward at the end of the range of motion.

Dumbbell Biceps Curl

Prime mover: Biceps Brachii

Begin in a seated or standing position with the appropriate dumbbells in hand and the arms fully extended. Initiate the curl by flexing the elbow to move the dumbbell toward the shoulder. The elbows will stay close to the sides of the body throughout the range of motion. Slowly extend the elbow to release the weight back to the starting position.

> **TRAINING TIP:**
>
> Whether seated or standing, trainers should cue clients to brace the core and relax the shoulders away from the ears throughout the range of motion. Clients should avoid swinging, allowing the elbows to splay out from the sides of the body, or "cheating" to get a full range of motion.

CHAPTER 14

NUTRITION FOUNDATIONS

LEARNING OBJECTIVES

1 | Name the three macronutrients and their primary functions in the body.

2 | List the general recommendations for macronutrient intake.

3 | Define dehydration and explain the general recommendations for water intake.

4 | Explain the nutritional importance of minerals, vitamins, and antioxidants.

5 | List the general recommendations for micronutrient intake.

6 | Describe the recommendations of The Dietary Guidelines for Americans.

7 | Explain how to read a nutritional food label and visualize general portion sizes.

8 | Name and describe common diets and eating patterns.

There are two primary categories of nutrients that make up the human diet. They include the **macronutrients** carbohydrates (carbs), fiber, fats, protein, and water and **micronutrients**, such as vitamins, minerals, and **antioxidants**. Each plays an important role in general health, normal body function, recovery, and human performance. Any fitness professional will confirm that most of the success of a fitness or performance program lies in the nutritional habits of the individual. For that reason, a personal trainer should be able to identify and explain the role of the major nutritional components of a healthy diet, recognize and make suggestions to improve unhealthy eating habits, and be prepared to answer the nutritional questions a client is sure to have.

TEST TIP!

It is outside the scope of practice for a Certified Personal Trainer to prescribe meal plans to clients. However, they can review a client's eating habits and make suggestions of ways they can improve and eat to support their fitness goals.

MACRONUTRIENTS

The three macronutrients required by the body are carbohydrates, protein, and fat. Each is needed in large quantities daily to support the body's normal functioning and to support additional physical activity. To create molecules within the body that are usable for repair and growth, there is a delicate balance that must be achieved between **catabolism** and **anabolism**. Catabolism describes the breaking down of more complex molecules into simple molecules, like when a protein is broken down into individual **amino acids**. Anabolism describes the opposite—the creation of more complex molecules from more simple molecules, like when amino acids are linked together to form proteins. Each macronutrient has specific and, in some cases, unique physiological uses that a fitness professional should be familiar with.

CARBOHYDRATES

Carbs are the main source of energy for the human body. After being digested, carbohydrates are processed into **glucose**, which is converted to energy and used to support various metabolic processes including physical and mental activity. When sugar moves into the cells, blood glucose begins to stabilize. If all the glucose is not used for energy, some of it is stored in the liver as **glycogen**.

The primary source of energy for high-intensity exercise comes from carbohydrates. Carbs protect muscle mass (protein) from being catabolized during exercise and fuel the central nervous system and brain. Limiting carbs results in more nitrogen loss. Nitrogen is a

MACRONUTRIENTS: A type of food necessary in large quantities in the diet to support function and energy production (i.e., carbohydrate, protein, and fat.)

MICRONUTRIENTS: Substances required in small quantities in the diet for optimal body functioning; vitamins and minerals.

ANTIOXIDANTS: Substances that protect the body from free radicals and the cellular damage they cause.

CATABOLISM: The breaking down in the body of complex molecules into more simple molecules.

ANABOLISM: The building of complex molecules in the body from more simple, smaller molecules.

AMINO ACIDS: Simple organic compounds known as the building blocks of proteins.

GLUCOSE: A simple sugar the body uses for energy production on the cellular level.

GLYCOGEN: The stored form of glucose found in the liver and muscles.

component of amino acids, and when there is not enough present, muscle breakdown occurs. There are two types of carbohydrates: simple and complex.

Simple Carbohydrates

Simple carbohydrates are just that—simple, short-chain carbohydrates. They are small molecules known as **monosaccharides** (the simplest form of sugar) and **disaccharides** (two monosaccharides together). Simple sugars are easily broken down and converted to energy because they are relatively small molecules. Therefore, when simple carbs are eaten, blood glucose levels will increase quickly. Simple carbohydrates are naturally occurring in fruits, vegetables, milk, and milk products. **Processed foods** also contain simple carbohydrates. Sucrose, maltose, and lactose are common disaccharides, and glucose and fructose are common monosaccharides.

MONOSACCHARIDES:
Any of the class of sugars that cannot be hydrolyzed to give a simple sugar.

DISACCHARIDES:
Any of a class of sugars with molecules that contain two monosaccharide residues.

PROCESSED FOODS:
Foods that have been frozen, packaged, enhanced with vitamins or minerals (fortified), previously cooked, or canned to preserve them for consumption.

Complex Carbohydrates

Complex carbohydrates are made of larger molecules that are broken down into monosaccharides. Starches and fibers, whole grain breads and cereals, starchy vegetables, and legumes are examples of complex carbohydrates. These carbs are known as polysaccharides (meaning many monosaccharides) and contain longer chains of sugar, which take longer to digest. Therefore, the consumption of complex carbs can help to maintain blood sugar levels and prevent rapid blood glucose fluctuations.

Glycemic Index

All foods affect blood glucose differently, and sugar levels are not dependent on just the type or amount of carbs consumed. The measure of how quickly blood glucose increases after carbohydrate ingestion is known as the **glycemic index (GI)**. Foods are scored from 1 to 100, with the slower-digesting carbs (blood glucose increases at a slower rate) at the low end and fastest-digesting carbs (blood glucose increases at a faster rate) at the high end. Pure glucose measures 100 on the glycemic index. Proteins and fats are not scored on this index. The GI of a food is typically considered to be low, medium, or high according to the following ranges:

GLYCEMIC INDEX (GI):
A system that ranks foods on a scale from 1 to 100 based on their effect on blood sugar levels.

Low GI: 1 to 55

Medium GI: 56 to 69

High GI: 70 and above

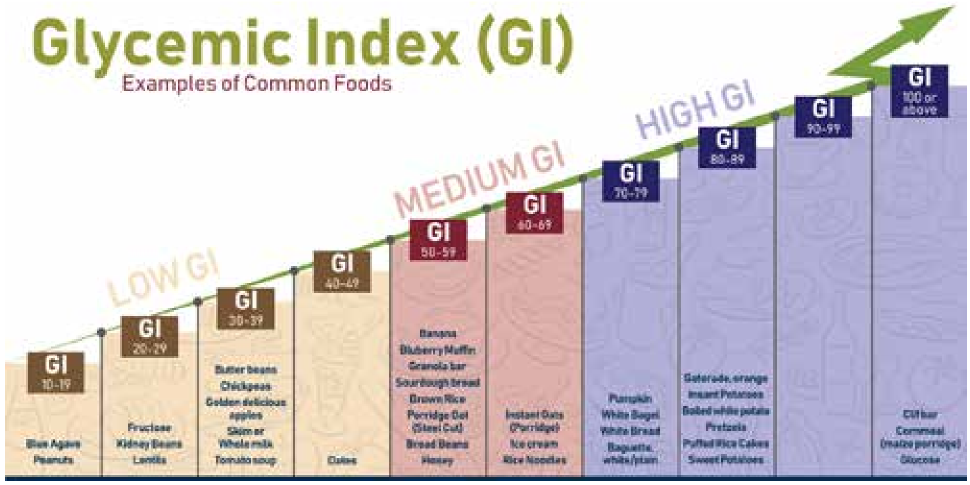


Figure 14.1 Glycemic Index

The GI of a food depends on several factors, including the type of sugar. Fructose has a value of 19, whereas maltose, for example, has a value that exceeds the normal GI scale at 105. Foods that are high in the component of starch called amylose have a lower GI because they are difficult to digest. Amylose and amylopectin molecules make up starch and can sometimes be resistant to digestion. In addition, processed foods will generally have a higher GI than less processed or whole foods.

INSULIN:
A hormone produced in the pancreas to regulate blood sugar.

HYPOGLYCEMIA:
The condition of lower-than-normal blood glucose

OBESITY:
An abnormal or excessive accumulation of body fat that may cause additional health risks.

DIABETES:
A condition characterized by an elevated level of glucose in the blood

The preparation and ripeness of food can alter the GI of a food. The longer a food is cooked, the higher the GI. Heat makes the chemical bonds in carbohydrates easier to break by digestive enzymes. Complex carbohydrates in fruit break down into simple carbohydrates as the fruit ripens. Unripe bananas have a GI of 30, and an overripe banana has a GI of 48.

The GI is a useful tool in determining the impact of foods on blood sugar. Foods with a high GI will increase **insulin** levels, causing **hypoglycemia** and increasing hunger. This could lead to overeating and weight gain. Foods with a low GI are digested slowly and do not increase insulin as dramatically. This increases satiety and keeps hunger at a more manageable level.

Some studies have found that eating lower GI foods results in less overeating, a better cholesterol reading, and decreased risk of **obesity** or **diabetes**. If the client has diabetes, then eating a diet of low GI foods may reduce the complications of diabetes. Low-glycemic foods do not spike blood sugar levels and therefore help maintain insulin sensitivity. This also allows the body's cells to use glucose more effectively.

It should also be noted that the combinations of foods can affect their glycemic impact and digestion. For example, a meal high in fat will require more time in the stomach for the breakdown and packaging of dietary fat before the stomach is emptied. A higher-fat meal will also promote the body's release of insulin, which serves to control blood glucose levels. This can reduce the immediate GI impact of the meal consumed and delay or reduce the amount of glucose in the bloodstream. On the other hand, a meal low in fat but high in carbohydrate or sugar can exaggerate the body's GI response and cause a rapid change in blood sugar and insulin production—greater than any one meal ingredient alone.

Intake Recommendations: Carbohydrates

Carbohydrates are essential nutrients that most people need in their diets in significant quantities for good overall health. The acceptable macronutrient distribution range for daily carbohydrate intake for adults is 45 to 65 percent of total daily Calories, as recommended by the Dietary Guidelines for Americans. This means that for a diet of 2,000 Calories per day, carbohydrate intake should be around 900 to 1,300 Calories. For weight loss, daily carbohydrate intake can drop to as low as 25 to 40 percent.

The **US Department of Agriculture (USDA)** and other major nutritional science institutions recommend getting carbohydrates from unprocessed or minimally processed whole grains, vegetables, fruits, and beans. Processed food includes foods that have been frozen, packaged, enhanced with **vitamins** or **minerals** (fortified), previously cooked, or canned to preserve them for consumption. Conversely, **unprocessed foods** are the natural, edible parts of an animal or plant that have not been cooked, frozen, or otherwise fortified for preservation. These may also be referred to as fresh or raw foods.

Unprocessed carbs naturally contain **fiber**, while processed carb options often have the fiber removed. The lack of fiber in refined carbs may promote overeating and increase weight gain.

US DEPARTMENT OF AGRICULTURE (USDA):
A US federal department that manages programs for food, nutrition, agriculture, natural resources, and rural development.

VITAMINS:
Organic compounds essential for normal growth and nutrition.

MINERALS:
Elements in food that the body needs to develop and function.

UNPROCESSED FOODS:
Fresh or raw foods that are the natural, edible parts of an animal or plant.

FIBER:
A type of carbohydrate derived from plant-based foods that the body is unable to break down.

Table 14.1 Food Sources of Carbohydrates

CARBOHYDRATE SOURCE	GRAMS OF CARBOHYDRATES PER 100 GRAMS OF SOURCE
Almonds	4 g
Apple	9 g
Asparagus	1 g
Banana	19 g
Barbecue sauce	8 g
Beef sirloin	0 g
Beer	2 g
Bread (brown, one slice)	48 g
Broccoli	2 g
Butter	Trace
Cashews	28 g
Celery	1 g
Cheddar cheese	Trace
Cheese pizza	25 g
Cheesecake	35 g
Chicken	0 g
Coconut	6 g
Cod	0 g
Coffee	0 g
Crab	0 g
Cream cheese (plain)	Trace
Doughnut	49 g
Flounder	0 g

Table 14.1 Food Sources of Carbohydrates (CONT)

CARBOHYDRATE SOURCE	GRAMS OF CARBOHYDRATES PER 100 GRAMS OF SOURCE
Goat milk	5 g
Grapes	13 g
Hamburger	22 g
Hardboiled egg	Trace
Honey	76 g
Human milk (breast milk)	7 g
Jelly	69 g
Lettuce	1 g
Mango	15 g
Margarine	Trace
Mayonnaise	Trace
Mustard	21 g
Onion	5 g
Orange	6 g
Oysters (raw)	Trace
Peanut butter	13 g
Peanuts	6 g
Pickles	6 g
Pineapple	12 g
Pistachios	19 g
Plain yogurt	6 g
Pork chop	0 g
Potato	20 g

Table 14.1 Food Sources of Carbohydrates (CONT)

CARBOHYDRATE SOURCE	GRAMS OF CARBOHYDRATES PER 100 GRAMS OF SOURCE
Prawns/shrimp	0 g
Raisins	64 g
Red wine	Trace
Rice	30 g
Salami (sliced)	2 g
Salmon	0 g
Scallops	Trace
Skim milk	5 g
Spinach	1 g
Sponge cake	53 g
Swiss cheese	Trace
Tuna	0 g
Turkey (roasted)	0 g
Vegetable oil	0 g
Vinegar	1 g
Walnuts	5 g
Whole milk	5 g

FIBER

Dietary fiber is a type of carbohydrate found in plant sources that the body cannot digest. Fiber is an important nutrient that supports digestion, weight management, blood sugar, and cholesterol. It promotes bowel movements and helps get rid of harmful substances in the body. This keeps the digestive system clean and healthy. There are two types of fiber: soluble and insoluble.

Figure 14.2 Sugar (left), Starch (middle), and Fiber (right)

Soluble Fiber

Soluble fiber dissolves in water and absorbs water from partially digested food. It helps slow the digestion process and regulate blood glucose levels, which leads to lower levels of **low-density lipoprotein (LDL)** cholesterol. Foods rich in soluble fiber include beans, oatmeal, nuts, lentils, apples, and blueberries. High-fiber foods such as fruits are low-calorie foods, which make it easier to lower caloric intake.

LOW-DENSITY LIPOPROTEIN (LDL): The form of lipoprotein in which cholesterol is transported in the blood. It is sometimes considered the “bad cholesterol.”

Insoluble Fiber

Insoluble fiber does not dissolve in water and instead adds bulk to the stool. This helps food move through the digestive tract. It promotes regularity, prevents constipation, and cleanses the colon. Adding bulk to a diet increases satiety, leading to less eating. Whole wheat bran, whole grain couscous, brown rice, nuts, legumes, carrots, cucumbers, and tomatoes are good sources of insoluble fiber.

Many foods provide both soluble and insoluble fiber. The more natural a food is, the more fiber it contains. Processed foods have less fiber, and meat, dairy, and sugar have no fiber. When foods are refined, such as white rice and bread, the fiber has been removed.

Prebiotics

Prebiotics are fibers that are fermented in the gut. Bacteria necessary for digestion use prebiotics as food. Some whole grains, bananas, greens, onions, garlic, soybeans, and artichokes contain prebiotic fibers. These foods contain plant fibers that help healthy bacteria grow in the gut. Prebiotics also improve calcium absorption, metabolism, and digestion and help process carbohydrates.

Intake Recommendations: Fiber

Fiber is essential to one's health, yet the typical American still falls short of the recommended daily amount. The National Academy of Medicine recommends that women consume 25 grams of fiber per day and men consume 38 grams. Although beneficial to overall health, increasing fiber intake too quickly could lead to gas, bloating, and cramps. Gas is a by-product of digesting fiber and a common side effect of high-fiber diets.

Though fiber is removed from processed foods, many of them have added fiber. These types of food can help individuals increase their daily intake. Ingredients such as polydextrose, psyllium husk, pectin, and soluble fiber dextrin are examples of added fiber. Eating foods with added fiber may increase overall intake for improved health. However, the nutrition label should be examined closely for added sugar and/or sodium, and intake should be monitored.

FIBER AND DISEASE

The body cannot digest fiber, but it is a vital nutrient for good health and longevity. Many studies have been conducted on the role of dietary fiber intake and disease prevention. Adequate fiber intake has been found to reduce instances of the following:

- **Heart disease**. Fiber protects the body against heart disease by decreasing bad cholesterol (Low-Density Lipoprotein or LDL) and improving insulin resistance.
- **Type 2 diabetes**. An increase in complex carbohydrate and fiber intake can help regulate blood sugar and prevent the progression of type 2 diabetes.
- **Diverticulitis**. Fiber softens the stool, which can prevent the inflammatory condition in the intestines and colon.
- **Colon cancer**. Fiber in the diet keeps the intestinal tract moving and healthy, which, in turn, keeps the colon functioning properly and reduces the risk of colon cancer.
- **Breast cancer**. Research has found a 12–19 percent lower risk of breast cancer in adolescent and adult females who consumed adequate fruits and vegetables (fiber) daily.

FATS

Fats—sometimes referred to as lipids—are necessary for vital bodily functions. They are organic molecules made up of carbon and hydrogen elements joined together in long groups called **hydrocarbons**. The arrangement of these hydrocarbon chains and their interaction with each other determine fat type. In addition, fat stores energy, protects vital organs, provides insulation, transports fat-soluble vitamins, and plays a role in tissue growth and hormone production. It also helps the body use vitamins and keeps skin healthy. **Fatty acids** are the

FATS:
Organic compounds that are made up of carbon, hydrogen, and oxygen. Fats are a source of energy in foods and are also called lipids. They come in liquid or solid form.

HYDROCARBONS:
A compound of hydrogen, and carbon, such as any of those that are the chief components of petroleum and natural gas.

FATTY ACIDS:
The smaller, absorbable building blocks of the fat that is found in the body.

smaller, absorbable building blocks of the fats found in the body and the fats humans ingest, which come in several forms including saturated and unsaturated fats. Three fatty acids combine with glycerol to form a **triglyceride**. Triglycerides are a type of fat and in fact are the most common form of fat in the body (bodyfat). The body makes triglycerides and as a part of the diet they make up the majority of the fats that we eat.

TRIGLYCERIDE:
A chemical compund formed when three fatty acids combine with glycerol. The most abundant fat in the body.

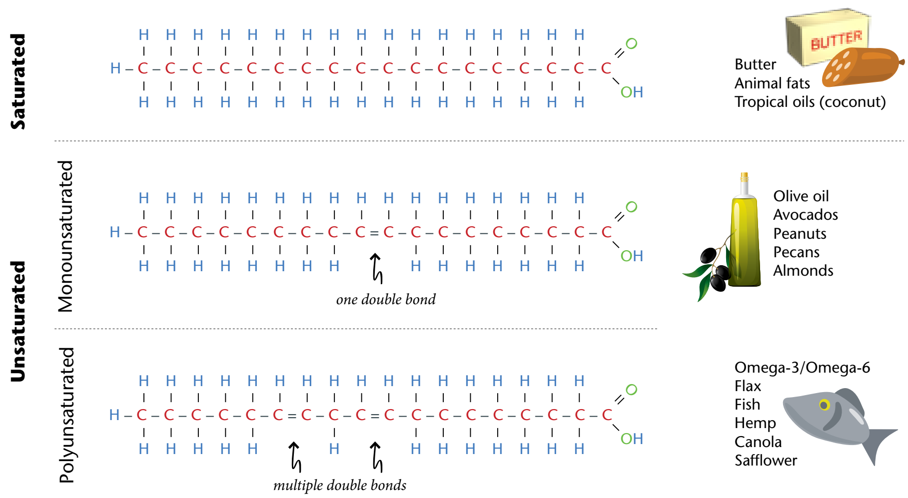


Figure 14.3 Structure of Fats

Saturated Fat

Saturated fats are usually solid at room temperature and have no double bonds within the molecular structure. Therefore, it is "saturated" with hydrogen atoms. Saturated fats are considered to be a detrimental fat and can cause cholesterol buildup in the arteries and increase the risk for heart disease. Food sources include butter, solid shortening, lard, cheese, red meat, ice cream, coconut oil, and palm oil.

Unsaturated Fat

Unsaturated fats are considered to be a beneficial fat and are usually liquid at room temperature. Two types of unsaturated fats are monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA). Monounsaturated fats such as omega-9 fatty acids are so called because they have only one double bond in their molecular structure.

Polyunsaturated fats have more than one double bond. Polyunsaturated fats include omega-3 fatty acids, where the position of the double bond is found three carbon atoms from the end of the molecular chain acids, and omega-6 fatty acids, where the last double bond is found six carbon molecules from the end of the fatty acid chain.

HIGH-DENSITY LIPOPROTEIN (HDL): A lipoprotein that removes cholesterol from the blood. It is sometimes considered the "good cholesterol."

CORONARY ARTERY DISEASE (CAD): The narrowing or blockage of coronary arteries.

OMEGA-6 FATTY ACIDS: A family of pro-inflammatory and anti-inflammatory polyunsaturated fatty acids that have in common a final carbon-carbon double bond.

OMEGA-3 FATTY ACIDS: An unsaturated fatty acid occurring chiefly in fish oils.

EICOSAPENTAENOIC ACID (EPA): A fatty acid found in fish and fish oils, which is believed to lower cholesterol, especially cholesterol bound to low-density lipoproteins.

DOCOSAHEXAENOIC ACID (DHA): An omega-3 fatty acid that is a primary structural component of the human brain, cerebral cortex, skin, sperm, testicles, and retina.

Sources of monounsaturated fats include olive oil, sesame oil, canola oil, peanut butter, peanuts, cashews, and avocados. Sunflower seeds, pumpkin seeds, corn oil, safflower oil, soybean oil, pine nuts, walnuts, salmon, tuna, and sardines are good sources of polyunsaturated fatty acids. Unsaturated fats are often labeled as a "good fat" because they improve **high-density lipoprotein (HDL)** (HDL cholesterol) levels, reducing the risk for heart disease.

Trans Fat

Trans fats are a type of unsaturated fat. Known as another detrimental fat, trans fats are both naturally occurring and man-made. Natural trans fats come from animal products such as beef, lamb, and dairy, and artificial trans fats are created by adding hydrogen to liquid vegetable oils. Artificial trans fats are used to prolong the shelf life of processed foods.

Trans fat can be found in some vegetable shortenings and margarine, crackers, cookies, snacks, and foods fried in partially hydrogenated oil. The problem with trans fat is that it elevates LDL cholesterol and lowers HDL cholesterol. This may increase the risk of **coronary artery disease (CAD)**.

Essential Fatty Acids

Essential fatty acids cannot be synthesized by the human body, which means they must be obtained from the diet. The primary essential fatty acids are linoleic acid **omega-6 fatty acids** and linolenic acid **omega-3 fatty acids**. Others include arachidonic acid (omega-6), **eicosapentaenoic acid (EPA)**, and **docosahexaenoic acid (DHA)** (omega-3). Arachidonic acid is required by the body but can be made from other essential fatty acids. EPA and DHA are also required by the body but are made from other essential fatty acids.

Table 14.2 Sources of Essential Fatty Acids

FATTY ACIDS	FOOD SOURCES
Linoleic acid (omega-6)	Safflower oils, sunflower oils, corn oils, soy oils, primrose, pumpkin, wheat germ
Linolenic acid (omega-3)	Fish oils, flaxseed, pumpkin, soy, and canola
Arachidonic acid (omega-6)	Chicken, beef, pork, fish
EPA and DHA (omega-3)	Cold-water fatty fish, salmon, shrimp, oysters, trout

Intake Recommendations: Fats

The **American Heart Association (AHA)** recommends keeping fat calories to 30–35 percent of daily Calorie intake. Staying closer to 20 percent is beneficial for weight loss and maintenance. The International Olympic Committee recommends following a meal plan with no less than 15–20 percent of fat for highly active individuals and athletes.

AMERICAN HEART ASSOCIATION (AHA):
A nonprofit organization that funds cardiovascular research and educates consumers on healthy living and good cardiac care.

Table 14.3 Fat Recommendations Based On Calorie Intake

Total calories per day	15 PERCENT		20 PERCENT		25 PERCENT		30 PERCENT		35 PERCENT	
	Calories	Grams	Calories	Grams	Calories	Grams	Calories	Grams	Calories	Grams
3,000	450	50	600	67	750	83	900	100	1,050	117
2,500	375	42	500	56	625	69	750	83	875	97
2,250	338	38	450	50	563	63	675	75	788	88
2,000	300	33	400	44	500	56	600	67	700	78
1,750	263	29	350	39	438	49	525	58	613	68
1,500	225	25	300	33	375	42	450	50	525	58

The requirements for essential fatty acids vary by age. Although many studies have shown that essential fatty acids play a critical role in preventing cardiovascular disease, cancer, arthritis, hypertension, and diabetes. Fatty acids are also critical for optimal brain and vision function. The **Recommended Daily Allowance (RDA)** for essential fatty acid is general, and there may be differences for special populations, including athletes. The following are the nutritional reference intakes as published by the National Academy of Medicine in 2006:

RECOMMENDED DAILY ALLOWANCE (RDA):
The average daily level of intake that is sufficient to meet the nutrient requirements of nearly all (97%-98%) healthy people.

Linoleic acid: 17 grams per day for men ages 19–50; 12 grams per day for women ages 19–50

Alpha-linolenic acid: 1.6 grams per day for men ages 19–50; 1.1 grams per day for women ages 19–50

Table 14.4 Food Sources of Fat

FAT SOURCE	GRAMS OF FAT PER 100 GRAMS OF SOURCE
Almonds	54 g
Apple	Trace
Asparagus	Trace
Banana	Trace
Barbecue sauce	7 g
Beef sirloin	21 g
Beer	Trace
Bread (one slice)	1–2 g
Broccoli	Trace
Butter	81 g
Cashews	47 g
Celery	Trace
Cheddar cheese	34 g
Cheese pizza	12 g
Cheesecake	35 g
Chicken	7 g
Coconut	62 g
Cod	1 g
Coffee	Trace
Crab	5 g
Cream cheese (plain)	47 g
Doughnut	16 g
Flounder	11 g

Table 14.4 Food Sources of Fat (CONT)

FAT SOURCE	GRAMS OF FAT PER 100 GRAMS OF SOURCE
Goat milk	5 g
Grapes	Trace
Hamburger	10 g
Hard-boiled egg	11 g
Honey	Trace
Human milk (breast milk)	4 g
Jelly	0 g
Lettuce	Trace
Mango	Trace
Margarine	80 g
Mayonnaise	79 g
Mustard	29 g
Onion	Trace
Orange	Trace
Oysters (raw)	1 g
Peanut butter	54 g
Peanuts	34 g
Pickles	Trace
Pineapple	Trace
Pistachios	54 g
Plain yogurt	4 g
Pork chop	19 g
Potato	Trace

Table 14.4 Food Sources of Fat (CONT)

FAT SOURCE	GRAMS OF FAT PER 100 GRAMS OF SOURCE
Prawns/shrimp	2 g
Raisins	Trace
Red wine	0 g
Rice	Trace
Salami (sliced)	45 g
Salmon	8 g
Scallops	1 g
Skim milk	Trace
Spinach	1 g
Sponge cake	27 g
Swiss cheese	29 g
Tuna	22 g
Turkey (roasted)	7 g
Vegetable oil	100 g
Vinegar	0 g
Walnuts	52 g
Whole milk	9 g

PROTEIN

Protein is made of chains of amino acids, which are necessary for building and maintaining body tissues. Protein may be broken down for energy, but it is not a preferred energy source for the body. Typically, protein breakdown for energy occurs when intake of the other macronutrients is insufficient, during times of starvation (overall negative energy balance), or in cases of extreme exertion. To determine the metabolic use of protein, scientists measure nitrogen levels. A positive nitrogen balance occurs during periods of growth and recovery. A negative nitrogen balance happens when the body uses more protein than is taken in. Examples might be starvation, infection, or after burn injury.

Amino Acids

Amino acids are the building blocks of protein. They are made of the following four elements: hydrogen, oxygen, nitrogen, and carbon. The human body requires 20 different amino acids for proper tissue growth and function. Of those, nine are **essential amino acids** that must be obtained from the diet.

ESSENTIAL AMINO ACIDS:
Amino acids that are not made by the body in the optimal amounts and therefore must be obtained through the diet.

Table 14.5 Amino Acids

9 ESSENTIAL AMINO ACIDS	NON-ESSENTIAL AMINO ACIDS
Cannot be made by the body, must be obtained from the diet.	Not essential in the diet as the body can synthesize it.
Isoleucine (BCAA)	Alanine
Leucine (BCAA)	Arginine
Histidine	Asparagine
Lysine	Aspartic acid
Methionine	Cysteine
Phenylalanine	Glutamic acid
Threonine	Glutamine
Tryptophan	Glycine
Valine (BCAA)	Proline
	Serine
	Tyrosine

Proteins are either complete or incomplete. A **complete protein** has all the essential amino acids in sufficient amounts. For example, dairy, eggs, meat, poultry, seafood, and soy protein are complete proteins. Quinoa and soy are plant-based complete proteins.

COMPLETE PROTEIN:
A food source containing all nine essential amino acids the body needs.

INCOMPLETE PROTEINS:
A food source that lacks one or more of the nine essential amino acids.

Incomplete proteins are either missing or do not have an adequate amount of one or more essential amino acids. Most plant-based sources of protein—beans, peas, grains, nuts, seeds, greens—do not have a complete amino acid profile. Incomplete protein sources, when eaten together, can provide a complete amino acid profile. These are called complementary proteins.

Consuming complete protein is critical to maintaining lean body mass. Combinations of incomplete proteins may be used to ensure adequate intake of essential amino acids. These can include nuts with whole grains such as peanut butter on whole wheat toast. Whole grains with beans, such as beans and rice or hummus and pita bread, also make a complete protein. Beans with nuts can be combined to make a complete protein as well.

Intake Recommendations: Protein

Protein intake is weight-adjusted and decreases with age. Intake recommendations vary based on physical activity, sex, and health status. It is also dependent upon client goals. Increasing protein intake leads to greater strength and muscle mass gains when paired with resistance exercise. When in a negative energy balance, it helps preserve muscle mass. Increased protein intake also limits age-related muscle loss and provides greater **muscle protein synthesis (MPS)**.

MUSCLE PROTEIN SYNTHESIS (MPS):
A process that produces protein to repair muscle damage and oppose muscle breakdown.

ESTIMATED AVERAGE REQUIREMENT (EAR):
The average daily nutrient intake level that is estimated to meet the requirement of half the healthy individuals in a specific life stage or sex.

WEIGHT-ADJUSTED RECOMMENDATIONS

Guidelines for protein intake include the **estimated average requirement (EAR)** and the RDA, which are 0.66 and 0.80 per kilogram (kg) of body weight per day. These recommendations are independent of age, sex, and body composition. It is important to recall that protein is needed during times of growth. Humans experience the fastest rate of growth during infancy. So, protein intake should be high during this time.

During childhood, up until the adolescent growth spurt, protein intake is reduced by 1.0 grams per kilogram (g/kg). The recommendation for adults is further reduced by 0.4 g/kg. However, these calculations are for sedentary individuals and do not take into account body composition goals, level of activity, or health-related issues impacting protein needs. Muscle growth, physical strength, and other physical-related goals require more protein intake.

ACTIVITY-ADJUSTED RECOMMENDATIONS

The RDA of protein is 0.8 g/kg of body weight or 0.36 grams per pound (g/lb) of body weight. Most research points to an optimal intake of 0.7–1.0 g/lb or between 10 percent and 35 percent of daily calories.

To promote skeletal muscle protein growth and physical strength in individuals with minimal physical activity, 1.0 g/kg of body weight per day is recommended. For those involved in moderate physical activity, 1.3 g/kg per day is recommended, and for intense physical activity 1.6 g/kg per day is recommended. Studies show that long-term consumption of protein at 2 g/kg of body weight per day is safe for healthy adults.

For every one gram of protein, there are four Calories, and the tolerable upper limit—the highest nutrient intake that will likely not generate adverse health effects in most adults in the general population—is 3.5 g/kg of body weight. Protein intake impacts metabolic rate, increasing the number of Calories burned. Recent studies have shown that protein intake of around 25–30 percent of daily Calories boosts metabolism by 80–100 Calories per day. Adequate consumption of high-quality protein from plant sources and animal products is essential for human growth and development. Plant-based protein sources contain unsaturated fat, which lowers LDL cholesterol—a risk factor for heart disease. Plant sources also contain no cholesterol.

Table 14.6 Plant-Based Sources of Protein

FOOD TYPE	FOOD SOURCES
Legumes	Lentils, peas, edamame, soybeans, peanuts
Beans	Adzuki, black, fava, chickpeas, kidney, pinto
Nuts	Almonds, pistachios, cashews, walnuts, pecans
Seeds	Hemp, pumpkin, sunflower, flax, sesame, chia
Whole grains	Kamut, teff, wheat, quinoa, rice, millet, oat,
Vegetables and fruits	Corn, broccoli, asparagus, brussels sprouts

Table 14.7 Food Sources of Protein

PROTEIN SOURCE	GRAMS OF PROTEIN PER 100 GRAMS OF SOURCE
Almonds	17 g
Apple	0.2 g
Asparagus	2 g

Table 14.7 Food Sources of Protein (CONT)

PROTEIN SOURCE	GRAMS OF PROTEIN PER 100 GRAMS OF SOURCE
Banana	0 g
Barbecue sauce	2 g
Beef sirloin	24 g
Beer	0.3 g
Bread (brown, one slice)	8 g
Broccoli	3 g
Butter	0.4 g
Cashews	18 g
Celery	0.9 g
Cheddar cheese	26 g
Cheese pizza	9 g
Cheesecake	4 g
Chicken	29 g
Coconut	5 g
Cod	21 g
Coffee	0.2 g
Crab	20 g
Cream cheese (plain)	8 g
Doughnut	6 g
Flounder	25 g
Goat milk	3 g
Grapes	1 g

Table 14.7 Food Sources of Protein (CONT)

PROTEIN SOURCE	GRAMS OF PROTEIN PER 100 GRAMS OF SOURCE
Hamburger	14 g
Hardboiled egg	12 g
Honey	0.4 g
Human milk (breast milk)	1 g
Jelly	0.6 g
Lettuce	1 g
Mango	0 g
Margarine	0.4 g
Mayonnaise	2 g
Mustard	29 g
Onion	0.9 g
Orange	0 g
Oysters (raw)	11 g
Peanut butter	23 g
Peanuts	17 g
Pickles	0 g
Pineapple	0.5 g
Pistachios	19 g
Plain yogurt	4 g
Pork chop	22 g
Potato	2 g
Prawns/shrimp	23 g

Table 14.7 Food Sources of Protein (CONT)

PROTEIN SOURCE	GRAMS OF PROTEIN PER 100 GRAMS OF SOURCE
Raisins	1 g
Red wine	0.2 g
Rice	2 g
Salami (sliced)	19 g
Salmon	20 g
Scallops	23 g
Skim milk	10 g
Spinach	5 g
Sponge cake	6 g
Swiss cheese	29 g
Tuna	23 g
Turkey (roasted)	28 g
Vegetable oil	Trace
Vinegar	0.4 g
Walnuts	11 g
Whole milk	3 g

WATER

Water makes up around 60 percent of total body weight in adults and about 75 percent in children. Water is critical to life and plays many important roles in the body. It keeps tissues in the mouth, eyes, and nose lubricated and lubricates the joints. Water also protects vital organs and tissues and prevents constipation and **dehydration**. It dissolves certain minerals and carries nutrients and oxygen to the cells. It also plays a critical role in regulating body temperature and helps the kidneys and liver by flushing out waste products from the body.

DEHYDRATION:
A harmful loss or removal of water in the body.

TEST TIP!

It is important to remember the 3-3-3 rule:

The body can go:

3 minutes without air,

3 days without water,

and 3 weeks without food.

Many factors influence how much water the body needs to function properly. Hot climates, physical activity, fever, and diarrhea or vomiting increase the body's need for water. Body composition and size, age, and medical conditions also influence fluid intake needs. Without adequate water intake, the body becomes dehydrated. When dehydrated the body cannot maintain proper temperature, **electrolytes** become unbalanced, joints may not work properly, and blood pressure may increase or decrease. Water in the body can be divided into **intracellular fluid (ICF)** and **extracellular fluid (ECF)**. ICF is water found within the cells of the body, while ECF is water found outside the cells and between tissues. Approximately two-thirds of the body's total water is found within the cells, and one-third of the body's total water is found outside the cells.

ELECTROLYTES: Minerals in the body that have an electric charge.

INTRACELLULAR FLUID (ICF): Water found within the cells of the body.

EXTRACELLULAR FLUID (ECF): Water found outside the cells and between tissues.

Table 14.8 Intracellular and Extracellular Fluid Table

	INTRACELLULAR FLUID (ICF)	EXTRACELLULAR FLUID (ECF)
Found	Enclosed within cell membranes	Outside of cell membranes: • 25% within vascular system, makes up plasma portion of blood volume • 75% known as interstitial fluid, which surrounds cells and connective tissues
Makes up	About 2/3 of the body's water	About 1/3 of the body's water
Higher In	Potassium and magnesium	Sodium and chloride
Lower In	Sodium and chloride	Potassium and magnesium

Signs and symptoms of dehydration include increased thirst, dry mouth, very yellow or dark urine, very dry skin, dizziness, rapid heart rate, headache, lack of energy, tiredness, confusion, fainting, heat cramps, heat stroke, brain swelling, seizures, fluid loss resulting in a reduction of blood volume and insufficient blood pumping by the heart (hypovolemic shock), organ failure, and death.

INTAKE RECOMMENDATIONS: WATER

In general, between 91 and 125 fluid ounces or 2.7 to 3.7 liters of water per day is recommended for adults. About 20 percent of that intake comes from food. The human body relies on water to function properly. Cells and skin need water to function, which is why it is important to stay hydrated.

Drinking fluids is not the only way to maintain water levels, however. Fruits and vegetables are an effective source of water as well. Vegetables consisting of mostly water include cucumbers, cabbage, lettuce, and celery. Fruits made up of mainly water include tomatoes, watermelon, apples, and oranges. Other foods high in water content are yogurt, soup, tea, cottage cheese, and shrimp.

MICRONUTRIENTS

Macronutrients such as carbohydrate, fiber, fat, protein, and water are those nutrients that are needed in large amounts in the diet. The body also requires micronutrients. Micronutrients (vitamins and minerals) are chemical elements or other substances needed in only trace amounts to support normal growth and development. Although they are only needed in small amounts, micronutrients play critical roles within the body.

MINERALS

The body needs several minerals to support bone development and growth as well as muscle, heart, and brain function. For example, calcium helps maintain teeth and bones, helps blood to clot, and aids in nerve and muscle function. Iron forms blood cells and transports oxygen, and potassium works to regulate water balance in the cells, helps with nerve function, and regulates heart rate. Sodium is known as an electrolyte and helps balance water levels in the cells and stimulates nerves. Zinc helps with carbon dioxide removal, helps heal wounds, and forms enzymes.

Some minerals are required in large quantities (macrominerals), while others are only required in trace amounts (trace minerals).

Table 14.9 Macrominerals and Microminerals

MACROMINERALS	TRACE MINERALS
Calcium	Cobalt
Chloride	Copper
Magnesium	Fluoride
Phosphate	Iodine
Potassium	Iron
Sodium	Manganese
	Selenium
	Zinc

Minerals are not a direct source of energy, meaning they do not provide Calories in the diet. They enter the body in the simplest form, and the body does not need to break them down before they can be absorbed. Minerals are also resistant to damage from heat. This means that storing and cooking minerals do not affect their functions.

Minerals found in foods come from the environment, such as the soil and water a plant takes up while growing. They are then incorporated into the animals that consume those plants. So, regardless of whether a human consumes the plant directly or an animal product, all minerals come from nature.

VITAMINS

Vitamins are also micronutrients, and each plays a specific role in the body like promote cell function, growth, and development. These organic compounds are needed in small amounts and are required to live. The human body does not produce enough on its own and therefore vitamins must be obtained from food. Vitamins are broken down into categories: fat-soluble and water-soluble.

Oftentimes, people struggle with how they look and feel because their physiology doesn't work the way it should. This can be a hormonal imbalance, but it's more often dietary deficiency—not getting the right nutrients in the right amounts to get the best results. When the body is deficient in key nutrients, normal physiology doesn't work properly. And when the body doesn't work as it should, oftentimes people feel ill, perform poorly, and will fail to see physical adaptations as expected. Energy levels, appetite, strength, endurance, and mood all rely on getting enough of these essential nutrients.

Dietary deficiencies, therefore, are the first red flag that indicates something's wrong. And they are more common than one may think. Chances are clients have at least one deficiency, no matter how good they think their eating habits are. Some of the most common micronutrient deficiencies are:

- Vitamin B7
- Vitamin D
- Vitamin E
- Chromium
- Iodine
- Molybdenum

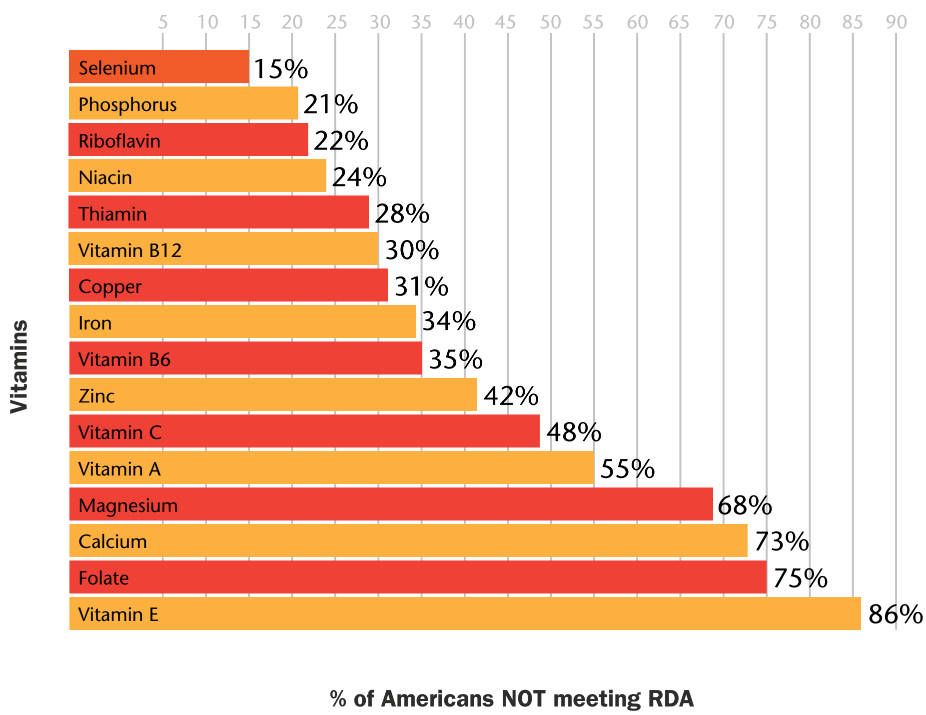


Figure 14.4 Percentage of the US Population Not Meeting the RDA

Source: US Department of Agriculture (2009).

For this reason, a fitness professional should help clients identify what they feel physically and mentally during training while monitoring their eating habits to ensure overall nutrient intake is adequate and supports their fitness goals. It is important to note that fitness professionals should refer clients to a dietician or their physician for deficiency testing and dietary modifications to specifically address micronutrient deficiencies.

Fat-Soluble and Water-Soluble Vitamins

Fat-soluble vitamins are absorbed along with fat in the diet. They can be stored in fatty tissue in the body. Water-soluble vitamins are broken down and absorbed with water but are not stored in the body.

Table 14.10 Vitamins and Minerals Overview

	VITAMIN	NECESSARY FOR:	FOOD SOURCES:
FAT SOLUBLE	**Vitamin A**	Eyes, bones, immunity, reproductive function	Liver, carrots, pumpkin, sweet potatoes, spinach, collards, kale, egg yolks, beets, mustard greens, winter squash
	Vitamin D	Bone health, blood calcium levels, cell growth, immunity, teeth integrity	Rainbow trout, salmon, swordfish, tuna, halibut, sardines, rockfish, egg yolks, mushrooms, shrimp, beef liver
	Vitamin E	Protecting cell membranes and other fatty acids from oxidation, protecting white blood cells, immunity, overall antioxidant function	Almonds, sunflower seeds, spinach, Swiss chard, avocado, peanuts, turnip greens, hazelnuts
	Vitamin K1	Blood coagulation and bone metabolism	Kale, collards, spinach, turnip greens, beet greens, dandelion greens, Swiss chard, brussels sprouts, broccoli, asparagus
	Vitamin K2	Bone metabolism, appropriate calcium deposition, supporting growth and development	Cheese, egg yolks, grass-fed butter, chicken liver, chicken breast, beef, dairy

Table 14.10 Vitamins and Minerals Overview (CONT)

	VITAMIN	NECESSARY FOR:	FOOD SOURCES:
WATER SOLUBLE	**Vitamin B1 (Thiamin)**	Acting as an enzyme cofactor for carbohydrate and amino acid metabolism	Sunflower seeds, pork, peas, barley, navy beans, black beans, lentils, oats, asparagus, beef liver, tahini, pinto beans
	Vitamin B2 (Riboflavin)	Acting as an enzyme cofactor for carbohydrate and fat metabolism	Beef liver, cottage cheese, yogurt, soybeans, white mushrooms, milk, spinach, whole wheat, almonds, eggs, shrimp
	Vitamin B3 (Niacin)	Carbohydrate and fat metabolism, DNA replication and repair	Beef liver, yellowfin tuna, chicken breast, pork loin, salmon, swordfish, whole wheat, buckwheat, mushrooms, canned tomato products
	Vitamin B5 (Pantothenic Acid)	Assisting with fat and carbohydrate metabolism, cholesterol production, and supporting hair, skin, eyes, liver, nervous system, reproductive function, red blood cell production, adrenal gland function, and digestion	Shiitake mushrooms, avocado, trout, yogurt, chicken, lobster, peas, crab, crimini mushrooms, sweet potatoes, potatoes, lentils, egg yolk, beef liver, turkey
	Vitamin B6 (Pyridoxine)	Acting as an enzyme cofactor for carbohydrate and amino acid metabolism, synthesis of blood cells	Tuna, turkey, beef, chicken, salmon, sweet potatoes, sunflower seeds, chickpeas, potatoes, pork loin, bananas, swordfish, spinach, plantains
	Vitamin B7 (Biotin)	Acting as an enzyme cofactor in carbohydrate, fat and protein metabolism	Nuts, egg yolks, sweet potatoes, onions, liver, salmon, peanuts, mushrooms, pork, chocolate, oats, tomatoes
	Vitamin B9 (Folate)	Acting as an enzyme cofactor for amino acid metabolism, DNA synthesis, metabolism of homocysteine	Spinach, lentils, pinto beans, chickpeas, asparagus, broccoli, romaine lettuce, cowpeas, black beans, kidney beans, chicken liver
	Vitamin B12 (Cobalamin)	Formation of blood, nervous system function, enzyme cofactor in metabolism of homocysteine	Shellfish, beef liver, beef, sardines, salmon, tuna, cod, dairy
	Vitamin C (Ascorbic Acid)	Collagen synthesis, immune function, synthesis of hormones, synthesis of neurotransmitters, synthesis of DNA, enhancement of iron absorption, anti-oxidation	Sweet peppers, citrus fruits, broccoli, strawberries, kiwi, guava, kohlrabi, papaya, brussels sprouts

Table 14.10 Vitamins and Minerals Overview (CONT)

MINERAL	NECESSARY FOR:	FOOD SOURCES:
Calcium	Bone/tooth health, acid-base balance, nerve impulse transmission, muscle contraction	Green vegetables, soybeans, nuts/seeds, fish, dairy
Chloride	Fluid balance, nerve impulse transmission, digestive health, antibacteria	Table salt
Choline	Cell membranes and neurotransmitters, liver metabolism, transportation of nutrients, controls homocysteine levels in fetus during pregnancy	Shellfish, beef and beef liver, eggs, salmon, pork, chicken, tomato products
Chromium	Glucose transport, metabolism of DNA/RNA, immune function	Broccoli, barley, oats, onions, green beans, tomatoes, potatoes, prunes, nuts, brewer's yeast
Copper	Assisting many enzyme systems, iron transport, immune function	Sesame seeds, cashews, mushrooms, barley, soybeans, tempeh, sunflower seeds, navy beans, garbanzo beans, lentils, walnuts, liver, seafood
Fluoride	Teeth and bone health	Seafood, legumes, whole grains, drinking water (check local levels), green tea
Iodine	Synthesis of thyroid hormones, temperature regulation, reproductive health, nervous system health	Sea vegetables, saltwater seafood, dairy, eggs, strawberries
Iron	Oxygen transport, hemoglobin, myoglobin, assists in enzyme systems	Soybeans, lentils, spinach, beans, olives, raisins, brown rice, broccoli, pumpkin seeds, tuna, flounder, chicken, pork, beef

Table 14.10 Vitamins and Minerals Overview (CONT)

MINERAL	NECESSARY FOR:	FOOD SOURCES:
Magnesium	Assisting more than 300 enzyme systems, bone health, muscle contraction, immunity, regulate blood sugar and blood pressure	Legumes, spinach, Swiss chard, nuts, seeds, whole grains, fruits, avocado, poultry
Manganese	Assisting various enzyme systems, bone/cartilage health	Whole grains, nuts, legumes, seeds, tea, leafy green vegetables
Molybdenum	Acting as an enzyme cofactor involved in carbon, nitrogen, and sulfur cycles, metabolism of drugs/toxins (e.g., purines, nitrosamines)	Legumes, nuts, whole grains
Phosphorus	Fluid balance, bone health, part of ATP	Dairy, soybeans, sardines, beef liver, lentils, pumpkin seeds, eggs, almonds, peanuts, peanut butter
Potassium	Fluid balance, nerve impulse transmission muscle contraction	Vegetables, fruit, dairy, fish
Selenium	Carbohydrate and fat metabolism, antioxidant, immune function	Tuna, shrimp, sardines, salmon, poultry, cod, chicken, Brazil nuts, mushrooms, barley, whole grains, walnuts, eggs
Sodium	Fluid balance, acid-base balance, nerve impulse transmission, muscle contraction	Salt, greens, most foods contain some sodium
Sulfur	Certain B-vitamins and amino acids, acid-base balance, detoxification of liver	Protein dense foods
Zinc	Assisting more than 100 enzyme systems, immune health, growth/sexual maturation, gene regulation	Beef, sesame seeds, pumpkin seeds, lentils, chickpeas, cashews, whole grains, oats, oysters, turkey, shrimp

Antioxidants

Free radicals are molecules with unpaired electrons, and they are created in the body during cellular metabolism. People are also exposed to free radicals in the environment, such as tobacco, alcohol, pollution, ultraviolet (UV) rays from the sun or artificial UV rays from tanning beds, or from substances found in food.

These imbalanced molecules travel around the body looking for another electron to pick up to balance the electrical charge of the atom. This causes damage to cells, proteins, and DNA. Damage from free radicals may contribute to chronic diseases from cancer to heart disease, **Alzheimer's disease**, and vision loss. Antioxidants work to prevent or delay damage caused by free radicals. Antioxidants donate electrons to free radicals to neutralize the charge and prevent damage.

ALZHEIMER'S DISEASE:
Progressive mental deterioration that can occur in middle or old age, due to generalized degeneration of the brain.

The following substances are known for their antioxidant properties:

- Beta-carotene
- Coenzyme Q10
- Glutathione
- Flavonoids
- Lipoic acid
- Manganese
- Phenols
- Phytoestrogens
- Polyphenols
- Selenium
- Vitamin C
- Vitamin E

US DEPARTMENT OF HEALTH AND HUMAN SERVICES:
A US federal department that oversees public health, welfare, and civil rights issues.

DIETARY GUIDELINES FOR AMERICANS:
Guidelines for healthy, lifelong eating habits for Americans two years of age and older.

FOOD AND DRUG ADMINISTRATION (FDA):
A US federal department that regulates the production and distribution of food, pharmaceuticals, tobacco, and other consumer products.

EATING PATTERN:
The types of food and beverages an individual consumes.

DIETARY GUIDELINES AND MYPLATE

The **US Department of Health and Human Services** and US Department of Agriculture (USDA) create and update the **Dietary Guidelines for Americans** to promote sustainable, healthy food choices for lifelong health and good nutrition. With the aim of preventing chronic diseases such as cancer, hypertension, stroke, heart disease, and other chronic conditions, the guidelines address what to eat and what to avoid eating for optimal health.

Foods available to American consumers today include fresh, packaged, and processed products. To make the best choices, it is important for consumers to read and understand food labels. Even the simplest food packaging includes a nutrition label, a list of ingredients, and often nutrition and health benefit claims. The **Food and Drug Administration (FDA)** regulates each of these elements for accuracy and effectiveness.

The current dietary guidelines are useful for making healthy food choices and crafting a well-rounded **eating pattern**. Nutrition coaches and fitness professionals can use these guidelines as the basis for helping clients develop healthier eating habits to support their goals.

The first half of the 164-page Dietary Guidelines contains chapters related to various nutrition topics.

The second half of the Dietary Guidelines contains the Dietary Guidelines Appendix with helpful tables of foods, nutrient sources, calorie intake, and more.

In addition to nutrition, the Dietary Guidelines also contains information about physical activity recommendations.

Figure 14.5 The Dietary Guidelines for Americans

THE DIETARY GUIDELINES FOR AMERICANS

The Dietary Guidelines are organized progressively, starting with five core concepts, which are followed up with more detailed guidelines for food choices.

Concept one: following a healthy eating pattern across the lifespan.

All food and beverage choices matter. Choosing a healthy eating pattern at an appropriate calorie level will help achieve and maintain a healthy body weight, support nutrient adequacy, and reduce the risk of chronic disease.

Concept two: focusing on variety, **nutrient density**, and food amounts.

NUTRIENT DENSITY:
The amount of nutrients in a food relative to the number of calories it provides, usually measured per 100 kilocalories.

To meet nutrient needs within calorie limits, it is important to choose a variety of nutrient-dense foods across and within all food groups in recommended amounts.

Concept three: limiting calories from added sugars and saturated fats and reducing sodium intake.

A healthy eating pattern should be low in added sugars, saturated fats, and sodium.

Concept four: shifting to healthier food and beverage choices.

It is important to choose nutrient-dense foods and beverages across and within all food groups in place of less healthy choices and consider cultural and personal preferences to make these shifts easier to accomplish and maintain.

Concept five: supporting healthy eating patterns for all.

Everyone has a role in helping to create and support healthy eating patterns in multiple settings nationwide, from home to school, at work, and in communities.

The Dietary Guidelines' key recommendations for healthy eating patterns should be applied in their entirety. There are complex, interconnected relationships between dietary components that can be missed if only a few recommendations are followed.

Limiting Added Sugars

It is equally important to consider what to limit in a diet for a healthy eating pattern. These include **added sugars**, certain fats, and sodium. These are of concern for public health in the United States. Specified limits can help individuals achieve healthy eating patterns within Calorie limits.

ADDED SUGARS:
Any type of sugar that is added to a food or beverage when it is processed. This is compared to natural sugars found in whole foods, such as fruit or milk.

The recommendation for added sugars, those sugars not found naturally in whole foods, is to limit consumption to less than 10 percent of daily Calories. This is based on modeling of food patterns and national data on calorie intake. Once all the recommended food groups are consumed for a typical individual, there is no room for added sugars.

Limiting Unhealthy Fats

Calories from saturated and trans fats should be limited to less than 10 percent of Calories per day. This recommendation is based on research that shows replacing saturated fats with unsaturated fats is associated with a reduced risk of cardiovascular disease. As with added sugars, once food recommendations are met within a day, there is little room for extra calories from saturated fats.

Limiting Sodium

Sodium intake is recommended in quantities less than 2,300 milligrams per day. This is the tolerable upper intake level set by the National Academy of Medicine for people ages 14 and older. The Dietary Guidelines for Americans provides a recommendation for younger children.

Limiting Alcohol

The current recommendation for alcohol consumption is to limit beverages to one drink per day for women and two per day for men, which is considered moderate drinking. Consuming more than the recommendation is considered heavy drinking and carries health risks. The Dietary Guidelines for Americans provides more information about who should abstain completely.

THE FOOD PYRAMID TO MYPLATE

A previous representation for the Dietary Guidelines, and one that most consumers still recognize, is the Food Pyramid. It acted as a visual tool to help individuals make better choices about food and create a healthy eating pattern.

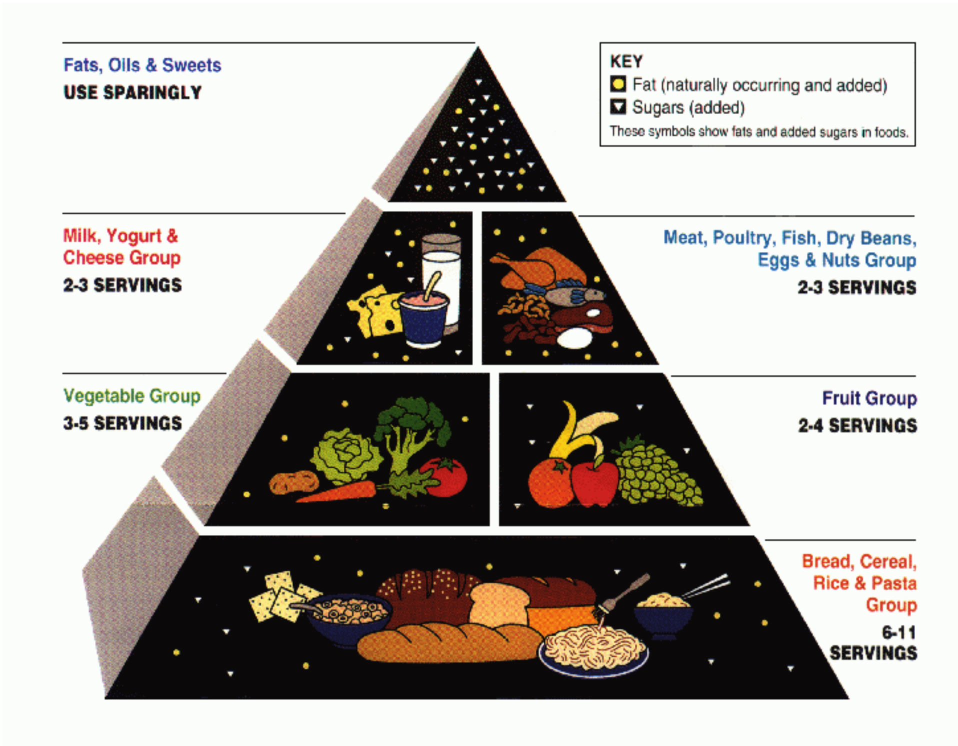


Figure 14.6 The Food Pyramid (Retired)

The Food Pyramid used the number of servings per day of each food type to represent how much the average American should consume. It included servings for grains, vegetables, fruits, meats and other protein sources, dairy, and fats. The gradual thinning of the categories up the pyramid was intended to demonstrate that grains should be the focus of the diet, with each subsequent food group making up a smaller and smaller portion. Left out, however, was a distinction between healthier whole grains and processed, sugary foods such as white pasta and cereals that are now known to have contributed to the US obesity epidemic.

Newer resources take fats, oils, and sweets out of the graphics completely. Processed foods, desserts, and sugary beverages are now treated as foods to avoid as much as possible. The food pyramid is also now thought to have put too little focus on fruits, vegetables, and protein sources. The research that led to the transition from the Food Pyramid to **MyPlate** puts a greater focus on the Dietary Guidelines and choosing larger quantities of healthy whole foods.

MYPLATE:
The current visual nutrition guide published by the USDA Center for Nutrition Policy and Promotion.

While the Food Pyramid was a popular resource, it is now considered dated. It has been replaced with the simplified, updated MyPlate representation. The official reason for the change is to simplify the visual tool and to promote healthy eating for a new generation of Americans. The guidelines presented are the same as those from the Dietary Guidelines, but the MyPlate tools and graphics are intended for use by the general population. They provide resources that fitness professionals can use to communicate effectively with clients.

MyPlate is shaped like a plate with colorful fractions dedicated to dairy, vegetables, fruits, protein, and grains. This helps people visualize filling their plates at each meal with appropriate amounts of each food type. It is easy enough for a child to understand. Fats and sugars previously at the top of the Food Pyramid are left off the MyPlate graphic because of how they contribute to obesity in the overall population. Fitness professionals can use the MyPlate graphic as a teaching tool to explain healthy food choices and proportions to their clients.

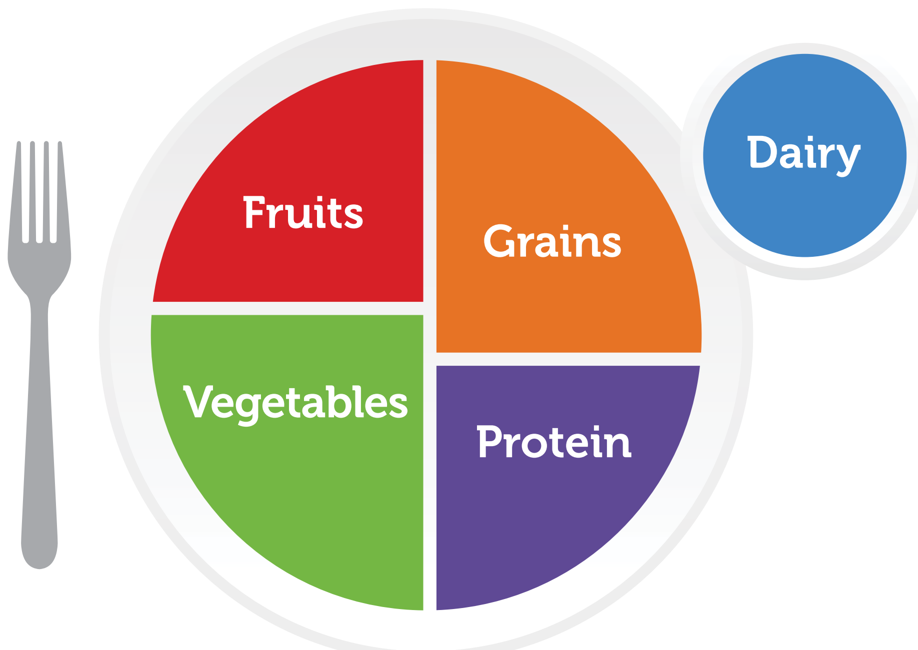


Figure 14.7 MyPlate

FRUITS AND VEGGIES

According to the USDA, half of a healthy plate should be fruits and vegetables. The focus should be on choosing whole fruits and vegetables, which may include fresh, frozen, dried, or canned products with no additives. One can enjoy fruits as a sweet snack or dessert or with meals to increase daily intake. Vegetables should be varied in type and color. There are several healthful ways to prepare vegetables: sautéed, roasted, raw, or steamed.

GRAINS

Whole grains should fill up a quarter of a well-rounded plate. At least half the grains consumed daily should be whole grains. Any processed product is considered whole grain if the first or second item on the ingredients list is whole grains. Whole grain foods include brown rice, oatmeal, popcorn, whole wheat pasta, and whole grain breads.

PROTEIN

Lean proteins make up the final quarter of MyPlate. Seafood, beans, unsalted nuts and seeds, eggs, poultry, and lean meats are great choices for protein. It is important to choose a variety of protein sources for building muscle tissue; for bone, blood, and skin health; and to produce hormones. Consuming protein from several different sources provides a variety of amino acids for the body to use.

DAIRY

For dairy products, MyPlate encourages a switch to low-fat or fat-free products to reduce saturated fat intake. Foods such as sour cream, heavy cream, and regular cheese can be replaced with lower-fat varieties.

Simple changes such as choosing vegetable oils instead of butter and choosing water over sugary drinks can have a big effect over time. Nutrition coaches and trainers can encourage change by focusing their clients on small steps. A client should choose one thing to change at a time, such as adding a fruit to every meal for a week or increasing the serving of vegetables in each meal.

Habits generally take two to four weeks to form, and consistency is key. When it comes to eating, overhaul diets that change everything about one's diet at once are impossible to maintain. The guidelines are a great way to inform and promote small, sustainable lifestyle changes.

UNDERSTANDING FOOD LABELS

Being able to read and comprehend the nutritional content of the food an individual consumes is an important component of success. Personal trainers should have a strong understanding of how to read nutrition labels, which foods are good sources of certain nutrients, and understand the dietary guidelines so they can easily relay it to their clients. While most foods have a list of ingredients and some also have Calorie and nutrients-per-serving information listed on the package, most fresh and whole foods do not have a package to list this information on. So, this information comes from reading the nutrition labels of products that have **nutrition facts** and using the many credible online resources available for those that do not.

NUTRITION FACTS:
A label required by the FDA on most food and beverages that details the food's nutrient content.

INGREDIENT LIST:
A list provided on a food label of each ingredient in a product in descending order of prominence.

Under the FDA nutrition labeling regulations, certain ingredients and nutrition information must be listed on most packaged foods and supplements. Food labels will have ingredient listings and other nutritional information, such as the amount of fat, protein, carbohydrates, and certain vitamins and minerals. The only vitamins and minerals required to be listed on a food label are vitamin D, calcium, potassium, and iron. If a vitamin or mineral claim is made or it is added to the product, then it must also be listed on the nutrition panel. An **ingredient list** will name each ingredient in descending order of amount, with the first ingredient being the most prominent. If water is the first ingredient on the list, then water is the most prominent ingredient. However, the exact amount of each ingredient will not be provided in the ingredient list.

NUTRITION FACTS LABELS

The nutrition facts label is designed to provide information that can help consumers make informed choices about the food they purchase and consume. The FDA seeks to protect and inform the consumer by making the label conveniently located on the packaging, easy to read, and precise in its details.

Easy to Read

Current nutrition facts labels have been updated to make them easier to read. The original look of the label remains, but there are important updates including the bolding and increase in text size for details like serving size (the amount of food in one serving), Calories per serving (number of Calories in one serving), and servings per container (the total number of servings in the entire package).

DAILY VALUE (DV):
Reference amounts expressed in grams, milligrams, or micrograms of nutrients to consume or not to exceed each day.

Manufacturers must declare the amount, in addition to percent **daily value (DV)**, of vitamin D, calcium, iron, and potassium in each serving of a product. Daily values are reference amounts of nutrients to consume or not to exceed and are used to calculate the percent daily value that manufacturers include on the label. They can voluntarily declare the gram amount for other vitamins and minerals if they are present or added to the product as well.

The footnote has been updated to better explain what percent daily value means. It will read: "*The % daily value indicates how much a nutrient in a serving of food contributes to a daily diet. 2,000 Calories a day is used for general nutrition advice." The percent daily value helps consumers understand the nutrition information in the context of a total daily diet of 2,000 Calories, unless otherwise specified on the label.

Note: The images above are meant for illustrative purposes to show how the revised nutrition facts label might look. All labels represent fictional products.

Figure 14.8 Sample Food Labels

Added sugars, in grams and as the percent daily value, are now included on the nutrition facts label. Scientific data shows that it is difficult to meet nutrient needs while staying within Calorie limits if more than 10 percent of total daily Calories are consumed through added sugar, and this is consistent with the 2021–2025 Dietary Guidelines for Americans.

Also required are the amounts of vitamin D, potassium, iron, and calcium. Any other listed vitamins and minerals are optional. While continuing to require “total fat,” “saturated fat,” and “trans fat” on the label, “Calories from fat” is no longer listed. The importance lies in the type of fats consumed versus the Calories from fat.

Serving Sizes and Labeling Requirements

By law, serving sizes must be based on the amounts of foods and beverages that people are actually eating, not what they should be eating. The amounts people consume for a serving have changed over time, and a reference amount is a standard used to determine serving sizes by the FDA. For example, the reference amount for a serving of ice cream was previously half of a cup but is now two-thirds of a cup, and the reference amount for a yogurt cup has decreased from eight ounces to six ounces.

Figure 14.9 How Serving Sizes Have Changed- Then (right) versus now (left)

Package size affects what people eat, so for packages that are between one and two servings, such as a 20-ounce soda or a 15-ounce can of soup, the Calories and other nutrients will be required to be labeled as one serving. If the package is larger, the addition of another column with the words "per package" details the nutritional values if the entire package is consumed at once, as well as the reference amount for a single serving.

COMMON DIET TRENDS

DIET:
The foods that a person or community eats most often and habitually; a choice of regular foods consumed for the purpose of losing weight or for medical reasons.

The word "**diet**" originates from the Greek word diaita, meaning "way of life." The initial meaning included everything that encompasses a lifestyle. Today the term has a more limited meaning. It describes the foods that a person habitually eats, whether it be to lose weight, maintain or improve health, or for medical reasons.

Many people use the term "diet" to refer to a pattern of eating with the goal of rapid weight loss, extreme physical transformation, or prevention of chronic disease. A well-balanced diet and consistent, healthy eating habits provide more stable health and weight benefits over time.

There are many different diet plans targeted to consumers. They promise a range of benefits:

- Rapid weight loss
- Long-term weight loss
- Improved gut health
- Lower risk of diabetes
- Improved cardiovascular health
- Lower blood pressure

Some diets have delivered everything they promise. The World Health Organization (WHO) has even recognized some popular diets as sustainable and healthy lifestyle choices. However, other diets fall by the wayside because they don't deliver results or are harmful. To help guide clients, a fitness professional must be aware of popular trending diets and their risks and benefits.

DETOX DIET

A detox diet is based on the idea that the body benefits from periodic detoxification. There is a lot of variety in detox diets, but they generally begin with a period of fasting followed by a strict diet of raw fruits and vegetables, water, or juices. The initial fast can range from two days to a week, followed by two to seven days of liquid or decreased calorie intake.

Also known as cleanses, detox diets claim to cleanse the body of toxins, refresh the digestive tract, and reset metabolism. Weight loss may be significant on a detox, but it is largely a result of water loss. Some individuals report a boost in energy during and after a detox. Science suggests this is a result of removing processed foods and sugars from the diet while reducing calorie intake. Short term, this can be beneficial, but detoxing for extended periods of time is contraindicated. There is no solid research to prove a cleanse or detox is necessary or beneficial unless ordered by a licensed health professional.

There are several popular cleanses, including the colon cleanse, juice cleanse, and the liver detox.

LOW- AND NO-FAT DIETS

The American Heart Association recommends that no more than 30 percent of daily Calories come from fat. However, the safe lower limit for fat consumption has never been established. During the low-fat food trend, many manufacturers reduced fat in products like yogurt, cheese, milk, cereals, salad dressing, nut butters, pastries, frozen desserts, and butter substitutes. They replaced the fat with fillers, sugars, and chemicals for better taste, texture, and consistency. These artificial additives can cause gastrointestinal distress, digestion issues, and skin problems.

A very low-fat diet can initially lead to weight loss if calorie guidelines are followed. However, critics warn that the benefits are negated by decreases in plasma cholesterol levels and health issues for special populations like pregnant or lactating women, children, and the elderly.

It is also important to note that dietary fat is important for hormone production and regulation. A low-fat diet can upset hormone balance and cause health problems in both men and women.

EATING BY BLOOD TYPE

A popular diet in the early 2000s was the genotype or blood type diet. A naturopathic physician named Peter D'Adamo developed the diet after theorizing that a person's blood type determines how they respond to certain foods.

D'Adamo created a guide to eating by blood type:

- **Blood Type A:** People with this blood type should consume fruit, vegetables, tofu, seafood, soy, and whole grains, and avoid most meats. Ideally, their diet is mostly vegetarian, with some fish, and largely organic and fresh because of a sensitive immune system.
- **Blood Type B:** People with this blood type should choose green, non-starchy vegetables (spinach, asparagus, green beans, artichokes), lean meats (except chicken), and low-fat dairy while avoiding corn, wheat, lentils, tomatoes, and peanuts. Because of digestive sensitivity, this diet is supposed to be largely gluten-free.
- **Blood Type AB**: AB types should focus on tofu, seafood, dairy, and green leafy vegetables while avoiding caffeine, alcohol, and cured meats. These individuals supposedly have low stomach acid.
- **Blood Type O:** Type Os should eat a diet of lean meats, poultry, fish, and vegetables while avoiding grains, beans, and dairy.

A study with more than 1,400 subjects found some interesting results. Regardless of their blood type, the participants were given a list of foods to choose from for a one-month period. Based on their natural food choices, researchers determined which of the blood type diets they most closely followed. Researchers also assessed the participants' cardiovascular health and made other physical health measurements.

Those who followed the Type A pescatarian diet (plant-based diet that allows dairy, eggs, fish, and other types of seafood) had reductions in their BMI, waist circumference, blood pressure, cholesterol levels, and insulin resistance. The AB diet protocol showed reductions in blood pressure, cholesterol levels, and insulin resistance but no change in BMI or waist circumference. Type O meat-eating dieters had a reduction only in blood triglycerides, and Type B eaters showed no significant changes.

None of the research completed on genotype or blood type dieting supported the claims that a certain blood type responded more to a certain diet or that there were better results than an average calorie-restricted diet.

RAW FOOD DIET

Proponents of the raw food diet believe that cooking foods to certain temperatures leaches nutrients and destroys proteins and enzymes. The diet is rich in foods like pressed fruit and vegetable juices, raw or dehydrated fruits and vegetables, raw nuts and seeds, raw and sprouted grains and legumes, and fermented items like sauerkraut and kimchi. Dieters may also eat raw eggs, fish, and some types of meat.

The raw diet is not marketed as a weight loss diet but a disease prevention plan. The main claim of proponents is that the diet improves enzyme activity and digestion, but this remains unproven.

Critics of the raw food diet have a lot of concerns, including the risks of eating raw and undercooked meat and animal products. Raw meats and animal products can carry pathogens like salmonella, E. coli, staphylococcus, and listeria. They can cause serious infections that may be fatal. For vegan raw dieters, deficits in some micronutrients, like B12, may be an issue. Vitamin B12 is found in meat, chicken, dairy, and eggs and is a vital component for maintenance of the body's blood and nerve cells.

LOW-ENERGY DIET (LED) AND VERY LOW-ENERGY DIET (VLED)

Low- and very low-energy diets are physician-supervised. A low-calorie diet is considered 800–1,200 Calories daily while a very low-Calorie diet is less than 800 Calories daily. These diets can be successful for weight loss because of the drastic Calorie restriction conducted in a clinical setting. Without guidance, it is very difficult to adhere to these restrictions.

Clinical studies following individuals on LEDs and VLEDs found body weight reductions of 10–15 percent. These diets help with weight loss, weight maintenance, management of conditions like obesity, type 2 diabetes, sleep apnea, and cardiovascular disease.

Exercise is generally not recommended on low- and very low-calorie diets. Research has shown that weight loss and maintenance on these diets are most successful with higher protein levels and lower glycemic index foods. This allows blood sugar to stay relatively consistent, reduces blood insulin spikes for those with diabetes or prediabetes, and decreases hunger.

After the initial weight loss on LEDs and VLEDs, weight gain is typical without ongoing support. This is driven by downregulation of hunger hormones and the tendency to exceed the maximum Calorie recommendations. Individuals are hungrier and feel less satisfied after eating and, without guidance, tend to overeat. The addition of reduced-Calorie meal replacements and fortified formulas for the maintenance phase promotes satiety and prevents binging.

In some clinical settings, dieters may be able to maintain weight loss with one to three meal replacements (or formulas) daily to keep the Calorie count as low as possible. Depending on the macronutrient makeup of the diet, some individuals achieved and sustained ketosis as a by-product of the diet.

PLANT-BASED DIETS

PLANT-BASED DIET: Eating mostly or entirely foods that are plants or derived from plants.

A **plant-based diet** minimizes, restricts, or completely leaves out meat and animal products. Research has shown that adopting a plant-based diet is not only cost-effective but can help lower body mass index (BMI), blood pressure, cholesterol levels, and heart disease risk factors. There are several variations of a plant-based diet.

Vegan

Vegans do not consume or use any animal products or by-products. This includes meat, poultry, game, fish, eggs, dairy, honey, and animal-derived food ingredients like gelatin. A vegan diet may be limited in omega fatty acids, vitamin B12, and folate. Vegans may need to supplement these nutrients.

Lacto-Vegetarian

This diet does not allow for any meat, poultry, fish, or eggs but does include dairy. Again, folate, vitamin B12, and omega fatty acids may be limited for lacto-vegetarians. Including dairy increases calcium intake, protects bones, and aids in muscle tissue functioning and metabolic processes.

Ovo-Vegetarian

An ovo-vegetarian eats eggs and foods with eggs as ingredients but not any dairy or meat. The inclusion of eggs makes up for the loss of some B vitamins. Eggs provide high-quality protein.

Lacto-Ovo Vegetarian

This is the most common type of vegetarianism and what most people mean when using the term. Lacto-ovo vegetarians eat dairy and eggs but no meat, poultry, or fish.

Pescatarian

A diet that allows for dairy, eggs, fish, and other types of seafood is pescatarian. The name derives from the Spanish word for fish, *pescado*. Frequent fish consumption poses a risk of mercury exposure, but it is possible to choose types of seafood with less mercury. And there are benefits too: fish is a lean protein source, and fatty fish provides essential omega fatty acids.

Pollotarian

Derived from the Spanish word for chicken, a pollotarian diet includes dairy, eggs, and chicken as well as other poultry. Individuals on this diet must be careful to get enough iron, zinc, and vitamin B12 from foods or supplements.

Flexitarian

A flexitarian enjoys a mostly vegetarian diet but may occasionally consume any type of fish, poultry, or seafood. The diet is mostly plant-based but leaves room for animal products. Between 2 and 5 percent of the US population is vegetarian or vegan. Plant-based diets are generally beneficial for overall health but do not necessarily improve weight loss. These diets are supported by researchers and health professionals and have no real adverse health effects.

Studies have shown that vegans have a decreased risk for diabetes, hypertension, and cardiovascular disease as compared to those who eat plant-based diets with some eggs, dairy, or meat.

Table 14.11 Plant-Based Eating Styles

PLANT-BASED TYPE	MEAT	GAME	POULTRY	FISH	EGGS	DAIRY	NOTHING ANIMAL-DERIVED
Vegan	✕	✕	✕	✕	✕	✕	✓
Lacto-vegetarian	✕	✕	✕	✕	✕	✓	✕
Ovo-vegetarian	✕	✕	✕	✕	✓	✕	✕
Lacto-ovo-vegetarian	✕	✕	✕	✕	✓	✓	✕
Pescatarian	✕	✕	✕	✓	✓	✓	✕
Pollotarian	✕	✕	✓	✕	✓	✓	✕
Flexitarian	✕	✕	Some	Some	✕	✕	✕

KETOGENIC (KETO) DIET

KETO DIET:
A popular diet that reduces carbohydrate intake to deliberately increase fat metabolism and ketones in the blood.

The **keto diet** is also based on restricted carbohydrate intake. On the keto diet, only about 20 percent of daily Calories come from carbs. This amounts to about 50 grams based on a 2,000-Calorie diet.

The remaining Calories are divided between fats (55–60 percent) and protein (30–35 percent). This is approximately 275–300 grams of protein and 66–77 grams of fats daily.

KETOSIS:
A metabolic process that occurs when the body does not have enough carbohydrates for energy; the liver metabolizes fatty acids to produce ketones as a replacement energy source.

If executed correctly, the keto diet will lead to a state of **ketosis** in the first week. Ketones are naturally produced as an energy source by the liver when insulin and glucose are low. They are a product of fat metabolism and can act to suppress appetite and fuel the body. Once ketosis is achieved, the goal is to consistently remain in this state.

Studies have shown that the benefits of keto include an increase in HDL cholesterol, a decrease in LDL cholesterol, lower blood glucose levels, and significant BMI reduction and weight loss. If carbohydrates are reintroduced in the diet, the results reverse.

KETOACIDOSIS:
An increase in blood acidity caused by excess ketones in the bloodstream.

Ketoacidosis is a dangerously high level of ketones in the blood. It requires immediate medical care. This extreme condition is usually caused by starvation, but it may be triggered by following a ketogenic diet.

The keto diet can also cause side effects similar to those of any low-carb diet: headache, fatigue, bad breath, constipation, and dehydration. A study done by the Harvard School of Public Health also connected carb-restrictive diets to an increased risk of kidney stones, osteoporosis, and increased blood levels of uric acid.

ATKINS DIET

The Atkins Diet is both a brand and a diet that has been popular for years. Food products made and packaged specifically for Atkins dieters are widely available and easy to find, making it a convenient choice.

The diet is very low in carbohydrates, with 90–95 percent of Calories from protein and fats. For an average 2,000-Calorie diet, this amounts to 1,800 calories a day from fat and protein and 200 Calories daily from carbohydrates (50 grams or less).

Research has shown that low-carb diets such as this can increase metabolic output (basal metabolic rate) by 50–90 Calories a day. But eating this way may also reduce the hormones leptin and ghrelin, which in turn increases appetite. These effects can be counteracted by reducing fat intake and increasing calories from protein sources to about 30 percent.

Critics of the Atkins diet say it causes low energy, impairs cognitive function, and increases gastrointestinal distress because of the high levels of fat. The first two weeks of the diet, the induction phase, limits carbohydrates to just 20–25 grams per day. This is intended to induce ketosis.

Phases two, three, and four slowly reintroduce carbohydrates back into the diet starting at 25–50 grams per day, finally going up to 100 grams per day for the long-term maintenance phase.

Despite the restrictions with Atkins, research has shown that adherence to the diet can improve **metabolic syndrome** and diabetes, reduce high blood pressure, and lower cardiovascular disease risk. Weight loss depends on the total calories consumed in the diet.

The risks of the Atkins diet have been studied, but the long-term health effects are still relatively unknown. It is too new to have enough data to make this determination. Health professionals generally have several concerns about a high-fat, low-carbohydrate diet:

- Deficiencies in trace minerals and vitamins
- Inadequate fiber
- No better long-term weight loss results than low-calorie diets

Additionally, there are side effects of a low-carb diet, including bad breath, headaches, fatigue, dizziness, constipation, and dehydration.

METABOLIC SYNDROME:
A cluster of at least three biochemical and physiological abnormalities associated with the development of cardiovascular disease and type 2 diabetes.

ANIMAL PRODUCTS: Any material derived from the body of an animal, including dairy products, eggs, honey, and gelatin.

CARNIVORE DIET

The carnivore diet consists of eating meat and **animal products** exclusively. Beef, lamb, pork, veal, chicken, and eggs are staples of the diet. Carnivore dieters avoid vegetables, low-lactose dairy, fruits, legumes, nuts, seeds, and grains. Carb restriction on the carnivore diet triggers ketosis. It is the ketogenic state that produces weight loss on this diet.

Supporters of the diet cite human evolution as support for the carnivore diet. They believe that because humans evolved as hunters, they are designed to eat and process meat and animal products. Weight loss and ketosis are often considered the main benefits of the diet. Some people also report better digestive health and higher testosterone levels.

Long-term kidney damage from high protein intake is under investigation. Studies have shown that the carnivore diet can lead to higher blood serum fat levels over time. Critics of the diet also cite nutrient deficiencies, specifically plant-based vitamins and minerals, as a major issue. Additionally, high protein intake increases uric acid in the blood, which can lead to conditions like gout.

PALEO DIET

The Paleo diet has gained momentum in the past 10 years and is relatively popular. Many people refer to it as “clean eating.” It differs from the carnivore diet by including fruits, vegetables, nuts, and seeds. Paleo dieters avoid dairy products, legumes, processed foods, and refined sugars. It is a simple plan based on ancestral hunting *and* gathering. It is generally low in carbohydrates and high in protein.

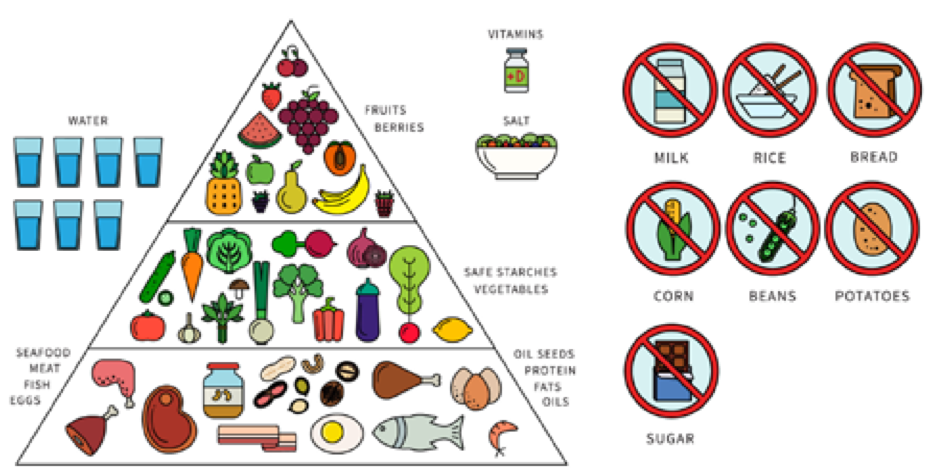


Figure 14.10 The Paleo Diet Pyramid

People who turn to the Paleo diet are usually looking to lose or maintain weight and to eat a simple, healthy diet. The simpler diet plan, along with avoidance of sugar and processed foods, naturally leads to a lower Calorie intake. Paleo has become very popular, and it is now easier to find related products in grocery stores and restaurants. However, purchasing a processed product for a diet that promotes unprocessed eating defeats the purpose. People truly interested in a strict Paleo diet should avoid consuming anything other than whole foods.

Studies show that this well-balanced approach can reduce overall weight without compromising muscle tissue. It has been shown to reduce bad cholesterol and blood triglycerides, lower blood pressure, and decrease resting insulin levels.

Critics raise concerns about the nutrition of the Paleo diet for active people and athletes. The avoidance of grains and carbs reduces energy levels. Studies of athletes have shown that individuals need between three and six grams of carbohydrates per pound of bodyweight to support their activity levels.

The diet is also challenging for vegetarians and vegans as eating legumes is discouraged. Legumes are a major protein source for most plant-based eaters. More research is needed to study the long-term effects of the Paleo diet.

GLUTEN-FREE

Gluten is a mix of proteins found in grains like wheat, rye, and barley. It gives elasticity to dough made from these grains. In individuals with **celiac disease**, gluten triggers an immune response that damages the lining of the small intestines. This causes discomfort and disrupts nutrient absorption. Ultimately, it can lead to serious health conditions, including depression, infertility, headaches, skin rashes, seizures, and neuropathy. Some people are sensitive to gluten but have less severe reactions.

A gluten-free diet may include:

- Fish, poultry, and meat
- Dairy without added ingredients
- Gluten-free grains like quinoa, rice, and oats
- Starches like potatoes, corn, almond flour, and corn flour
- Nuts and seeds
- Vegetable oils and butter
- Eggs
- Fruits and vegetables

GLUTEN:
A mixture of proteins found in wheat, rye, and barley and gives dough its elastic texture.

CELIAC DISEASE:
An autoimmune disorder that affects the small intestines and that is caused by gluten in the diet.

Gluten-free adherents avoid anything with wheat, barley, or rye. This includes ingredients and foods like malt, beer, and brewer's yeast. Candy, baked goods, popcorn, pretzels, chips, crackers, and many condiment sauces like soy sauce and teriyaki sauce include gluten or gluten-based ingredients.

Avoiding gluten isn't necessary for anyone without a gluten allergy or celiac disease, but many healthy people choose this diet. Cutting out wheat and other grains is essentially a low-carbohydrate approach, which can lead to weight loss. Depending on the foods eaten, a gluten-free diet may lead to improved cholesterol levels, better digestive health, and the elimination of many processed foods from the diet.

Without guidance or balanced, healthy food choices, a gluten-free diet may increase calorie intake. Many processed gluten-free foods include added sugar and calories to replace the grains removed. Studies have also shown that a gluten-free diet can cause constipation or diarrhea. To go gluten-free healthfully, individuals should reach for naturally gluten-free foods: vegetables, fruits, fresh meat, fish, dairy products, and poultry.

Another concern critics have about any diet that cuts out gluten is that wheat products are often fortified with micronutrients like vitamin B and iron. There is a risk of deficiencies on this diet.

THE DASH DIET

DASH stands for Dietary Approaches to Stop Hypertension. It was developed based on research conducted by the National Institutes of Health. The primary audience for the DASH diet is anyone with high blood pressure, with the goal of reducing hypertension with fewer or no medications.

The diet is simple. There are no special food restrictions, just a weekly plan of a healthy 2,000 Calories per day. The diet focuses on low-fat dairy, fish, poultry, beans, nuts, and vegetable oils while avoiding fatty meats, full-fat dairy, coconut and palm oil, and sweets. The DASH diet can be followed with a normal sodium intake of up to 2,300 milligrams daily or with reduced sodium intake of up to 1,500 milligrams daily.

The DASH diet recommends that 55 percent of daily Calories come from carbohydrates, approximately 27 percent from unsaturated fats, 6 percent from saturated fats, and 18 percent from protein. Tips include filling the plate with colorful, whole foods and including two or more servings of fruits and vegetables per meal, with a particular emphasis on dark, leafy green vegetables. In addition to lowering blood pressure, the DASH diet has other health benefits: prevention of bone loss, improved cardiovascular health, and weight loss or maintenance.

MEDITERRANEAN DIET

Global health and wellness research has shown that people who live in several Mediterranean countries, including Greece, Spain, and Italy, have lower rates of chronic health issues. This is widely attributed to the typical diet of the region.

The benefits of the Mediterranean diet are so widely recognized and accepted that the WHO and the United Nations Educational, Scientific, and Cultural Organization (UNESCO) have added the diet to its list of intangible cultural heritages. The listing aims to protect the "skills, harvesting, cooking, and consumption of food" that the diet promotes.

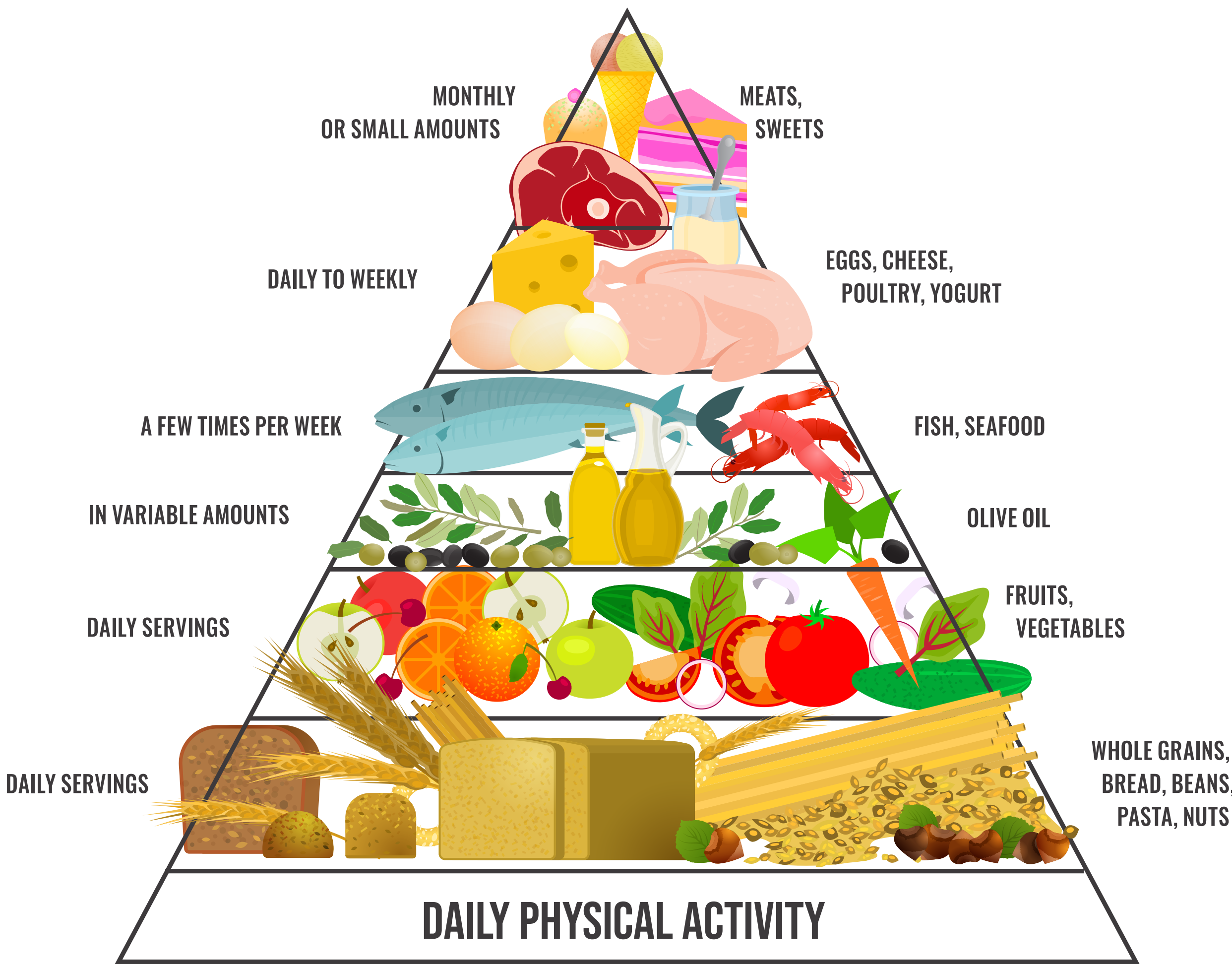


Figure 14.11 The Mediterranean Diet

The Mediterranean diet consists of moderate portions of fruits, vegetables, whole grains, legumes, potatoes, nuts, seeds, olive oil, fish, poultry, dairy, and eggs, with minimal red meats. Olive oil, nuts, and seafood are eaten regularly in this diet. The high levels of heart-healthy omega-3 fatty acids in them may be a major reason that chronic disease and cardiovascular risks are lower in the Mediterranean population. The diet is often recommended to people who have a high risk of heart attack, arterial plaques, and stroke.

The fresh, light foods that make up this diet are filling and satisfying. Over time, this naturally leads to a decrease in calorie intake and helps promote weight loss. Studies have shown that the Mediterranean diet can reduce cardiovascular disease risk up to 30 percent and trigger a significant reduction in the risk of developing type 2 diabetes.

INTERMITTENT FASTING

FASTING:
Abstaining from consuming food for a period of time.

Intermittent **fasting** is a type of diet that focuses on the timing of food intake in a 24-hour period or weekly rather than on specific types of food. There are two popular variations of the fasting diet: 5/2 and 16/8.

The 5/2 Diet

The 5/2 fasting diet involves eating a normal, balanced, and healthy diet five days a week and fasting for two days. The fasting days are not strictly days with no food. The idea is to consume 25 percent—or even less—of a normal day's Calories.

With 2,000 Calories for a normal day, this means eating just 500 Calories or less on fasted days. The fasted days should not be consecutive, and this eating plan does not restrict types of food. The simplicity of the diet makes it easy for most people to maintain. Over the course of a week, it is possible to reduce calorie intake by about 3,000 Calories, or one pound of bodyfat.

The 16/8 Diet

The 16/8 method involves abstaining from food entirely for 16 consecutive hours per day and eating only during an eight-hour window each day. The eight hours should align with the most active hours of the day to avoid fatigue.

Figure 14.12 16/8 Fasting

For example, for an adult who gets up at 7:00 a.m., works from 9:00 a.m. to 5:00 p.m., works out at 6:00 p.m. and goes to bed at 11:00 p.m., a good time for the eight-hour eating window is between 10:00 a.m. and 6:00 p.m. There are no food requirements, but as with the 5/2 plan, the diet should be balanced and healthful.

Both of these popular versions of intermittent fasting work by reducing the overall Calories consumed and encouraging healthy eating habits. This type of dieting works best for those clients who are able to eat a normal or recommended amount of Calories most of the time. Studies have shown that fasting not only helps people consume fewer Calories but also leads to moderate weight loss, less muscle wasting, decreased serum leptin and blood levels of triglycerides, and increased LDL cholesterol.

Intermittent fasting isn't for everyone. For some clients, it may be too difficult to restrict Calories during fasting periods or to avoid food entirely for 16 hours. The struggle can lead to an unhealthy relationship with food and eating and even binge eating. For those who are able to abstain with minimal side effects or distress, intermittent fasting can have positive benefits.

CARB CYCLING

CARB CYCLING: increasing and reducing carb intake on a daily, weekly, or monthly basis.

Carb cycling is another dietary approach that focuses on timing. It involves making targeted reductions and increases to carb intake on a daily, weekly, or monthly basis.

This style of diet is often used by fitness and bodybuilding competitors. It may also appeal to people trying to lose fat, bust a weight loss plateau, or maintain a high level of physical performance while dieting. The frequency and duration of cycling carbohydrates depend on activity level. In general, carb intake is reduced or cut during low-activity periods and increased during performance and high-activity periods.

There are several situations in which carb cycling can be useful. It's possible to drop carbs for a period of time, for instance, to reach the desired bodyfat percentage. From there, carbs are slowly reintroduced. Bodybuilders and figure competitors use this strategy. Endurance and strength athletes often increase carb intake ahead of a competition or race to ensure adequate and even excess glycogen stores. For general fitness enthusiasts, an easy way to carb cycle is to keep to a lower carb diet during the work week and increase carbs on off days. Athletes will cycle according to training and activities, adding more carbs on heavy workout days and less on low-intensity or rest days.

REFEED: Reintroducing carbohydrates into the diet after an extended reduction of a week or more.

When carbs are added back into the diet after an extended phase of dieting (for example, a week or longer), this is called a **refeed**. This decreases the hormone leptin to help reduce the feelings of hunger and boost the resting metabolic rate, which can be downregulated with prolonged low-Calorie intake.

There are few good studies on carb cycling because it is a style of eating with a lot of individual variety. However, research on low carbohydrate intake suggests it may improve insulin sensitivity and promote the use of fat as fuel. Much of the feedback on carb cycling is based on personal experiences and anecdotal evidence. Risks of carb cycling are like those for low-carbohydrate diets during periods of low or minimal intake. The refeed period may turn into an unhealthy binge.

LIMITING FACTORS FOR NUTRITIONAL CONSISTENCY

There are many choices a client may make that keep them from seeing results or success. When related to nutrition, these are known as **nutritional limiting factors**, and they can include:

- Overeating processed foods
- Not eating enough protein
- Not eating enough vegetables
- Eating too much too quickly
- Eating without being hungry
- Not eating when they feel hungry
- Skipping meals
- Consuming too many sugar-sweetened beverages
- Poor sleep and recovery
- Using food to manage emotional stresses
- Lack of basic food preparation skills

NUTRITIONAL LIMITING FACTORS: The nutritional choices a client makes that keep them from making progress or seeing results.

Once a client ensures they are making the right nutritional selections, the amount of food and macronutrient breakdown of their food can be addressed to ensure they are supporting their health and fitness goals. In a nutritional coaching program that stays within the scope of a personal trainer, clients may receive resources like handbooks, websites, databases of food facts, spreadsheets for logging, and help when planning meals. However, optimal nutrition is more than just counting calories. In fact, Calorie counting is not very accurate since it depends on the person reporting the intake and can be affected by things like differences in food preparation and labeling accuracy.

PORTION SIZES

Personal trainers can help clients easily establish how much food they should be consuming using their own hand as the measuring device.

- Protein portions should be about the size of the palm of the hands
- A portion of vegetables should be about the same size as a fist
- A cupped hand is a serving of carbohydrates
- A fat portion should be about the size of a thumb

The hand is a helpful portion size tool for several reasons. First, the hands are portable. Second, they are scaled to the size of the person. Larger people need more food and tend to have larger hands, while a smaller person likely needs less food and has smaller hands. Third, someone can control their intake by not counting Calories directly but controlling their portions.

Assuming clients eat about four meals a day, the following details a good starting point for most clients:

Table 14.12 Approximate Portion Sizes Per Meal By Sex

MALES—FOR EACH MEAL
2 palms of protein-dense food
2 fists of vegetables
2 cupped handfuls of carbohydrates
2 thumbs of fat-dense foods
FEMALES—FOR EACH MEAL
1 palm of protein-dense food
1 fist of vegetables
1 cupped handful of carbohydrates
1 thumb of fat-dense foods

CALORIE CONTROL: A SIMPLE GUIDE

For Men

Calorie counting is often complicated, tedious, and inaccurate. So here is an easier way to control Calories. No weight-scales or measuring cups. No calculators or smart phones. Just the ability to count to two. And your hand. **To build your meals:**

2 palm portions of protein dense foods with each meal

2 fists of vegetables with each meal

2 cupped handfuls of carb dense foods with each meal

2 entire thumbs of fat dense foods with most meals

Note: Your hand size is related to your body size, making it an excellent portable and personalized way to measure and track food intake.

Also note: Just like any other form of nutrition planning, this guide serves as a starting point. Stay flexible and adjust your portions based on hunger, fullness, and other important goals.

CALORIE CONTROL: A SIMPLE GUIDE

For Women

Calorie counting is often complicated, tedious, and inaccurate. So, here is an easier way to control Calories. No weigh-scales or measuring cups. No calculators or smart phones. Just the ability to count to one. And your hand. **To build your meals:**

1 palm portion of protein dense foods with each meal

1 fist of vegetables with each meal

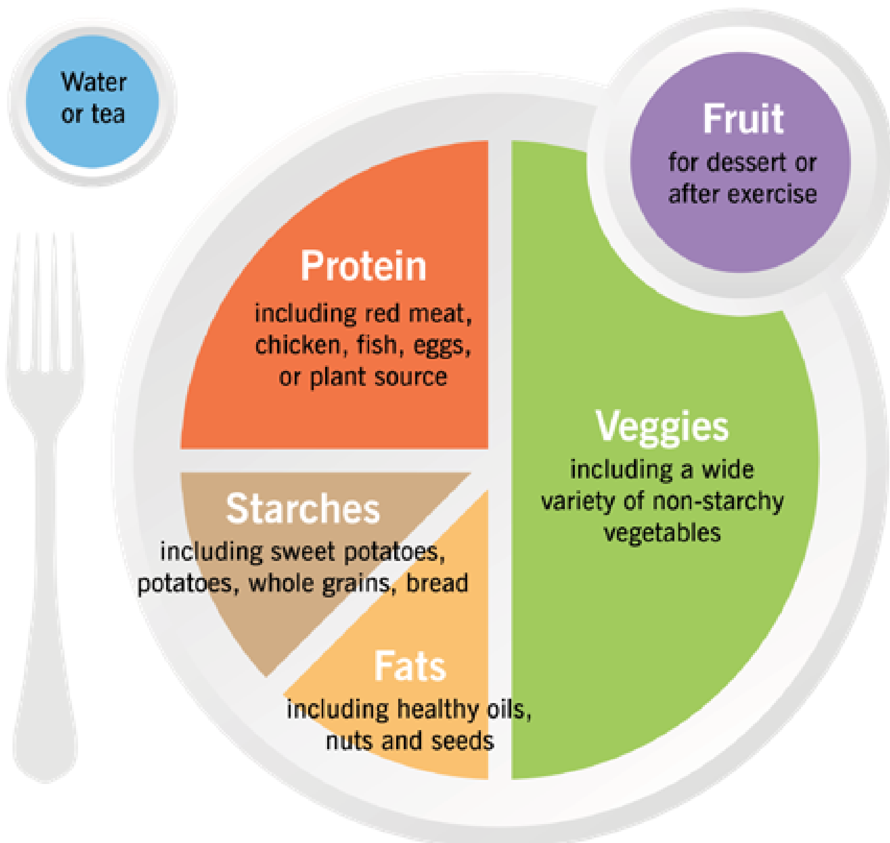
1 cupped handful of carb dense foods with each meal

1 entire thumb of fat dense foods with most meals

Note: Your hand size is related to your body size, making it an excellent portable and personalized way to measure and track food intake.

Also note: Just like any other form of nutrition planning, this guide serves as a starting point. Stay flexible and adjust your portions based on hunger, fullness, and other important goals.

IDEAL STARTER PLATE



- Eat slowly and stop eating when you're 80% full.
- Follow hunger cues. Eat more or less based on your apppetite.
- Choose mostly whole foods with minimal processing.
- Choose local or organic foods when possible.
- Use smaller or larger plates based on your own body size.

Note: Just like any other form of nutrition planning, this guide serves as a starting point. Stay flexible and adjust your portions based on hunger, fullness, and other important goals.

CHAPTER 15

SUPPLEMENTATION

LEARNING OBJECTIVES

1 | Explain the importance of vitamins and minerals in supplements.

2 | Identify supplements that enhance exercise performance and recovery.

3 | Define the benefits of incorporating ergogenic aids and botanicals in a person’s nutrition plan.

VITAMINS: Organic compounds essential for normal growth and nutrition.

MINERALS: Elements in food that the body needs to develop and function.

DIETARY SUPPLEMENT: A product containing one or more dietary ingredients that is intended to supplement a person's nutrition plan.

DIETARY INGREDIENT: A vitamin, mineral, herb, botanical, or amino acid used to supplement a nutrition plan to increase total dietary intake of ingredients.

HERB: Any plant with leaves, seeds, or flowers used for flavoring food and medicine.

BOTANICAL: Substance obtained from a plant and used as an additive.

AMINO ACID: A simple organic compound known as the building block of proteins.

PERFORMANCE SUPPLEMENTS: Supplements intended to help enhance athletic performance.

Personal trainers are often asked about supplementation and the extent to which nutrients, compounds, and products influence health and fitness goals. Supplements make it easier to consume adequate amounts of **vitamins** and **minerals**, which are essential nutrients the body needs in small amounts. Even though small amounts are required, it can be difficult to sustain a broad, healthy nutrition plan consisting of nutrient-rich foods such as fruits, vegetables, whole grains, low-fat protein, and legumes. While it is not the responsibility, or within the scope of practice, of a personal trainer to prescribe and recommend dietary supplements, knowledge of dietary supplements can help fitness professionals provide appropriate supplement *guidance*, increasing value and support for members and clients. Fitness professionals can help clients navigate misinformation and understand what they should look for to ensure their dietary supplements are safe, effective, of a superior quality, and free from contaminants, banned substances, or impurities.

WHAT IS A DIETARY SUPPLEMENT?

The National Institutes of Health defines a **dietary supplement** as a product that contains one or more dietary ingredients and is intended to supplement a person's nutrition plan. Before digging into commonly used dietary supplements, it is important to know that the Federal Food, Drug, and Cosmetic Act defines a **dietary ingredient** as a vitamin, mineral, **herb**, **botanical**, or **amino acid**. It is a substance used to supplement a nutrition plan by increasing the total dietary intake. This could be a concentrate, metabolite, constituent, extract, or combination of the preceding substances. Common supplements may be designated as **performance supplements**, nutritional supplements, **ergogenic aids**, and botanical supplements.

Table 15.1 Supplement Categories

TYPE	NUTRITIONAL SUPPLEMENTS	PERFORMANCE SUPPLEMENTS	ERGOGENIC AIDS	BOTANICAL SUPPLEMENTS
Description	Natural or synthetic nutrients intended to supplement a nutrition plan	Vitamins, minerals, proteins, herbs, and amino acids consumed to promote metabolic and physical performance and recovery	Compounds consumed to specifically enhance performance during exercise or competition	Made from plant parts or extracts and intended to supplement a nutrition plan

Supplements can come in many different forms including capsules, tablets, liquids, and powders.

Unlike prescription drugs, dietary supplements are not required to be tested for safety or effectiveness before going to market. While the **Food and Drug Administration (FDA)** is not in the business of approving dietary supplements, it can "disapprove" them and remove a product that is shown to be harmful or a public health risk. Also, it is illegal to market a dietary supplement product as a treatment or cure for a specific disease or as being able to alleviate the symptoms of a disease.

ERGOGENIC AIDS:
Substances that enhance energy production and provide athletes with a competitive advantage.

FOOD AND DRUG ADMINISTRATION (FDA):
A US federal department that regulates the production and distribution of food, pharmaceuticals, tobacco, and other consumer products.

NUTRITIONAL DEFICIENCIES

There are many elements to an effective nutrition plan, and supplements may serve as a vital component. These elements include nutrition awareness, food quality and portion control, eliminating nutrient deficiencies, and engaging in regular exercise. Nutrient deficiencies can be problematic, contributing to chronic conditions. According to the World Health Organization (WHO), iron deficiency is one of the most common nutrient deficiencies contributing to worldwide **anemia**. There are many conditions that can cause anemia, among them are genetic factors, impaired metabolism, heavy menstruation, and even intestinal diseases. Anemia affects one-third of the world's population and contributes to increased morbidity and mortality. Supplementation may help eliminate nutrient deficiencies such as this.

ANEMIA:
A condition marked by a deficiency of red blood cells or of hemoglobin in the blood resulting in extreme fatigue.

There are special situations where some individuals may be at risk of developing nutritional deficiencies, so there are cases where taking dietary supplements can be a good idea. Individuals restricting calories by consuming less than 1,200 Calories a day are at risk of missing out on important nutrients. Individuals with food allergies or intolerances are more likely to avoid complete food groups such as whole grains or dairy, respectively, and they will have to obtain nutrients from alternative sources. Additionally, people who spend little to no time outside under the sun, or those who consistently use sunscreen outside, may eventually create a vitamin D deficiency. Also, women contemplating pregnancy and those who are pregnant will require additional folate to prevent certain birth defects and more iron to increase the blood supply for a growing baby.

NUTRIENT REQUIREMENTS

Every five years, the United States Department of Health and Human Services and the United States Department of Agriculture (USDA) publish the *Dietary Guidelines for Americans*. The *Dietary Guidelines for Americans* provides science-based advice on nutrient needs to promote optimal health and reduce the risk of chronic disease. Its focus is on providing quantitative guidance about foods, and it emphasizes giving recommendations about food and beverages. In contrast, the Food and Nutrition Board, an arm of the National Academy of Medicine, has set standards for nutrient requirements in the form of **Dietary Reference Intakes (DRIs)**. A subgroup of these DRIs is the **Recommended Daily Allowance (RDA)**, which provides a safe and adequate reference for most people to decrease their risk of chronic disease. The RDA specifies the amount of a vitamin or mineral that is needed to maintain health and stay nourished. It is based on an average daily level of intake sufficient to meet the nutrient requirements of most people, in this case, 97–98 percent of healthy people. RDAs were originally set to be a standard that would serve as a goal for optimal nutrition. These references are meant to be applied to people of different ages. According to the USDA, many people do not meet the RDAs for many micronutrients and these RDAs are not intended for individuals with deficiencies.

DIETARY REFERENCE INTAKES (DRIS): A set of standards estimating how much of a nutrient should be ingested that is used in planning eating patterns for healthy individuals.

RECOMMENDED DAILY ALLOWANCE (RDA): The average daily level of intake that is sufficient to meet the needs of nearly all (97%-98%) healthy people.

NUTRITIONAL SUPPLEMENTS

According to a 2019 consumer survey given by the Council for Responsible Nutrition, supplement use is at an all-time high with **multivitamins/minerals (MVMs)** being the most used. Most individuals take supplements to maintain or improve health and to help fill small nutritional gaps. Additionally, of all the supplements that a client may ask about, the most common is typically an MVM formula. The notion that a person can get everything they need by eating a balanced diet is confounded by many factors such as current health status, food intake, and lifestyle. The 2020–2025 *Dietary Guidelines for Americans* states that the general population in the US fails to meet the recommendations for food groups and nutrient intakes. This means most Americans have eating patterns that are not aligned with dietary recommendations. Moreover, they are not meeting their intake needs for nutrients such as vitamins and minerals.

MULTIVITAMINS/ MINERALS (MVMS): Supplements or pills containing a combination of vitamins and minerals.

Supplements are not intended to cure or treat medical conditions, and that application exceeds a personal trainer's scope of practice. However, MVM supplement use is warranted to prevent long-term nutrient insufficiencies associated with premature aging and higher risk of age-related decline. As clients age, their nutritional needs increase, which means being aware of what foods are consumed becomes critical. MVMs offset deficiencies that worsen from inadequate food intake and certain medications.

DAILY VALUES: VITAMINS

The **Daily Value (DV)** is what an individual typically sees on the label of a dietary supplement. It was developed by the FDA to help the consumer determine how much of a nutrient is in a serving when compared to the requirement for that nutrient. Labels are expressed with the "%DV" symbol and show the percentage of a serving that contributes to obtaining the total DV. For example, if the DV for a vitamin is 500 micrograms (mcg) and the container for a supplement indicates the supplement has 50 mcg in a serving, then an individual will meet 10 percent of their need for the day with one serving. The DV is meant to make it easier for individuals to understand what their daily dietary needs are. Since labels are small, the number is just one value and can sometimes be the same as the RDA.

DAILY VALUE (DV): Reference amounts expressed in grams, milligrams, or micrograms of nutrients to consume or not to exceed each day.

Table 15.2 RDA for Vitamins

VITAMIN	PURPOSE	FOODS		DV
Biotin	• Energy storage • Protein, carbohydrate, and fat metabolism	Avocados Cauliflower Eggs Fruits Whole grains	Liver Pork Salmon	30 mcg
Folate/Folic acid *Important for pregnancy*	• Prevents birth defects • Protein metabolism • Red blood cell formation	Asparagus Avocado Beans and peas Enriched grain products	Green leafy vegetables Orange juice	400 mcg DFE

Table 15.2 RDA for Vitamins (CONT)

VITAMIN	PURPOSE	FOODS		DV
Niacin	• Cholesterol production • Converts food into energy • Digestion • Nervous system function	Beans Beef Enriched grain products Nuts	Pork Poultry Seafood Whole grains	16 mcg
Pantothenic acid	• Converts food into energy • Fat metabolism • Hormone production • Nervous system function • Red blood cell formation	Avocados Beans and peas Broccoli Eggs Milk Mushrooms	Poultry Seafood Sweet potatoes Whole grains Yogurt	5 mcg
Riboflavin	• Converts food into energy • Growth and development • Red blood cell formation	Eggs Enriched grains Meats Milk	Mushrooms Poultry Seafood Spinach	1.3 mcg
Thiamin	• Converts glucose into energy • Nervous system function	Beans and peas Enriched grain products Nuts	Pork Sunflower seeds Whole grains	1.2 mcg

Table 15.2 RDA for Vitamins (CONT)

VITAMIN	PURPOSE	FOODS		DV
Vitamin A	• Growth and development • Immune function • Reproduction • Red blood cell formation • Skin and bone formation • Vision	Cantaloupe Carrots Dairy products Eggs **Fortified** cereals	Green leafy vegetables Pumpkin Red peppers Sweet potatoes	900 mcg RAE *Current RDAs from the DRI reports for vitamin A are expressed as micrograms of retinol activity equivalents (RAE).*
Vitamin B_6	• Immune function • Nervous system function • Protein, carbohydrate, and fat metabolism • Red blood cell formation	Chickpeas Fruits (other than citrus) Potatoes	Salmon Tuna	1.7 mg
Vitamin B_{12}	• Converts food into energy • Nervous system function • Red blood cell formation	Dairy products Eggs Fortified cereals	Meats Poultry Seafood	2.4 mcg
Vitamin C	• Antioxidant • Collagen and connective tissue formation • Immune function • Wound healing	Broccoli Brussel sprouts Cantaloupe Citrus fruits and juices	Kiwi Peppers Strawberries Tomatoes and tomato juice	90 mg

FORTIFIED:
Having had vitamins or other supplements added so as to increase the nutritional value.

Table 15.2 RDA for Vitamins (CONT)

VITAMIN	PURPOSE	FOODS		DV
Vitamin D *Deficient in most Americans*	• Blood pressure regulation • Bone growth • Calcium balance • Hormone production • Immune function • Nervous system function	Eggs Fish Fish liver oil Fortified cereals Fortified dairy	Fortified margarine Fortified orange juice Fortified soy beverages Sunlight	20 mcg
Vitamin E	• Antioxidant • Formation of blood vessels • Immune function	Fortified cereals Fortified juices Green vegetables Nuts and seeds	Peanuts Vegetable oils Wheat germ	15 mg AT *Current RDAs from the DRI reports for vitamin E are expressed as milligrams of alpha-tocopherol (mg AT).*
Vitamin K	• Blood clotting • Strong bones	Broccoli Collard greens Kale	Spinach Turnip greens	120 mcg

Note: AT = alpha-tocopherol; DFE = dietary folate equivalent; mcg = microgram; mg = milligram; RAE = retinol activity equivalent (adapted from FDA fact sheet)

DAILY VALUES: MINERALS

Minerals are inorganic elements found in soil and water that the body needs to function properly and develop. The body requires a certain amount of minerals to build strong bones and convert food into energy. A client's nutrition plan should provide all the minerals the body needs to maintain cell and immune system function, but for various reasons, individuals can become deficient. Having a poor nutrition plan over a prolonged period can lead to mineral deficiencies. In addition, the ability of the body to absorb calcium typically decreases with age, so regular calcium supplementation will become important as people get older. Each mineral serves its own purpose, is found in a variety of foods, and is required in different amounts.

Table 15.3 RDA for Minerals

MINERAL	PURPOSE	FOODS		DV
Calcium	• Blood clotting • Bone and teeth formation • Constriction and relaxation of blood vessels • Hormone secretion • Muscle contraction • Nervous system function	Almond, rice, coconut, and hemp milks Dairy products Fortified cereals	Fortified juices Fortified soy beverages Green vegetables Tofu	1,300 mg
Chloride	• Acid-base balance • Converts food into energy • Digestion • Fluid balance • Nervous system function	Celery Lettuce Olives Rye Salt substitutes	Seaweeds Table salt and sea salt Tomatoes	2,300 mg

Table 15.3 RDA for Minerals (CONT)

MINERAL	PURPOSE	FOODS		DV
Chromium	• Insulin function • Protein, carbohydrate, and fat metabolism	Broccoli Fruits Grape and orange juices Meats	Spices (garlic and basil) Turkey Whole grains	35 mcg
Copper	• Antioxidant • Bone formation • Collagen and connective tissue formation • Energy production • Iron metabolism • Nervous system function	Chocolate and cocoa Crustaceans and shellfish Lentils	Nuts and seeds Organ meats Whole grains	0.9 mg
Iodine	• Growth and development • Metabolism • Reproduction • Thyroid hormone production	Breads and cereals Dairy products Iodized salt Potatoes	Seafood Seaweed Turkey	150 mcg
Iron	• Energy production • Growth and development • Immune function • Red blood cell formation • Reproduction • Wound healing	Beans and peas Dark-green vegetables Meats Poultry Prunes and prune juice	Raisins Seafood Whole-grain, enriched, and fortified cereals and breads	18 mg

Table 15.3 RDA for Minerals (CONT)

MINERAL	PURPOSE	FOODS		DV
Magnesium	• Blood pressure regulation • Blood sugar regulation • Bone formation • Energy production • Hormone secretion • Immune function • Muscle contraction • Nervous system function • Normal heart rhythm • Protein formation	Avocados Bananas Beans and peas Dairy products Green leafy vegetables Nuts and pumpkin seeds	Potatoes Raisins Wheat bran Whole grains	420 mg
Manganese	• Carbohydrate, protein, and cholesterol metabolism • Cartilage and bone formation • Wound healing	Beans Nuts Pineapple	Spinach Sweet potato Whole grains	2.3 mg
Molybdenum	• Enzyme production	Beans and peas Nuts	Whole grains	45 mcg

Table 15.3 RDA for Minerals (CONT)

MINERAL	PURPOSE	FOODS		DV
Phosphorus	• Acid-base balance • Bone formation • Energy production and storage • Hormone activation	Beans and peas Dairy products Meats Nuts and seeds	Poultry Seafood Whole-grain, enriched, and fortified cereals and breads	1,2500 mg
Potassium	• Blood pressure regulation • Carbohydrate metabolism • Fluid balance • Growth and development • Heart function • Muscle contraction • Nervous system function • Protein formation	Bananas Beet greens Juices Milk Oranges and orange juice Potatoes and sweet potatoes	Prunes and prune juice Spinach Tomatoes and tomato products White beans Yogurt	4,700 mg
Selenium	• Antioxidant • Immune function • Reproduction • Thyroid function	Eggs Enriched pasta and rice Meats Nuts	Poultry Seafood Whole grains	55 mcg

Table 15.3 RDA for Minerals (CONT)

MINERAL	PURPOSE	FOODS		DV
Sodium	• Acid-base balance • Blood pressure regulation • Fluid balance • Muscle contraction • Nervous system function	Breads and rolls Cheese Cold cuts and cured meats Mixed meat dishes Mixed pasta dishes Pizza	Poultry Sandwiches Savory snacks Soups Table salt	2,300 mg
Zinc	• Growth and development • Immune function • Nervous system function • Protein formation • Reproduction • Taste and smell • Wound healing	Beans and peas Beef Dairy products Fortified cereals	Nuts Poultry Seafood Whole grains	11 mg
Note: mcg = microgram; mg = milligram (adapted from FDA fact sheet)				

NUTRIENT ABSORPTION

It is critical for a fitness professional to understand the role the digestive system plays in nutrient absorption, especially for vitamins and minerals. The gastrointestinal (GI) tract coordinates and controls the absorption sites for nutrients and helps remove toxins. An individual with a fully functioning GI tract may absorb more than 95 percent of the food consumed. Dietary ingredients including vitamins and minerals are absorbed by the cells lining the inside of the digestive tract and are used for metabolic processes. The pathways of metabolism depend on nutrients that are broken down to produce energy, which helps the body build new cells and protein.

Organs such as the esophagus, stomach, and intestines work together to mechanically break down and digest food in the body. The absorption site of nutrients depends on the type of dietary ingredient. The duodenum is the first part of the small intestine leading to the jejunum, which makes up the middle part of the small intestine. This site is responsible for breaking down and absorbing nutrients, though some nutrients will be absorbed before reaching the small intestine or after in the ileum.

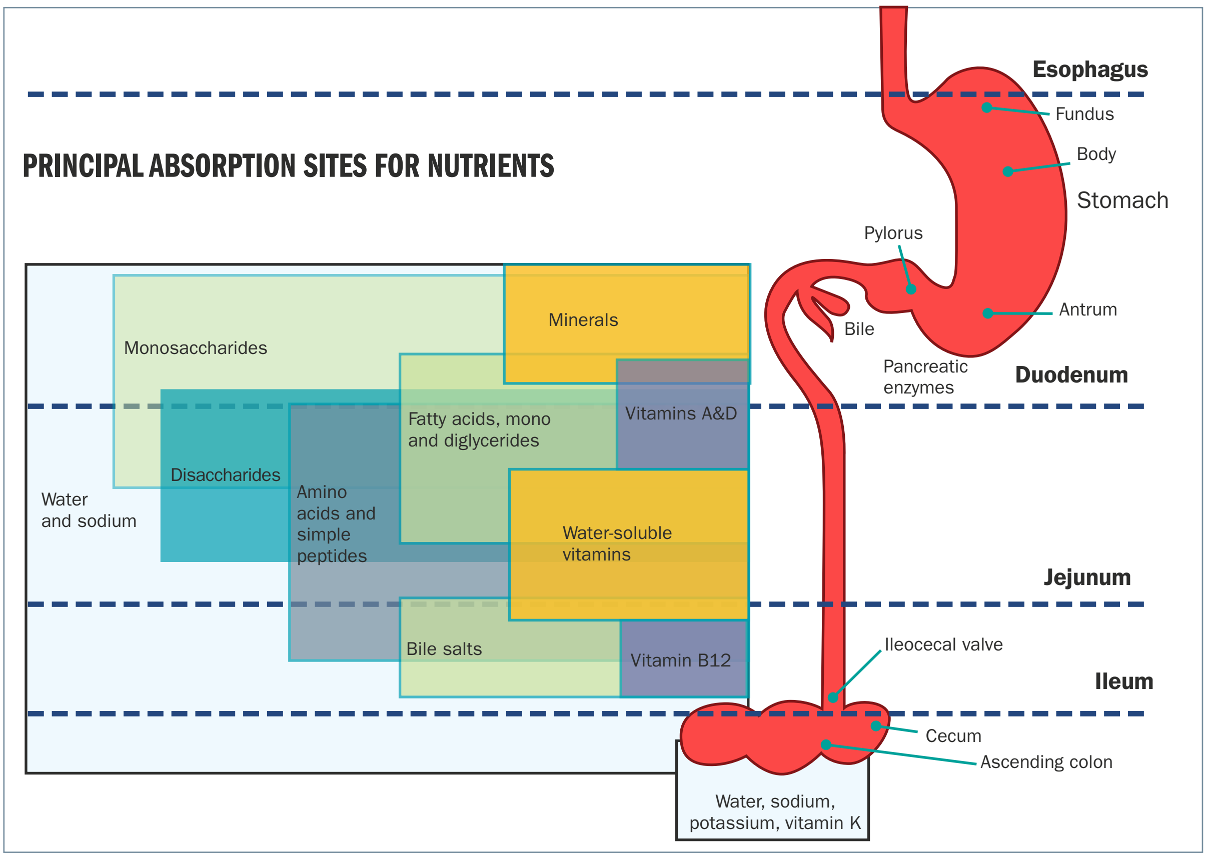


Figure 15.1 Principal Absorption Sites for Nutrients

SUPPLEMENTATION AND LIFE STAGES

All stages of life are unique and affect health and disease risk differently. Various guidelines offer specific recommendations for all life stages, including infants, toddlers, and pregnant and lactating women. Dietary guidelines from around the world can be found through the USDA's National Agricultural Library, which provides information on the nutrient needs necessary to support healthy dietary patterns for people in specific countries. Vitamin and mineral needs vary during each stage of life. Formulations should address common deficiencies without going over the **Upper Limit (UL)** suggested for each nutrient.

UPPER LIMIT (UL):
The highest level of nutrient intake that is likely to pose no risk of adverse effects for almost all individuals in the general population.

Some MVMs are made to supplement the general population while others are formulated to meet specific needs. A great example of this is iron and folate intake needing to be higher for menstruating women than for men of the same age. The daily recommendations for vitamins A, B, E, and K and the mineral zinc are based on body size, and since men are typically larger, they generally need to intake more than women.

A man's MVM supplement might contain extra lycopene, which has been shown to protect against prostate cancer. When choosing an MVM supplement, it is important to find the appropriate one based on sex and age. Children's vitamins are often made in a chewable form. They are made with fewer amounts of certain vitamins and minerals because some vitamins and minerals such as iron may be toxic to children at certain levels. However, for seniors, nutrients such as vitamins B12 and D are needed in larger quantities and become more prevalent in MVM supplements.

Ages 4–13

Nutritional requirements for children are higher than those for adults in proportion to body weight. Rapid growth and development make proper nutrition critical at this age. Unfortunately, intake recommendations are not based on data specific to children. Instead, adult intake values are reduced using a mathematical formula that accounts for metabolic body weight and growth.

Ages 13–18

During puberty, physical changes occur that affect males and females differently. Starting as young as 10 years of age and going up to 16 years, growth and cognitive development occur, which require adequate nutrient intake. The period that follows the onset of puberty and develops a child into an adult is called adolescence. Micronutrient intake during adolescence decreases in comparison to childhood, with childhood being the period that starts at two years of age and stops at adolescence. For example, the DV for vitamin A is higher during childhood. Some adolescents may also require combined calcium-magnesium supplements if dietary intake is not enough. In addition, many adolescents use sunscreen while outdoors; therefore, a vitamin D supplement may also be required.

Prenatal, Pregnant, and Breastfeeding

Proper nutrition is important all the time and even more important during pregnancy because the food women consume is also the main source of nutrients for the baby. It is crucial that women obtain adequate amounts of iron, folate, calcium, vitamin D, and protein. Maternal malnutrition may cause neural tube defects, premature birth, or low birth weight. Additionally, there is an increased risk of anemia as a woman's body attempts to increase her blood supply for her baby. Becoming severely anemic during pregnancy has been associated with an increased mortality rate during labor. Nutrient intake from a nutrition plan and supplements should ultimately support the mother and growing fetus. A woman's gynecologist should provide specific recommendations based on her individual needs.

Micronutrient intake is generally higher for lactating mothers than pregnant women. Exceptions to this are iron, folate, and calcium, which should be reduced during breastfeeding. Lactating women who meet the RDA for energy are likely to meet the RDA for all nutrients. To maintain health, lactating women should follow a nutrition plan consisting of nutrient-rich foods.

Elderly

Beginning at the age of 65, metabolism slows down, and nutrient intake requirements change. Folate intake should increase to help reduce homocysteine (an amino acid) levels in the blood. Vitamins B6 and B12 and folate break down homocysteine to create other chemicals the body needs. High homocysteine levels may indicate a vitamin deficiency. Without treatment, elevated homocysteine increases the risks for dementia, heart disease, and stroke. Increasing riboflavin intake may help prevent the development of age-related cataracts, a clouding in the lens of an eye and reduce the risk of fracture in women. Aging also reduces the capacity for the body to synthesize vitamin D in the skin. Therefore, the Linus Pauling Institute recommends a daily intake of 2,000 **international units (IU)** of vitamin D. In addition, calcium intake minimizes bone loss and should be at 1,000–1,200 milligrams (mg) per day. **Intrinsic factor (IF)**, necessary for vitamin B12 absorption in the gut, activity also tends to decrease.

INTERNATIONAL UNITS (IU):
The quantity of a substance that has a biological effect. Amount varies depending on the substance.

INTRINSIC FACTOR (IF):
A substance secreted by the stomach that enables the body to absorb vitamin B12.

MEAL REPLACEMENTS

Meal replacements are generally a prepackaged drink, bar, or powder used to replace a meal. The addition of vitamins and minerals in meal replacements makes them a convenient supplement for many individuals. Meal replacements may be popular in weight-loss programs, low-calorie diets, and even in medical weight-loss programs. Research on meal replacements proves that they work for weight loss. A meta-analysis of 30 weight-loss studies found that meal replacements were as effective as traditional meal plans. Participants in these studies often cited the convenience of meal replacements for weight-loss success. Nevertheless, fitness professionals should consider what research studies have shown about meal replacements before suggesting them.

Table 15.4 Meal Replacement Considerations and Research

MEAL REPLACEMENT CONSIDERATIONS AND RESEARCH	
Program length	Meal replacements significantly increase weight loss during the first four months of a program. Supports prolonged weight loss May be helpful for initial weight loss but not for long-term maintenance
Shakes and liquids	Meal replacement shakes and drinks are often associated with weight loss. Intake with 388 Calories (Cal) in total energy at dinner time alone contributed to improvement in body composition in men and women who were overweight or obese.
Solid meal replacements	Solid meal replacements may be better options for weight loss. May increase **satiety** and decrease hunger May also increase program compliance over the long term

SATIETY: The feeling of fullness and satisfaction.

There are many factors that contribute to how much people consume and the number of calories required. When nutrients are consumed in excess of calorie needs, these nutrients are stored as body fat. Meal replacement shakes are often higher in vitamin, mineral, and protein content, which can help those seeking lean mass gain. Understanding **energy balance** is crucial to knowing when and how to implement meal replacement shakes as a supplement to food.

ENERGY BALANCE: The state achieved when energy intake is equal to energy expenditure.

PERFORMANCE SUPPLEMENTS

Fitness professionals want clients to feel, look, and perform their best. Supplementation beyond a basic MVM aims to get the specific nutrients at the correct place and time to

CREATINE MONOHYDRATE (CM):
An organic compound that increases phosphocreatine levels and adenosine triphosphate (ATP) energy production leading to enhanced strength and power.

maximize performance and recovery. **Creatine monohydrate (CM)** taken pre-workout to maximize high-intensity muscle contractions and strength is an example of this. There are undoubtedly many more products and ingredients that prepare the body for exercise, impact performance, and enhance recovery.

Performance supplements contain different ingredients, many of which are vitamins, minerals, protein, creatine, and herbs. This category of supplements is intended to improve both activity and recovery. It includes ergogenic aids, which are specifically taken to improve activity or performance. The Office of Dietary Supplements lists the following ingredients as popular for exercise and athletic performance with suggested ULs based on past research studies.

Table 15.5 Popular Fitness Supplements for Exercise and Athletic Performance

INGREDIENT	EFFECT ON EXERCISE AND PERFORMANCE	SAFE GENERAL UL
Antioxidants (vitamin C, vitamin E, and coenzyme Q10)	Minimizes free radical damage to skeletal muscle Reduces muscle fatigue, inflammation, and soreness	Vitamin C: 2,000 mg/day Vitamin E: 1,000 mg/day Coenzyme Q10: 120 mg
Arginine	Increases blood flow and delivery of oxygen and nutrients to muscle Increases secretion of human growth hormone	Up to 9 g/day
Beta-alanine	Increases synthesis of carnosine, a dipeptide that buffers changes in muscle pH, reducing muscle fatigue	1.6–6.4 g/day for up to eight weeks
Nitrate (beetroot extract)	Dilates blood vessels in exercising muscle Improves energy production	310–682 mg or 2 cups of beetroot juice 2.5–3 hours before exercise
Branched-chain amino acids (BCAAs): leucine, isoleucine, and valine	Metabolized by mitochondria in skeletal muscle to produce energy during exercise	Up to 20 g/day in divided doses

BRANCHED-CHAIN AMINO ACIDS (BCAAS):
A group of three essential amino acids (leucine, isoleucine, and valine) that help the body build muscle and decrease muscle fatigue.

Table 15.5 Popular Fitness Supplements for Exercise and Athletic Performance (CONT)

INGREDIENT	EFFECT ON EXERCISE AND PERFORMANCE	SAFE GENERAL UL
Caffeine	Reduces perceived pain and exertion and increases fat metabolism	Up to 400–500 mg/day for adults
Calcium	Improves bone and joint health and helps muscles contract	Up to 2,500 mg/day
Citrulline	Increases delivery of oxygen and nutrients to muscle	6 g/day
Creatine	Helps muscles generate energy for short-term anaerobic activity	3–5 g/day for up to 12 weeks
Glutamine	Metabolism and energy production Improves immune function and preserves protein stores Reduces fatigue and decreases muscle soreness	0.42 g/kg of body weight
Iron	Increases oxygen uptake Reduces heart rate and decreases lactate concentration during exercise, which in turn increases blood flow	Up to 45 mg/day
Note: g = gram; kg = kilogram; mg = milligram. *See vitamin and mineral tables earlier in the chapter for reference*		

PROTEIN

Resistance and endurance exercise are recommended to build and maintain strength, maintain and improve health and counteract the effects of aging. Stronger muscles contribute to a more active lifestyle, which supports well-being and good health. Further, maintaining muscle strength reduces the risk of chronic disease, functional limitations, and physical disability.

Even though resistance training may lessen the **catabolic** effects of aging, muscle strength and metabolism still decline with age. Dietary protein supplementation counteracts these effects by boosting protein **anabolism**, and such supplementation is essential to maintain

CATABOLIC: Metabolic activity involving the breakdown of molecules such as proteins or lipids.

ANABOLISM: The building of complex molecules in the body from more simple, smaller molecules.

strength and general health even at a young age. When a client fails to consume adequate amounts of dietary protein, supplements can help make up for the deficiency. In addition, low-fat and low-calorie protein sources may be an ideal weight-loss solution for some because they provide an essential nutrient in a convenient form.

Protein Quality Scoring

To understand the rating scales used to classify proteins, a fitness professional should first consider what protein is needed for. Protein is made up of amino acids, with some of them being essential (the body cannot create them) and needing to be consumed from an outside source. Others are nonessential, and the body can manufacture them internally from other sources. Dietary protein must be consumed to get these essential amino acids (EAAs), and certain protein sources are better able to meet the EAA needs of the human body than others.

MUSCLE PROTEIN SYNTHESIS (MPS): A process that produces protein to repair muscle damage and oppose muscle breakdown.

BIOLOGICAL VALUE (BV): The percentage of protein used by the body.

BIOAVAILABILITY: The amount of a substance that enters the circulation when introduced into the body and is effective.

PROTEIN DIGESTIBILITY-CORRECTED AMINO ACID SCORE (PDCAAS): Measures the nutritional quality of protein.

DIGESTIBLE INDISPENSABLE AMINO ACID SCORE (DIAAS): Measures the amount of amino acids absorbed by the body.

As such, a way of "scoring" a dietary protein source on its ability to meet these essential needs was created. The higher the score, the higher the content of EAAs, and the better this food source could sustain all of protein's various functions in the body. However, it is important for a fitness professional to understand that once EAA needs are met, ingesting more of them will not cause greater **muscle protein synthesis (MPS)**. Higher-rated proteins can simply meet the needs of the body with less total protein. In contrast, eating lower-rated proteins will raise a client's total protein intake needs. In addition, the **biological value (BV)** of a protein measures the proportion of absorbed protein from a food that is incorporated into the proteins of the human body. The BV is measured in percentage values and expresses how readily the digested protein can be used in protein synthesis, which is also known as **bioavailability**.

The **protein digestibility-corrected amino acid score (PDCAAS)** measures the bioavailability of a protein and its amino acid profile. PDCAASs range from 0 to 1.00, but some proteins, such as whey protein isolate, can have a score higher than 1.00. This method was adopted in 2003 with some criticism, for example, about where the nitrogen was measured and the target research group of preschool-age children.

The latest measure of protein quality is the **digestible indispensable amino acid score (DIAAS).** Adopted in 2013, it also measures bioavailability and amino acid profile. The difference is that the PDCAAS measures how much protein is absorbed after it leaves the small intestine. These scores offer valuable insights when deciding which protein is right for a client.

PROTEIN SOURCES

Meat, poultry, seafood, beans, peas, eggs, and nuts are protein sources. The amount of protein a client needs depends on many factors including age, sex, and level of physical activity. Those who are more physically active need extra protein for muscle repair and growth. It is important to consider the quality of protein and to choose a variety of foods to improve the health benefits of protein.

Plant-Based Protein

Vegetarian and vegan nutrition plans may lead to insufficient protein intake because plant-based proteins naturally contain less amounts of total protein compared to animal-based protein sources. Vegetarians must consume a variety of plant-based foods to obtain the required amount of amino acids. These foods include legumes, soy products, grains, nuts, and seeds. Additionally, consuming more plant-based protein instead of animal-based protein has been shown to contribute to a reduced risk of chronic diseases.

> **TEST TIP!**
>
> Examples of high-protein plant-based foods include:
>
> Legumes
>
> Nuts
>
> Seeds
>
> Soy
>
> Hemp

Many plant-based protein sources are **incomplete proteins** and do not contain all the EAAs the body needs to build cells. Soy, chickpea, rice, spirulina, quinoa, oat, and hemp seed protein are popular alternatives to animal-based proteins. However, sometimes to make a **complete protein**, two foods need to be combined and consumed together. Examples of complete protein combinations include whole wheat toast and peanut butter, beans and rice, and pita chips and hummus.

INCOMPLETE PROTEINS: A food source that lacks one or more of the nine essential amino acids.

COMPLETE PROTEIN: A food source containing all nine essential amino acids the body needs.

Table 15.6 BV and PDCAAS of Plant-Based Protein

BV AND PDCAAS OF COMMON PLANT-BASED PROTEIN		
Protein Source	**BV**	**PDCAAS**
Soy protein isolate	94	1.00
Chickpeas	53	0.78
Rice	83	0.47
Spirulina	95	1.00
Quinoa	83	0.79
Oats	86	0.59
Hemp seed	86	0.52

Animal-Based Protein

Animal proteins such as meat, eggs, and milk are complete proteins. They contain all the EAAs the body needs. Other animal-based protein sources are fish, chicken, cheese, bison, and turkey. These high-quality protein sources contain adequate amounts of vitamin B12, vitamin D, and zinc, which are all found in larger quantities in animal-based proteins compared to plant-based ones.

Red meat is also a great source of protein and contains vitamins and minerals essential to health. For example, red meat contains enough iron to help make DNA and keep red blood cells healthy. However, there are studies showing that increasingly eating red meat, particularly processed meat, over a long period of time is linked to an increased risk of disease and mortality. For this reason, it is important for a client to focus on eating a variety of animal proteins and to limit unprocessed red meat consumption.

Milk-Based Protein

Whey and casein are two proteins that come from milk, and both contain all nine EAAs. In milk, casein are the curds, and whey is the liquid. When being processed into a powder, casein and whey are separated from each other. Whey contains a large amount of the amino acid L-cysteine and is one of the primary proteins found in dairy products. It also provides a large amount of EAAs needed for body function. On the other hand, casein is digested more slowly than whey, which means it releases amino acids gradually and is **anticatabolic**. This

ANTICATABOLIC:
Properties that protect muscle mass from being broken down.

helps reduce muscle breakdown in circumstances where a client may go a long period of time without eating. Casein is often consumed prior to sleep because this is generally a long fasting period.

Table 15.7 BV and PDCAAS of Animal-Based Protein

BV AND PDCAAS OF COMMON ANIMAL-BASED PROTEIN		
Protein Source	**BV**	**PDCAAS**
Whey protein isolate	104	1.00
Casein isolate	77	0.78
Fish	76	0.90
Chicken	79	0.95
Beef	80	0.92

Protein Timing

Protein timing is a controversial approach used to optimize training effects, such as muscle growth and strength gains. It is based on the idea of consuming protein as close to a training session as possible. This includes before, during, and after exercise.

The general train of thought is that after exercise there is a limited time window during which protein is needed to increase protein synthesis. A **refractory period** follows this short window, and it can take a few hours before a spike in MPS can occur again. So, it may be beneficial to consume a protein supplement before the refractory period.

REFRACTORY PERIOD:
A window where muscle protein synthesis (MPS) becomes resistant and amino acids are used for other processes.

A fast-acting protein such as whey that consists of leucine promotes optimal MPS. However, insulin is needed for protein and leucine to be effective, which is why a carbohydrate source paired with protein following a workout is more effective. Some studies report that this combination results in a larger increase of lean body mass compared to just a protein source alone.

Variables that a fitness professional should consider for total protein needs are a client's age, weight, caloric intake, activity level, and goals. The current RDA for healthy individuals is 0.8 grams (g)/kilogram (kg)/day, and for more active individuals, 1.4–1.6 g/kg/day is appropriate. Claims of increased muscle mass, increased fat loss, improved performance, and greater recovery influence the popularity of protein supplements. Consuming such high amounts of protein can be achieved more comfortably through protein supplements and may help clients reach the RDA.

GLUTAMINE

Glutamine is a conditionally dispensable amino acid found in dietary proteins and made by the body. It is not an EAA except in times of illness or stress. This is why glutamine plays a critical role in immune system function and gut health. It is produced naturally in the body, but supplementation may be beneficial when levels are low. When the body is under excess stress, such as during injury or illness, glutamine levels decrease. As a precursor for protein, glutamine supplementation plays a role in metabolism, nitrogen balance, and protein synthesis. These growth factors involve **cell proliferation**, which leads to an increase in cell number and assists with tissue growth.

CELL PROLIFERATION: The process by which a cell grows and divides to produce new cells.

Glutamine has anticatabolic effects, reduces cortisol levels, and elevates growth hormone levels. In research studies, glutamine has been shown to be effective in dosages of 2 to 5 g per day. Athletes have been known to consume up to 10 g per day. However, more current research is needed to establish and confirm any associated benefits. The benefits are interesting for athletes who engage in prolonged exercise, but beside minimal fatigue markers, glutamine supplementation seems to have little effect on physical performance.

Another study examined the effects of 30 g of glutamine in type 2 diabetes patients and showed a significant difference in reduced waist circumference and increased fat-free mass. It is important for a fitness professional to remember that glutamine is often combined with other dietary ingredients and ergogenic aids, so the benefits cannot be attributed to just glutamine.

Glutamine is the body's most abundant free amino acid. It is produced in the muscles and distributed by the blood to the tissues. During times of stress, the body may use more glutamine than the muscles can replenish, and muscle wasting can occur. After surgery or traumatic injury, protein, specifically nitrogen, is necessary to repair wounds and keep the vital organs functioning. About one-third of this nitrogen comes from glutamine.

OMEGA-3 FATTY ACIDS

Next to an MVM formula, omega-3 supplements are likely the second most commonly known supplement for consumers. Just as there are EAAs in protein, there are essential fatty acids in dietary fat. Fats are necessary in a nutrition plan for cellular health, but the typical American nutrition plan has an unfavorable ratio of omega-6 to omega-3 fatty acids. Simply put, omega-6 fatty acids tend to be pro-inflammatory, while omega-3 fatty acids tend to be anti-inflammatory.

The ratio of omega-6 to omega-3 fatty acids in typical Western diets is approximately 16:1, with most of those omega-6 fatty acids coming from vegetable oils. This includes sunflower oil, soybean oil, corn oil, cottonseed oil, and any processed foods that contain them. An ideal ratio would be 4:1. Fatty and oily fish are known to be the best dietary sources of omega-3 fatty acids, but many Americans do not consume enough of them. That is why omega-3 supplementation is highly recommended by most health and regulatory agencies and organizations worldwide.

Fish oil is a popular supplement taken to increase omega-3 intake, but increasing omega-3 intake to compensate for excess omega-6 fatty acids is not safe. It is crucial to decrease omega-6 fatty acids when the ratio of omega-6 to omega-3 fatty acids is extremely high. A ratio that is too high may contribute to increased inflammation in the body and is caused by consuming too much seed and vegetable oils.

As with any nutrient, supplementation should be considered if a client is not intaking enough through their nutrition plan. Dietary forms of omega-3 include fatty fish, nuts, seeds, and some plants. Two servings of fatty fish a week provide beneficial levels of the essential omega-3 fatty acids eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA).

As with all supplement use, it is best to look for a brand that is third-party validated for content and certified to be free of mercury and other environmental contaminants. Mercury is a well-known heavy metal and is linked to many degrees of toxicity. Fish contain mercury due to industrial sources giving off hazardous air pollutants that fall to the ground and contaminate the water. Since trace amounts of toxins remain in fish oil supplement products, it is important to select a brand validated by a third party.

Plant-Based Alternatives

Although DHA and EPA are found mostly in seafood, they are essential nutrients for fish and other sea creatures. Essential nutrients must be taken into the body from an outside source. Fish get dietary DHA and EPA from algae and seaweed. This means that DHA and EPA are not originally found in fish. Instead, fish absorb omega-3 by consuming algae.

Other plant-based sources of omega-3 are chia seeds, algal oil, hemp, walnuts, and flaxseeds. Algal oil is a vegan alternative to fish oil that is high in both DHA and EPA. One study found algal oil equal to cooked salmon in terms of omega-3 absorption. Omega-3 fatty acids are an essential part of **polyunsaturated fats** and have been shown to prevent heart disease and stroke.

POLYUNSATURATED FATS:
Fat molecules containing more than one unsaturated carbon bond, are liquid at room temperature, and solid when chilled.

ERGOGENIC AIDS

ANABOLIC-ANDROGENIC STEROIDS (AAS): Synthetic variations of the male sex hormone testosterone.

An ergogenic aid is a nutritional, pharmacologic, physiologic, or psychologic aid that enhances exercise capacity. Some techniques, such as carbo-loading, are safe and widely accepted. Others, such as the use of **anabolic-androgenic steroids (AAS)**, are banned by governing bodies. For this discussion, a fitness professional should recognize that steroids are not dietary supplements. Rather, they are drugs, and when used by healthy individuals with no physiological need other than the desire to look, perform, or recover better, steroids are illegal.

As for dietary supplements as ergogenic aids, the American Academy of Pediatrics opposes their use for young athletes. Allergic reactions and GI disorders may result from overusing supplements and may increase the risk for obesity in children and adolescents when used excessively. When and if applicable, a fitness professional should first discuss supplement recommendations with a parent or guardian before making any recommendations to a child or minor. The Academy of Nutrition and Dietetics, Dietitians of Canada, and American College of Sports Medicine published their position statement on nutrition and athletic performance in 2016, stating,

Supplement use is best undertaken as an adjunct to a well-chosen nutrition plan. It is rarely effective outside these conditions and not justified in the case of young athletes.

The effects of certain ergogenic aids must be carefully weighed before choosing to supplement. In most cases, performance and other gains can be realized through proper training and a well-balanced nutrition plan. Ergogenic supplement use will not make up for a poor nutrition plan and training. However, all else being equal and correct, there are some compounds that can be effective.

CREATINE

Creatine is one of the most researched and effective ergogenic supplements, with the monohydrate form being the most studied form of creatine. The goal of supplementing with CM is to increase intramuscular levels of creatine and speed the regeneration of creatine phosphate (CP), which is expended during energy production. Similar in concept to the carbo-loading done by endurance athletes to increase glycogen stores, strength and power athletes load creatine to increase CP levels, delaying its depletion and decreasing repletion time.

Activities dependent on CP as an energy source, including sprinting, resistance training, and other sports requiring repetitive bursts of speed and power (football, baseball, rugby, hockey, etc.), could also benefit from creatine supplementation. Creatine increases speed and energy in short bouts of high-intensity activities or sports, which leads to improved performance. Since aerobic/endurance activity is not CP dependent, creatine supplementation does not improve such activities.

Creatine may cause bloating and lead to water weight gain as a result of muscles retaining more water. In fact, due to the supplement drawing water into the muscles and the potential for weight gain associated with creatine-loading regimes, performance could theoretically be impaired. It is inadvisable for beginning exercisers to supplement with creatine. The ability to enhance muscle contractile strength and power relatively quickly can outpace the neurological adaptations that allow an exerciser to control those gains, increasing the possibility of an injury.

Women and men can expect the same types of responses to creatine supplementation. It is best to prepare a client for the possibility of weight gain, specifically from water retention, with this supplement. Creatine contains no calories and therefore has no impact on fat metabolism. However, individual physical responses to creatine supplementation are common, as with any supplement use. Creatine is an amino acid already naturally found in muscles, which means some clients may have higher levels than others to begin with. Each individual converts substances differently, and dietary intake can influence a client's normal creatine levels. Since dietary creatine is mostly obtained via animal muscle meats (beef, chicken, etc.), those who do not consume these foods often or at all will respond more dramatically to creatine supplementation.

BETA-ALANINE

Beta-alanine (BA) is a nonessential amino acid produced naturally in the body. It aids in the production of other protein building blocks, such as carnosine, and plays a role in muscle endurance during high-intensity exercise. BA supplementation has been shown to increase skeletal muscle levels of carnosine, which is an intramuscular pH buffer and antioxidant. Supplementing with BA can lower exercise-induced **acidosis**, potentially delaying fatigue and improving performance. In addition, free radicals are produced at an accelerated rate during exercise and are thought to contribute to exercise-induced damage and fatigue. Supplementation with BA may reduce these negative effects in exercising muscles and help maintain performance levels.

A systematic review of BA supplementation found moderate- to high-quality studies supporting the findings that BA may increase power output and training capacity, decrease feelings of fatigue and exhaustion, and have positive effects on body composition and carnosine

BETA-ALANINE (BA):
A nonessential amino acid that is naturally produced by the body.

ACIDOSIS:
When the kidneys and lungs cannot keep the body's pH in balance due to excess acid in body fluids.

content. Carnosine is a protein building block that is naturally produced in the body and mainly found in working muscles. In addition to muscle function, carnosine plays a role in heart and brain function by preventing cell damage. Carnosine studies show intake ranges of 4 to 6 g/day for at least two weeks to improve exercise performance. The most common side effect noted in BA supplementation is paresthesia. This is a harmless side effect and results in a numbness or tingling feeling in the face and neck.

Branched-Chain Amino Acids

Branched-chain amino acids (BCAAs) are a group of three EAAs including leucine, isoleucine, and valine. Leucine is an essential BCAA, and EAA formulas have been shown to play a role in MPS. Isoleucine and valine aid in muscle development, increase endurance, and promote muscle recovery and repair.

These EAA formulas, and leucine itself, stimulate MPS via a regulatory “switch” called the “mammalian target of rapamycin complex 1.” Studies have shown benefits such as increased and more rapid recovery following exercise, increased MPS (especially in older and elderly populations), decreased muscle protein breakdown, and reductions in muscle soreness.

The body uses amino acids to make proteins, which are the building blocks to cell, tissue, and organ function. BCAAs play an important role in metabolism including muscle growth, recovery, and repair while leucine and isoleucine specifically promote blood sugar control. However, the body requires all the EAAs for optimal benefits such as reducing exercise fatigue and improving energy metabolism.

STIMULANTS

STIMULANTS:
A class of drugs that temporarily improve physical or mental function.

Stimulants are often used in sports to enhance performance and by those seeking faster weight loss. These substances speed up body systems and elevate alertness, mood, and awareness. They can raise heart rate, temperature, blood sugar, and blood pressure; constrict blood vessels; and open the pathways of the respiratory system. In addition, they can decrease feelings of hunger or fatigue. Many stimulants can be addicting, but each has its own unique effects. They are often found in supplements, as seen with caffeine in energy drinks, which are often used to boost energy during workouts. Stimulants change the way the brain works by altering how nerve cells communicate. For example, they can cause a buildup of dopamine in the brain, making an individual feel intense pleasure and increased energy.

Caffeine is a popular stimulant that shows some benefit during exercise through increases in epinephrine. Epinephrine, also known as adrenaline, is a hormone produced by the adrenal glands and helps break glycogen down into glucose for usable energy. It also significantly increases power output for trained and sedentary clients. Research shows that caffeine may have a greater effect on mood and reaction time in abstained caffeine consumers compared to those who habitually consume caffeine.

Energy drinks often contain guarana, taurine, L-carnitine, and ginseng. Unfortunately, there is not enough existing research on these ingredients to determine whether they have any effect on energy separately or together. For example, L-carnitine may reduce fatigue for elderly people with low muscular endurance. However, other research on L-carnitine has found no influence on low-intensity, long-duration cardio exercise.

“Ginseng” is a general term that includes several different types of plants. Plants that fall under the “ginseng” label include ashwagandha (Indian ginseng), *Eleutherococcus senticosus* (Siberian ginseng), *Eurycoma longifolia* Jack (Malaysian ginseng), and many others. With such a variety of ginseng options, it is difficult to know which kind is used in energy drinks and what effects it might have.

BANNED SUBSTANCES

Some ergogenic aids have been banned for use by many organized sports organizations to prevent unfair advantages. Once an athlete consumes and exceeds certain levels of ergogenic aids, the side effects increase. Ergogenic aids are used to provide athletes with a competitive advantage and must be monitored. Part of the reason for their ban is the fact that they often have contaminants that can be harmful to health. They may also be listed as “not for human consumption” in some cases. Some ergogenic aids are available for therapeutic use monitored by a physician.

AAS are known for increasing muscle size and strength. A physician may prescribe steroids to treat hormonal issues including low testosterone or disease-related muscle loss. However, outside of a physician’s care, the use of steroids is inadvisable. A fitness professional should remember that AAS are not dietary supplements but drugs, and as such AAS exceed a personal trainer’s scope of practice.

TEST TIP!

Negative Mental Health Effects of AAS

- Paranoid jealousy
- Extreme aggression
- Delusions
- Impaired judgment
- Mood swings

Physical Effects

- Increased risk of liver disease
- Increased risk of cardiovascular disease
- Hypertension
- Acne
- Baldness

Effects in Men

- Shrinking testicles
- Breast growth
- Reduced sperm count
- Impotence
- Reduced sex drive
- Increased risk of prostate cancer

Effects in Women

- Deep voice
- Growth of facial and body hair
- Abnormal menstruation
- Enlarged clitoris
- Decreased breast size

Effects in Teens

- Premature puberty
- Stunted growth (closure of growth plates)

BOTANICAL SUPPLEMENTS

Botanical preparations are marketed in the US as dietary supplements and can include nutrients such as herbs, enzymes, organ tissues, amino acids, and vitamins and minerals. A botanical is a plant or plant part containing various medicinal properties. Due to their benefits on health, they have become increasingly popular. A fitness professional should keep in mind that they are not labeled as drugs but rather as dietary supplements because, by law, the manufacturers of supplements cannot claim their products treat or prevent any disease.

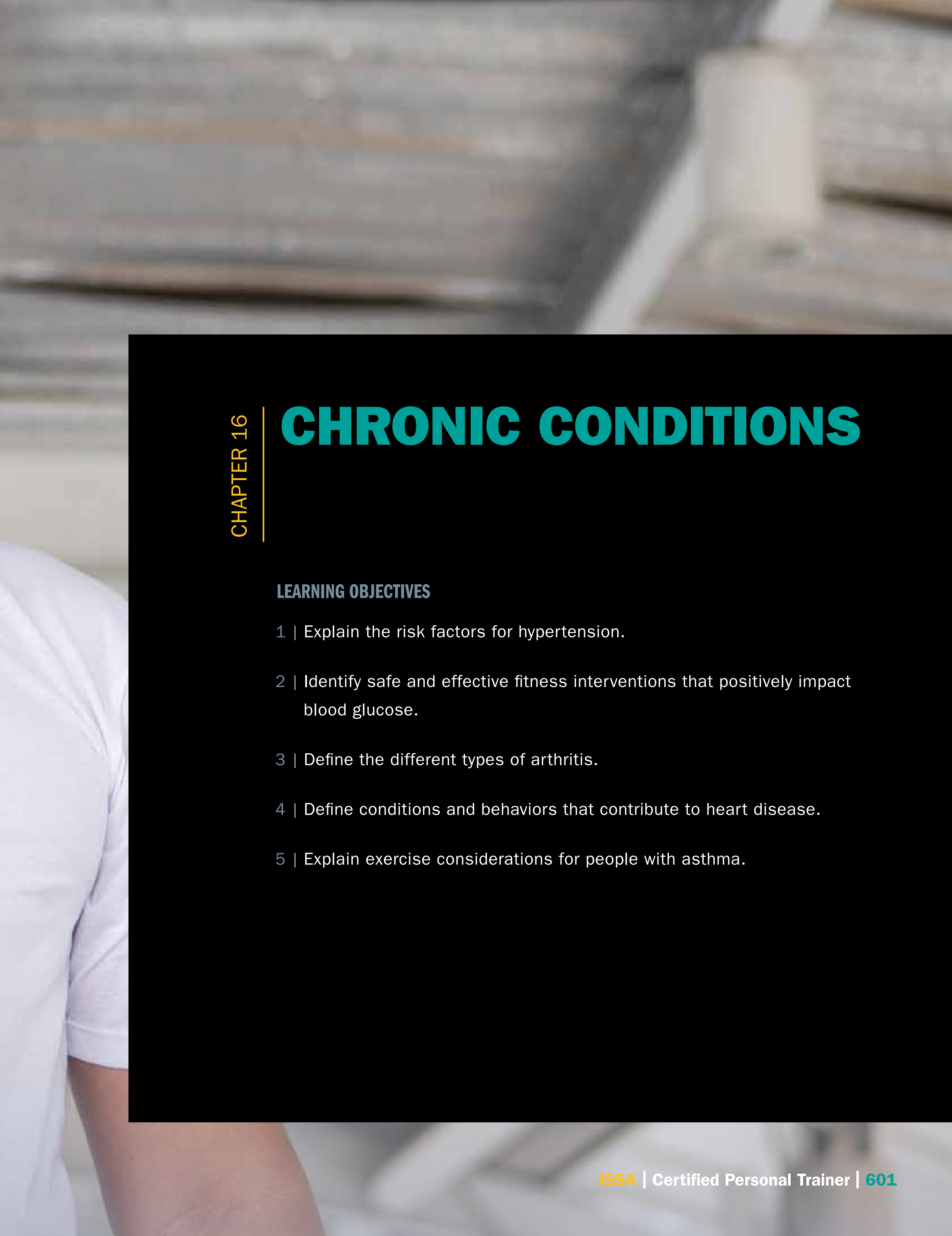
Botanical supplements are used to maintain or improve health by supplementing a nutrition plan with various health benefits. They come in many forms including fresh and dried plants, plant parts, and extracts. The safety of botanicals is determined by the makeup of the supplement, how the body responds to it, and the amount or dosage consumed. Each botanical is consumed for different reasons ranging from fat loss to immune system function, better sleep, and reduced anxiety. The following botanicals were selected for their popularity and prevalence in the health and fitness industry.

Table 15.8 Botanical Supplements

BOTANICAL	PRIMARY USAGE	RESEARCH	NOTES
Cannabidiol (CBD)	Reduce anxiety, improve sleep, and increase weight loss	Most research is done on mice, not humans. Results are inconclusive.	Dosages vary depending on form and use.
Cinnamon	Lower blood sugar by increasing insulin sensitivity	Proven effective as an antidiabetic compound and may reduce cholesterol	Taking 2 g/day shows anti-inflammatory properties and lower blood sugar levels.
Echinacea	Build up the immune system and protect against allergies	Results vary but show a reduction in length of sickness with supplementation.	No optimal dose or type
Garlic	Antioxidant and anti-inflammatory properties that protect against allergies and build immunity	Consistent findings for increasing HDL and decreasing LDL by 10–15 percent reduces blood pressure and frequency of the common cold.	Can be supplemented via a nutrition plan or aged garlic capsules. Taking 300 mg/day has been shown to manage hypertension.
Ginger	Improve the movement of food in the stomach for gut health and increase testosterone	No research regarding gut health, increase in testosterone found in infertile men	May increase HDL and decrease LDL. Reduces inflammatory markers. Comes in forms such as fresh or dried roots, tablets, and liquid extract.
Green tea	Increase norepinephrine and induce fat loss	Fat loss effect is minor and unreliable	May reduce LDL, lower fasting blood glucose, increase oxygen uptake, and reduce muscles soreness

Table 15.8 Botanical Supplements (CONT)

BOTANICAL	PRIMARY USAGE	RESEARCH	NOTES
Hoodia	Increase fat loss	Does not suppress appetite, may increase blood pressure and heart rate	Has a desired effect on appetite and weight loss. Little available research in humans.
Milk thistle	Promote cell repair for liver health and detoxification	No research to support claims	May reduce acne lesions with direct application to the skin
Saw palmetto	Increase testosterone levels and improve prostate health	Not effective at increasing testosterone or suppressing prostate growth	Mixed and inconsistent findings regarding sexual function
Valerian	Improve sleep and reduce anxiety	Research points to no effect.	May reduce menstrual pain and symptoms of PMS. Commonly used before bedtime.
Note: g = gram; HDL = high-density lipoprotein; LDL = low-density lipoprotein; mg = milligram reference the vitamin and mineral tables earlier in this chapter			



CHAPTER 16

CHRONIC CONDITIONS

LEARNING OBJECTIVES

1 | Explain the risk factors for hypertension.

2 | Identify safe and effective fitness interventions that positively impact blood glucose.

3 | Define the different types of arthritis.

4 | Define conditions and behaviors that contribute to heart disease.

5 | Explain exercise considerations for people with asthma.

There are many chronic conditions a client may have or may develop over their lifetime. A chronic condition is a health condition or disease that has long-lasting effects. Many are related to lifestyle and eating patterns and can be addressed with modifications of the same. However, some chronic conditions are hereditary and require additional adjustments and considerations. A fitness professional must have a clear understanding of common chronic conditions they may encounter for several reasons: first, to identify the limitations a client may have; second, to better create an effective training program with these limitations in mind; and third, to identify if and when a client should be referred to a health care professional for further guidance or modifications to treat a chronic condition.

It is important for the trainer to understand that the information presented in this chapter does not qualify them to adequately serve demographics with chronic conditions. It is meant to provide foundational knowledge the trainer can then build upon. Fitness professionals who desire to serve populations with chronic conditions should seek out advanced training, stay within their scope of practice, and always refer to other professionals when appropriate. Personal trainers should also be aware of clinical practice guidelines and work to collaborate with a health care team as a supporting professional.

HYPERTENSION: High blood pressure measuring more than 140/90 mm Hg.

BLOOD PRESSURE: The force of blood pushing against the walls of the arteries during the two phases of the cardiac cycle.

SYSTOLIC: The pressure in blood vessels when the heart beats (ventricular contraction).

DIASTOLIC: The pressure in blood vessels when the heart rests (ventricular filling).

STROKE: When the blood flow to the brain is interrupted long enough to cause damage.

RISK FACTORS: Variables associated with increased risk of disease or infection.

Before designing a program, a personal trainer should use the client intake paperwork to collect subjective and objective data on a client. This will help identify any potential chronic conditions. The trainer may also choose to require a physician's approval before the client begins a fitness program.

EXERCISE AND HYPERTENSION

The Centers for Disease Control and Prevention (CDC) reports that one in three adults in the United States has high blood pressure (HBP) or **hypertension**. Individuals with hypertension typically have **blood pressure** readings of over 140 **systolic** and 90 **diastolic**, and this can be problematic if they are considering starting an exercise program. Hypertension increases the risk for the two major leading causes of death for Americans: heart disease and **stroke**. Unfortunately, there are no signs or symptoms to alert an individual to any problems. The only way to diagnose the condition is by regularly checking one's blood pressure.

Of the roughly 75 million people suffering from hypertension, only about half of them have it under control. Increasingly, youth are being diagnosed with hypertension, and experts expect a steady rise in diagnosed cases for both populations. Although this condition is silent, there are **risk factors** to watch for that may help with prevention and/or early detection.

Lifestyle choices relating to diet and exercise affect blood pressure. Preexisting or current health conditions, including family history, also put individuals at a higher risk for developing hypertension.

Medications are often prescribed to control blood pressure, although leading research and treatment organizations suggest the first course of action should be lifestyle modification. Recent meta-analyses have established that both aerobic and resistance exercises can lower diastolic blood pressure. Even a small numerical drop in blood pressure values, such as 3 mm Hg, improves an individual's chances of surviving a heart attack by 5 percent and stroke by 8–14 percent.

Postexercise hypotension (PEH) is the term used to describe the initial drop in blood pressure within the first minutes after an exercise session. Symptoms can present themselves in the form of fatigue, hearing difficulties, nausea, dizziness, and fainting. Not all individuals may present symptoms, so the personal trainer should remain vigilant. Initial studies regarding PEH have been conducted on participants in walking and running programs as well as after bouts of resistance training, high-intensity interval training, yoga, and, most recently, playing active video games.

POSTEXERCISE HYPOTENSION (PEH): A drop in blood pressure in the first minutes after an exercise session.

It is important to make sure clients are well hydrated and incorporate active recovery periods within the workout when clients appear to be struggling during the session. Additionally, the personal trainer should collaborate with the health care provider to help clients develop healthier lifestyle habits, even if hypertension is **hereditary**, to prevent concurrent conditions from developing and negatively impacting client health.

HEREDITARY: Relating to the biological process responsible for passing on traits from one generation to another.

TEST TIP!

The prefix "hyper" is a Greek word that means "over." The difference between hypertension and hypotension can be distinguished by remembering this as someone with hypertension has HIGH blood pressure. The opposite would be hypotension.

BLOOD PRESSURE RISK FACTORS

To manually measure blood pressure, a cuff is wrapped around the arm just above the elbow. The cuff is inflated while the practitioner listens to the pulse at the anterior space of the elbow where the upper arm and forearm meet. The first number is the systolic and is recorded when the pulse is first heard. The air in the cuff is then slowly released, and the diastolic is recorded when the pulse can no longer be heard. Electronic blood pressure monitors can also be used but, while convenient, may not be as accurate. Values are measured in **millimeters of mercury**, or mm Hg. For example, the final value is written as 120/80 mm Hg.

MILLIMETERS OF MERCURY: The measure of a unit of pressure.

Table 16.1 Blood Pressure Levels

BLOOD PRESSURE	SYSTOLIC	DIASTOLIC
Normal	Less than 120 mm Hg	Less than 80 mm Hg
Prehypertension	120–139 mm Hg	80–89 mm Hg
Hypertension	140 mm Hg or higher	90 mm Hg or higher

There are many risk factors for developing hypertension. For most clients, HBP is the result of a combination of factors such as **obesity**, an unhealthy diet, and physical inactivity, as well as smoking and alcohol consumption. A personal trainer can determine if a client is at a high risk for hypertension by conducting a thorough evaluation before the first training session.

OBESITY: An abnormal or excessive accumulation of bodyfat that may cause additional health risks.

Obesity

Obesity is linked to higher levels of low-density lipoprotein (LDL) cholesterol and triglycerides and lower levels of high-density lipoprotein (HDL) cholesterol. When artery walls are hardened and narrowed with cholesterol plaque, the heart must work harder to pump blood through them, increasing intravenous pressure. Obesity is a major risk factor for hypertension.

DIABETES: A condition characterized by an elevated level of glucose in the blood.

ATHEROSCLEROSIS: The buildup of fats, cholesterol, and other substances in the artery walls.

Diabetes Mellitus

Diabetes impacts the body in a few ways that may contribute to increased blood pressure. It changes the way the body manages insulin and damages blood vessels. This leads to reduced nitric oxide levels, which regulate blood pressure. Low levels of nitric oxide in the blood can lead to **atherosclerosis**.

TEST TIP!

About 6 out of 10 people who have diabetes have high blood pressure. This means nearly 60 percent of people with diabetes mellitus have hypertension. Diabetes causes sugars to build up in the blood. The body will naturally try to get rid of excess sugar by urinating, leading to dehydration. This not only leads to increased blood pressure but also increases the risk for heart disease.

Unhealthy Diet

There are many components to one's diet that increase the risk for hypertension. High sodium and low potassium consumption are two components that increase blood pressure. Sodium intake can increase water retention, which in turn will increase blood flow resistance. It is important to counterbalance high levels of sodium with potassium. Potassium helps excrete sodium through urine and lessens resistance in blood vessels.

Physical Inactivity

Sedentary behaviors play a major role in developing hypertension. Staying physically active helps prevent weight gain and lessens the chance of other health issues developing. It is recommended to achieve at least thirty minutes of physical activity per day to lower the risk of hypertension.

Alcohol Consumption

Excessive alcohol consumption can raise blood pressure. The mechanism as to how this occurs remains inconclusive, but there are theories. One suggested mechanism is that too much alcohol creates inflammation within the body, which then creates oxidative injury to blood vessels. To avoid these negative effects, it is recommended to avoid alcohol or to drink in moderation. According to the Dietary Guidelines for Americans, moderate drinking is up to one drink a day for women and up to two drinks a day for men. Alcohol can contribute to unhealthy weight gain and may create a narrowing of blood vessels, both of which may compound and increase the effects of preexisting HBP.

Tobacco

Smoking can make breathing difficult and reduces the amount of oxygen that blood carries. Chemicals in tobacco, such as nicotine, damage lung tissue and arteries and lead to increased blood pressure.

As a reminder, the above information can be used to identify whether a client is at a high risk for hypertension, not to diagnose it. Small lifestyle modifications can help to reduce one's risk for chronic disease and promote longevity.

PROGRAM DESIGN

Improvements in diastolic blood pressure, strength, and cardiorespiratory fitness, and an increase in lean body mass can occur within eight weeks. These changes impact the health of the client, reducing the risk of HBP. However, one study that followed participants over the course of eight weeks noted no change in systolic blood pressure. Therefore, eight weeks may not be enough to start seeing improvements, so a 12-week program may be best.

A client should not expect to see changes in their blood pressure values until around week 12 in their training. Many studies have demonstrated a drop of about 3 mm Hg in systolic blood pressure after a 12-week fitness program. Again, this has significant value as it reduces cardiac and stroke morbidity.

Exercise Options

For clients with blood pressure over 160/100 mm Hg, their doctor should be consulted before beginning a weight-lifting routine as heavy resistance can temporarily increase blood pressure. Clients should not perform heavy overhead lifts but should vary exercises between the upper body and lower body.

Table 16.2 Exercise Options for Hypertension

TYPE OF ACTIVITY	FITNESS PRESCRIPTION
Cardiorespiratory exercise	150 minutes of moderate-intensity exercise per week Or 75 minutes of vigorous activity Or any combination of moderate and vigorous activity
Resistance exercise	Moderate-high intensity exercise two days per week. Increase intensity over time, warm-up, and cooldown.

CONCURRENT TRAINING: Including both cardiorespiratory exercise and resistance training into a fitness program.

Clients can also perform circuit training known as **concurrent training**, which may be the most efficient way to help clients lower blood pressure and reduce hypertension risk. It has a better overall impact on cardiovascular disease risk factors.

SPECIAL CONSIDERATIONS

Safety is always a top priority for fitness training. The main goal of designing a fitness program is to help the client integrate exercise into their lifestyle. Educating the client is a key component of helping the client develop **competency** and **autonomy**. Coaching points include the instruction of breath control, intensity control, and incorporating both a warm-up as well as a cooldown.

Controlled Breathing

It is important to advise the client not to hold their breath. Holding the breath while exercising increases intravenous pressure and may cause **syncope** and injury. Additionally, it is best to avoid using the **Valsalva maneuver** for those who have HBP. This maneuver is a technique used among some weight lifters to engage the core and maximize force production. It is particularly used when lifting heavy weight.

Maintaining Intensity

If a client is taking medication to control blood pressure, then it is necessary to adjust how the maximum heart rate is determined. **Beta blockers** block specific receptors to reduce the effects of signals sent to increase heart rate. When these receptors are blocked, the heart does not receive messages to speed up and maintains a slower rate and lower blood pressure.

Thus, to determine the maximum heart rate, a different equation must be used:

162 – (0.7 x age) = estimated maximum heart rate (HRmax)

Another appropriate measure for clients with hypertension is the **talk test**. If clients can carry a full conversation, they can pick up the pace. If brief exchanges are manageable, with the need to pause and breathe, the pace is just right. Clients should slow their pace when short sentences make them out of breath, or if they need to stop frequently.

Warm-Up and Cooldown

A warm-up is essential for clients with HBP as it allows the blood vessels to slowly expand to accommodate greater blood flow. A gradual warm-up should help the client achieve their target heart rate. At least 10 minutes is necessary, more if the client has been inactive for a long time. The cooldown at the end of the workout is equally important. It is important to not allow the client to immediately stop activity. The personal trainer can include flexibility or yoga postures to slowly bring the client's heart rate back to pre-exercise values. A proper cooldown will also reduce muscle soreness.

COMPETENCY:
The ability to do something successfully or efficiently.

AUTONOMY:
The need for self-governance and control over one's own behaviors.

SYNCOPE:
Temporary loss of consciousness related to insufficient blood flow to the brain.

VALSALVA MANEUVER:
The act of forcibly exhaling with a closed windpipe, where there is no air that is exiting via the nose or mouth.

BETA BLOCKERS:
One of the most widely prescribed classes of drugs to treat hypertension.

TALK TEST:
The ability to speak during exercise as a gauge of the relative intensity.

DIETARY APPROACHES TO STOP HYPERTENSION (DASH) DIET:
A low-sodium, whole-food diet created for the treatment of hypertension.

Healthy Food Choices

Dietary suggestions should be handled carefully. Personal trainers should check local laws to determine what information they are allowed to dispense within legal parameters. In most cases, it is acceptable to share widely published general nutrition knowledge. In this case, personal trainers may suggest the **Dietary Approaches to Stop Hypertension (DASH) diet**.

This DASH diet promotes eating plenty of vegetables, fruits, and whole grains. It suggests limiting fatty foods and sugars. This means eating fish, poultry, beans, and nuts but avoiding fatty meats, dairy, and tropical oils. Clients should choose foods that are low in sodium, low in saturated and trans fats, and rich in potassium, calcium, magnesium, fiber, and protein.

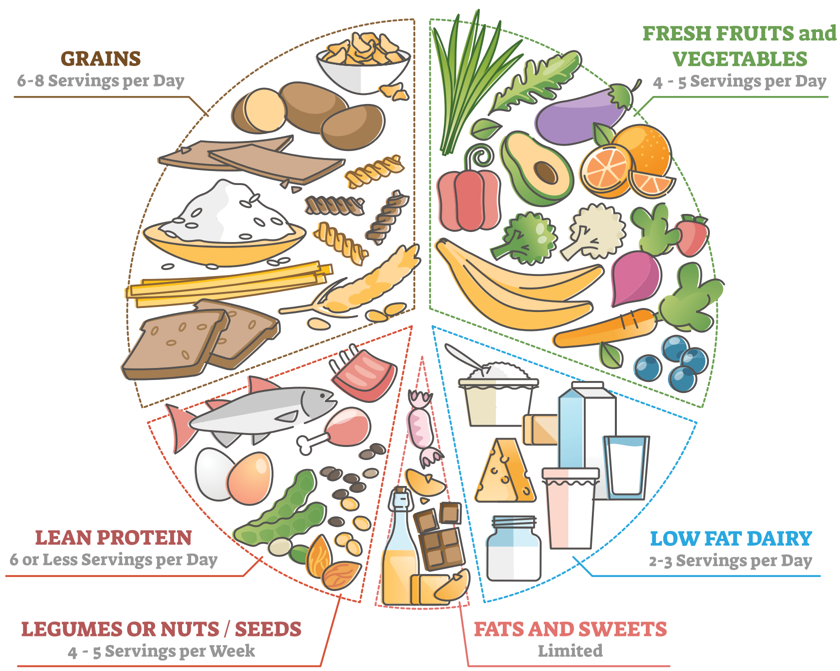


Figure 16.1 DASH Diet

INSULIN:
A hormone produced in the pancreas to regulate blood sugar.

HEART DISEASE:
A term used to describe several different heart conditions.

EXERCISE AND DIABETES

When someone eats a meal, the food is converted into energy for the body to use. In healthy individuals, the pancreas secretes **insulin**. Insulin regulates many metabolic processes that provide cells with energy. This helps the cells collect glucose from the blood to turn it into energy. In the case of diabetic clients, the body either doesn't make enough insulin to collect glucose from the blood, or the body doesn't use the insulin efficiently. In either case, what results is excess glucose in the blood, leading to **heart disease**, vision loss, or kidney disease over time.

Men with diabetes are two to three times more likely to suffer a cardiovascular disease-related event than men without diabetes. Women with diabetes are three to five times more likely than women without diabetes to suffer the same. Also, deaths related to myocardial infarction (heart attack) for men and women with diabetes are double that of their healthy counterparts. Diabetes negatively impacts the body through **cardiometabolic** conditions.

Prediabetes is the presence of diabetic indicators that are above normal and may possibly evolve into **type 2 diabetes** without proper intervention and control. In the US, one in three adults have prediabetes, many of whom have no idea they have the condition. **Type 1 diabetes** makes up just 5 percent of diagnosed cases of diabetes, while type 2 diabetes makes up the remaining 90–95 percent. Cases of diabetes have more than tripled in the last 20 years, costing over $325 billion in medical expenses and lost work and wages. Prediabetes, type 2 diabetes, and **gestational diabetes** are lifestyle diseases and can be reduced or prevented by participation in a lifestyle modification program.

> **TEST TIP!**
>
> A personal trainer can remember the purpose of insulin by thinking of insulin as the door of a castle that controls when glucose gets "in."

TYPES OF DIABETES

All carbohydrates are broken down into glucose in the blood. When the pancreas cannot produce insulin, the body is unable to transport this glucose from the blood to cells in the body. As a result, blood glucose levels rise, which leads to **hyperglycemia**. There are three main types of diabetes with each disease determined by insulin response.

Type 1 Diabetes

Type 1 diabetes is thought to be an autoimmune response in which the body attacks and destroys its own beta cells in the pancreas that make insulin. Nutrition and lifestyle habits do not cause this condition, and individuals with type 1 need to take insulin shots (or wear an insulin pump) every day.

CARDIOMETABOLIC:
A combination of metabolic dysfunctions mainly characterized by insulin resistance, impaired glucose tolerance, dyslipidemia, hypertension, and central adiposity.

PREDIABETES:
A condition where blood glucose is higher than it should be, but not in the diabetes range.

TYPE 2 DIABETES:
A long-term metabolic disorder that is characterized by high blood sugar, insulin resistance, and relative lack of insulin.

TYPE 1 DIABETES:
A chronic condition in which the pancreas produces little or no insulin.

GESTATIONAL DIABETES:
A condition characterized by an elevated level of glucose in the blood during pregnancy, typically resolving after the birth.

HYPERGLYCEMIA:
Elevated blood glucose.

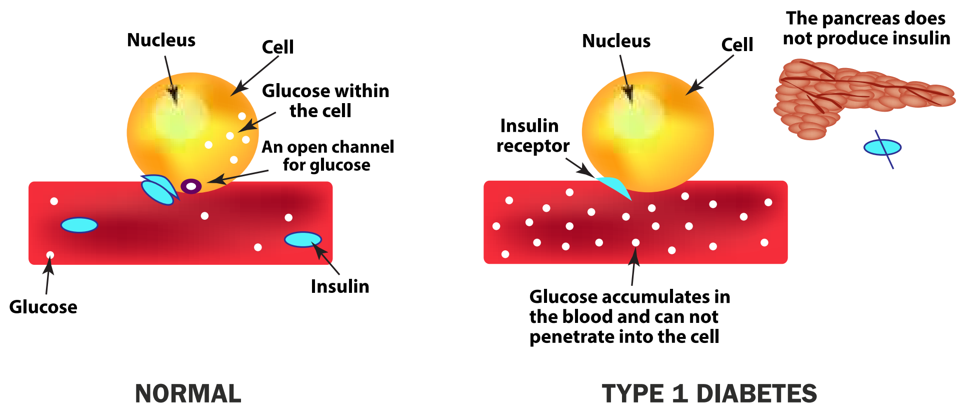


Figure 16.2 Type 1 Diabetes

Type 2 Diabetes

> **INSULIN RESISTANCE:** An impaired response of the body to insulin, increasing levels of blood glucose.

Type 2 diabetes is a preventable condition caused by unhealthy lifestyle habits. In this condition, cells do not respond normally to insulin, so the pancreas makes more to try and signal the cells to work. The pancreas cannot keep up with the demand and begins to shut down. This is known as **insulin resistance**.

Figure 16.3 Type 2 Diabetes

Gestational Diabetes

This condition occurs in pregnant women who do not have diabetes. Roughly 2 to 10 percent of pregnancies develop gestational diabetes. With all the physiological changes that happen in a woman's body during pregnancy, the body becomes insulin resistant, increasing the need for insulin. Some cases may be controlled by diet, and others need insulin injections. In most cases, it is resolved after the birth.

Exercise is a proven, safe, and effective intervention to lower blood glucose. When muscles contract during movement, cells can absorb glucose from the blood with or without insulin. During and after physical activity, insulin sensitivity is increased, and muscle cells will use available insulin to uptake glucose for energy. This is how exercise lowers blood glucose in the short term and how it gradually lowers **hemoglobin A1c (HbA1c)** after a regular physical activity program is implemented. The higher the glucose concentration in the blood, the higher the level of HbA1c.

HEMOGLOBIN A1C (HBA1C):
A minor component of hemoglobin to which glucose is bound.

HYPOGLYCEMIA:
The condition of lower-than-normal blood glucose.

RISK FACTORS

There is a chance that blood glucose may become too low. **Hypoglycemia** can happen quickly and needs to be treated immediately. Hypoglycemia can happen when there is too much insulin in the body, when a client has waited too long without a meal or snack, if they haven't eaten enough, or if they've already exercised or engaged in some sort of physical activity.

Symptoms of low blood sugar are different for everyone but may include the following:

- Shakiness
- Nervousness or anxiety
- Sweating, chills, or clamminess
- Irritability or impatience
- Dizziness and difficulty concentrating
- Hunger or nausea
- Blurred vision
- Weakness or fatigue
- Anger
- Stubbornness or sadness

At the same time, there are many risk factors for developing diabetes or hyperglycemia. Before prescribing a workout program, it is important to determine if any of the following are true. If so, clients are at a higher risk of developing diabetes.

Being Overweight

Being overweight is a primary risk factor for prediabetes, type 2 diabetes, and gestational diabetes. It is not a risk factor for type 1 diabetes. Diet and lifestyle choices don't affect type 1 diabetes because it is an autoimmune response (immune system attacking otherwise healthy cells). Though, all other types of diabetes can develop from having excess bodyfat, which is a direct result of nutrition and lifestyle choices. When a client's bodyfat increases, their body becomes more insulin resistant.

Age

Diabetes can develop at any age, but the risk of prediabetes increases after age 45. The risk of developing type 2 diabetes also increases after age 45. Type 1 diabetes is more likely to develop as a child, teen, or young adult, and gestational diabetes can occur at age 25. There is evidence showing a strong relationship between age of onset and type 2 diabetes. This research also shows that type 1 diabetes is most common in youth, accounting for more than 85 percent of all diabetes cases below the age of 20.

Family History

Family history is a strong indicator of the likelihood of developing diabetes. In most cases, the risk of prediabetes increases when a client has a parent or sibling with type 2 diabetes. Family medical history represents many genetic factors that can develop in the future. It is important for clients to know if they are at risk and immediately make necessary changes to their diet and lifestyle.

Physical Activity

Inactivity is a lifestyle choice that puts clients at a greater risk for prediabetes. Keeping clients engaged in physical activity helps prevent unhealthy weight gain. Exercise promotes effective use of insulin within muscle cells. This leads to the breakdown of sugar, which is used as energy, limiting glucose buildup in the blood.

Gestational Diabetes

POLYCYSTIC OVARY SYNDROME:
A hormonal disorder common among women of reproductive age.

If a woman has diabetes during pregnancy or gives birth to a baby over nine pounds, she will be at a higher risk for developing prediabetes. The child is also at a higher risk of developing prediabetes. Women with **polycystic ovary syndrome** have a higher risk of prediabetes too.

Ethnicity

Ethnicity is a risk factor for all types of diabetes. Black, Hispanic, American Indian, and Asian American people are at a higher risk for prediabetes and type 2 diabetes. African American, Hispanic and Latino American, American Indian, Alaska Native, Native Hawaiian, and Pacific Islander ethnicities are at a high risk for gestational diabetes. The Caucasian ethnicity is one of the only risk factors for type 1 diabetes.

PROGRAM DESIGN

First, it is important to have a physician's approval before moving forward. When meeting with a new client for the first time, a personal trainer should ensure they have visited with a diabetes educator. They must have a current record of blood sugar readings and know their signs and symptoms. Knowing how to treat their hypoglycemia or hyperglycemia is important.

Low- to moderate-intensity activity is safe and effective for helping clients with prediabetes and type 2 diabetes lower the risk of a cardiovascular disease event and developing other complications associated with diabetes. Clients with existing **retinopathy**, **neuropathy**, or **nephropathy** may also safely participate. However, vigorous activities such as high-impact exercise or heavy lifting should be avoided as they may increase the risk for a cardiac event or other injuries.

Moderate- to high-intensity training has been shown to reduce the risk of death for clients with diabetes regardless of their age, level of education, body mass index (BMI), blood pressure, total cholesterol, or smoking status. Exercise has also demonstrated a protective effect for clients at any level of BMI, blood pressure, cholesterol, or smoking. Although exercise is generally advisable for clients with diabetes, there are some contraindications to be mindful of.

Clients with type 1 or type 2 diabetes, who also have **advanced peripheral neuropathy** or **proliferative retinopathy**, should avoid vigorous aerobic activity and heavy lifting. Clients may still engage in low- to moderate-intensity aerobic activity and light resistance training. At each session, the personal trainer and client should discuss when the client last ate. A client's current blood glucose reading will reflect how long ago a client consumed food. Clients should have necessary insulin or glucose pills available for additional support during exercise.

Some data suggests that by working with a trained health and fitness professional, clients can reduce the risk of developing type 2 diabetes by 58 percent or up to 71 percent for clients over 60 years of age. When developing a fitness program for this demographic, small and sustainable lifestyle changes can be implemented. Clients should be educated on healthy food choices and finding ways to manage stress. Motivation and encouragement help clients as they face difficulties and setbacks. Clients shouldn't be instructed to change too much too soon. In addition, adequate sleep is essential. Finally, working with clients with diabetes should be a collaborative effort with health care providers, family, and friends.

RETINOPATHY:
Disease of the retina that results in impairment or loss of vision.

NEUROPATHY:
Disease or dysfunction of one or more peripheral nerves, typically causing numbness or weakness.

NEPHROPATHY:
Disease or damage of the kidney.

ADVANCED PERIPHERAL NEUROPATHY:
A result of damage to peripheral nerves that often causes weakness, numbness, and pain.

PROLIFERATIVE RETINOPATHY:
An overgrowth of blood vessels around the retina.

COMORBIDITIES:
The simultaneous presence of two chronic diseases or conditions in a person.

EXERCISE STRESS TEST:
An assessment that usually involves walking on a treadmill or riding a stationary bike while heart rhythm, blood pressure, and breathing are monitored.

KETOACIDOSIS:
An increase in blood acidity caused by excess ketones in the bloodstream

KETONES:
By-products of the breakdown of fatty acids.

SPECIAL CONSIDERATIONS

Any client with prediabetes, type 1 diabetes, or type 2 diabetes, with or without diagnosed **comorbidities**, should be required to undergo specialized screening by their physician before getting started with a physical fitness program.

In addition, an **exercise stress test** is recommended for all persons with type 2 diabetes who have been diagnosed with one or more comorbidities, such as cardiovascular disease, eye problems, nerve problems, and kidney problems. This includes clients who have greater-than-normal waist circumference, increased triglycerides, hypertension, advanced age (age 60 or over), a history of smoking, and a family history of cardiovascular disease.

Monitoring blood glucose before and after exercise is necessary to prevent hypoglycemia, hyperglycemia, and **ketoacidosis** which is an overproduction of **ketones**. This must be a collaborative effort between the fitness professional and client.

Tracking this data helps the trainer and client become familiar with how the client's blood glucose responds to exercise. The trainer can then use this data to demonstrate the benefits of physical activity to the client and track how the client's body reacts to different activities.

In addition to monitoring clients' blood glucose, foot care is important for clients with diabetes as well. Peripheral neuropathy, a complication of diabetes, can reduce pain sensations in the feet and mask injuries or issues. Clients should wear cotton socks and well-fitted athletic shoes appropriate for the activity. After each exercise session, the client should check their feet for sores, blisters, irritation, cuts, or other injuries.

Clients should also stay well hydrated during exercise and follow general nutritional guidance to help with fat loss and heart health. Diabetes self-care requires much of the individual and can become mentally and emotionally draining. Willpower is not enough for clients to succeed. The personal trainer must be a source of inspiration, motivation, and education and be encouraging, helping clients view setbacks as opportunities for growth and helping them develop habits around self-care that are simple, enjoyable, and rewarding.

EXERCISE AND ARTHRITIS

Arthritis, inflammation of the joints, comes in several forms and impacts the lives of over 50 million Americans. That number is expected to rise to almost 80 million people by 2040. The following list includes a description of each form, signs and symptoms, and causes and risk factors, and general guidelines are presented for creating safe fitness programs for this demographic.

Table 16.3 Arthritis Conditions

CONDITION	DESCRIPTION
Osteoarthritis	A degenerative joint disease caused by wear and tear of the joints. The hands, hips, and knees are most typically affected by osteoarthritis, causing loss of strength, reduced flexibility, reduced proprioception, and joint pain. Over 30 million US adults have this condition, 68 percent of whom are over 65 years old.
Rheumatoid arthritis (RA)	An autoimmune and inflammatory disease that most commonly affects the hands, wrists, and elbows. About 1 percent of Americans have this condition; two-thirds are women.
Fibromyalgia (FM)	A condition that causes pain all over the body, sleep problems, fatigue, and emotional and mental distress. Clients with this condition have **abnormal pain perception processing**, a side effect of the condition, which causes them to be much more sensitive to pain.
Gout	An inflammatory arthritis that affects one joint of the body at a time—typically the big toe. This condition comes and goes unpredictably. When the disease is active, it is called a **flare**, and when it is dormant, it is called a **remission**.

Osteoarthritis

In this condition, the cartilage within a joint breaks down, causing friction between bones and worsening over time. Friction within the joint causes pain or aching, stiffness, reduced range of motion, and swelling. In some cases, osteoarthritis reduces function and causes disability.

> **TEST TIP!**
>
> The prefix "osteo" refers to bone. This helps to make it clear that osteoarthritis is a breakdown and inflammation of the bone within a joint.

Rheumatoid Arthritis

With RA, the lining of the joint becomes inflamed, causing damage to joint tissue. This can cause long-lasting pain, poor balance, and deformities in the joints. As this condition is an autoimmune response, pain and aching, stiffness, tenderness, and swelling occur in more than one joint and on both sides of the body, whereas osteoarthritis may only present in one joint, unilaterally. Clients with RA may lose weight, suffer from fevers, fatigue, and weakness.

Fibromyalgia

Clients diagnosed with FM will experience the disease differently. Pain and stiffness all over the body, fatigue, depression and anxiety, sleep problems, headaches (migraines), and problems with thinking, memory, and concentration are common. Some clients may

OSTEOARTHRITIS: Degeneration of joint cartilage and the underlying bone.

RHEUMATOID ARTHRITIS (RA): A chronic progressive disease causing inflammation in the joints.

FIBROMYALGIA (FM): A chronic disorder characterized by widespread musculoskeletal pain, fatigue, and tenderness in localized areas.

ABNORMAL PAIN PERCEPTION PROCESSING: An increase in the subjective interpretation of discomfort due to abnormal sensory processing in the central nervous system.

GOUT: A disease in which defective metabolism of uric acid causes arthritis.

FLARE: A sudden surge in rheumatoid arthritis inflammation.

REMISSION: A significant reduction in symptoms and signs of rheumatoid arthritis.

experience numbness or tingling in the hands and feet and pain in the face or jaw, as well as digestive problems such as pain, bloating, constipation, or irritable bowel syndrome.

Additional complications include more hospitalizations, reduced quality of life, and high rates of depression and death from suicide and injuries. The exact causes of fibromyalgia are not known, but theories include genetics, infections, physical or emotional trauma, and stress.

Gout

HYPERURICEMIA: An abnormally high level of uric acid in the blood.

Though gout usually only occurs in one joint at a time—the big toe, lesser toe joints, ankle, or knee—it is intensely painful and accompanied by swelling, redness, and heat. This occurs due to **hyperuricemia**, or too much uric acid in the body. Uric acid crystals build up in the joints, fluids, and tissues.

All joints are required for movement, which is why arthritis pain and stiffness can be perceived as a barrier to physical activity. Many clients with arthritis will avoid leisure activities they once enjoyed and may miss work due to pain or immobility. The resultant inactivity causes muscle atrophy and weakness, leading to further reductions in activity and muscle wasting.

Although science does not support the notion, many people (some physicians included) still believe that intensive weight-bearing exercise causes undue stress on the joints, increasing disease activity and causing further joint damage. Still, others believe that physical activity, such as playing elite sports, causes arthritis and should be avoided. However, studies observing the joints of arthritis sufferers found similar degeneration in the joints of former athletes and the general population.

The key to success for clients with arthritis is a well-designed fitness program that addresses the specific needs and goals of the client. Though it will take between six and eight weeks for joints to get used to a new level of activity, the long-term benefits of exercise can help clients.

RISK FACTORS

Prior to describing exercise program design, it is important to understand the many risk factors associated with arthritis. Some risk factors, such as obesity and overuse, can play a critical role in day-to-day exercise prescription.

Age

The chance of developing rheumatoid arthritis and osteoarthritis increases with age. The highest onset for rheumatoid arthritis is around age 60 while most cases of fibromyalgia are diagnosed by middle adulthood. Aging causes bones to become less dense or more fragile. This changes the composition of bone and cartilage.

Sex

Women are more prone to rheumatoid arthritis and osteoarthritis. About two to three times more women than men have RA while osteoarthritis is more common in women after age 50. Two times more women than men have fibromyalgia. And more males than females are diagnosed with gout.

Obesity

Obesity is a major risk factor for all forms of arthritis. This includes rheumatoid arthritis, osteoarthritis, fibromyalgia, and gout. Being overweight places a greater load on the joints and increases stress. This leads to breakdown of cartilage at a faster rate, especially at the knees.

Genetics

Genetics is a risk factor for rheumatoid arthritis and osteoarthritis. One of the most significant risk factors for rheumatoid arthritis is human variation in genes called **human leukocyte antigen (HLA)**. These genes or proteins regulate the immune system. When they don't function, the body becomes more at risk for rheumatoid arthritis.

HUMAN LEUKOCYTE ANTIGEN (HLA): Genes that help the immune system distinguish the body's own proteins from foreign antigens.

Overuse

Osteoarthritis involves the breakdown of cartilage in the joint. This is caused by wear and tear on the joint over time. Overuse is also a risk factor for fibromyalgia. Pain and stiffness throughout the body can be exacerbated by overuse.

Smoking

Individuals with certain genes who are exposed to cigarette smoke are more likely to develop RA. Children exposed to smoke are two times more likely to develop RA as an adult than children who are not. Smoking can worsen symptoms of arthritis.

Health History

Women who have never given birth are at a greater risk of developing RA, and a protective effect has been found when women breastfeed. Comorbidities such as **lupus** or RA put clients at a higher risk for having fibromyalgia. Family history and **post-traumatic stress disorder (PTSD)** are also risk factors for fibromyalgia. For gout, certain health conditions such as congestive heart failure, hypertension, and diabetes put clients at a higher risk.

LUPUS: A chronic autoimmune disease that creates inflammation and pain in various parts of the body.

POST-TRAUMATIC STRESS DISORDER (PTSD): A persistent mental and emotional stress that occurs as a result of injury or psychological shock.

Nutrition

Poor nutrition is a risk factor for many health conditions. When it comes to arthritis, gout is the most affected by diet. Drinking alcohol and eating or drinking food or beverages high in

PURINES:
A number of biologically important compounds, such as adenosine, caffeine, and uric acid.

fructose increase the risk of gout. A diet high in **purines**—red meat, organ meat, anchovies, sardines, mussels, scallops, trout, and tuna—can make gout even worse.

PROGRAM DESIGN

Clients can rest assured that exercise is safe and will be effective at helping to manage symptoms, reduce arthritis pain, and reduce or prevent complications of comorbidities. The literature supporting physical activity in the treatment of arthritis far surpasses previous findings that were contradictory. But as previously mentioned, it is best to start low and go slow.

To begin, a fitness trainer should conduct a thorough assessment. In addition to gathering objective data via the PAR-Q and questionnaires, subjective data can be collected by doing physical assessments. The focus should be on functional muscle strength and posture. Arthritis exercise programs must focus on range of motion, isometric strength (tension with no movement), isotonic strength (tension with movement), and functional strength (tension doing specific activities) just like anyone else. Greater emphasis on a complete warm-up along with extra caution used when progressing exercises will be necessary.

Clients should perform a warm-up and slowly move joints through their full range of motion. Then they can begin isometric exercises, performed every other day. Isometric movements place the least amount of stress on joints.

After one to two weeks, depending on the client, isotonic exercises can be implemented. Isometric exercises can be gradually replaced to continue strengthening muscles. Once the client has a foundation of strength built, functional exercises can be incorporated. Appropriate activities include but are not limited to swimming, walking, table tennis, and dancing. Clients should avoid running and contact sports to reduce the risk of injury or aggravating the disease.

Aerobic Exercise

Clients can start with as little as 5 or 10 minutes of physical activity, two or three times per day, until they can reach the following recommendations:

- 150 minutes of moderate-intensity aerobic activity, or
- 75 minutes of vigorous-intensity activity, or
- A combination of moderate- and vigorous-intensity exercise (one minute of vigorous activity is similar to two minutes of moderate-intensity activity).
- Including low-impact exercises such as brisk walking, cycling, swimming, water aerobics, light gardening, group exercise classes, or aerobic dance classes.

Clients should incorporate flexibility training daily. Applying moist heat for 10 to 15 minutes even before stretching helps warm the connective tissue to avoid injury. In addition, the fitness trainer should advise clients to work on balance at least three days per week for 10 to 15 minutes per session. Exercises may include walking backward, standing on one foot, or tai chi. These can be included before or after an aerobic exercise session.

Strength Training

Personal trainers can help clients slowly meet the following recommendations for strength training. Suggesting that clients take pain medication before a workout should be avoided. Instead, trainers can work with clients to find the right time of day to exercise—when pain and discomfort are minimal, and joints are flexible.

Clients should aim for two to three days per week of resistance training. Some research has found that training two times per week produces about 80–90 percent of the strength gains achieved by training more frequently. But with the many fears clients face regarding exercise, starting out with just a couple of days per week will enhance program adherence, making it more difficult for clients to cite time constraints as an excuse. Clients should allow for 48 hours of rest between sessions.

It is reasonable to expect clients to achieve intensity levels around 80 percent of their one-repetition max (1RM) if they are allowed to slowly progress. Fitness programs can begin with single-set workouts of 6 to 10 exercises to move each of the major muscle groups. Even though single sets may not produce the same adaptations as multisets, clients will benefit from a more consistent, less time-consuming fitness regimen. Dropout rates go up dramatically when clients are required to exercise for more than 60 minutes, so clients should stick with whole-body fitness sessions. The added benefit is that whole-body workouts often result in greater overall strength and muscle hypertrophy, as well as improvements in aerobic capacity and endurance performance, than traditional split routines.

Suggested Exercise Progression for Those with Arthritis*

Week 1: one set of 15 repetitions at 60 percent 1RM

Week 2: two sets of 15 repetitions at 60 percent 1RM

Week 3: three sets of 15 repetitions at the same intensity

Weeks 4–6: three sets of 12 repetitions, increasing to 70 percent 1RM

Weeks 7–24: three sets of 8 repetitions, progressing to 80 percent 1RM

**Progression used in one scientific study on rheumatoid arthritis with positive results*

One- to two-minute rest periods between sets appears to be optimal to suit the needs of this demographic. In addition, using a 4:0:2:0 tempo (four-count eccentric to two-count concentric) has produced the most favorable results. Finally, it is important to teach clients how to breathe through movements to avoid the Valsalva maneuver and the resultant rise in blood pressure.

SPECIAL CONSIDERATIONS

Many of the recommendations made for general health are the same for persons with arthritis and include self-management skills, physical activity, engaging in group fitness programs, scheduling regular visits to the doctor, and maintaining a healthy body composition.

However, when arthritis is coupled with other health conditions, clients may find it difficult to meet specified guidelines. Certain comorbidities, such as heart disease, diabetes, and obesity, respond positively to increases in physical activity and improvements in diet, but in addition to citing lack of time, competing responsibilities, lack of motivation, and difficulty finding enjoyable activities, clients with arthritis cite other disease-specific barriers to fitness.

Clients can have a fear of making arthritis pain worse or causing additional joint damage. A fitness professional is responsible for helping eliminate uncertainty about how much and which type of exercises are safe for joints.

The CDC suggests the following SMART plan of action for clients with arthritis:

S: starting low and going slow

M: modifying activity when symptoms increase but trying to stay active

A: activities should be “joint-friendly”

R: recognizing safe places and ways to be active

T: talking to a health professional or certified exercise specialist

A fitness professional can help clients follow these guidelines and add the accountability, encouragement, and education they need to stick with it. When coaching clients, they should be educated on the benefits of exercise for their condition and taught proper exercise techniques, including form, breathing, and tempo. It is important to help clients find activities they enjoy and that are accessible.

Clients should integrate fitness into their lifestyle, rather than being forced to rearrange their life around fitness. A fitness professional should teach activities that clients can do safely with little equipment or fear of injury. And it is important to set expectations. For example, mild aches and pains are expected after a good workout session; joint swelling or stiffness means modifications should be made.

EXERCISE AND CORONARY HEART DISEASE

According to the CDC, every 40 seconds someone in the United States has a heart attack, which is roughly 790,000 Americans per year. Of those, just over 25 percent are individuals who have already had a heart attack. Perhaps the most devastating statistic, though, is that 20 percent of those heart attacks are silent—the heart attack occurs, the individual doesn't know it happened, and the damage to the heart is done.

Heart disease is the leading cause of death in the US for both men and women, and the leading cause of heart attacks is **coronary artery disease (CAD)**. Sometimes a severe spasm, while other times a sudden contraction of the coronary artery, stops the blood flow to the heart, causing a heart attack.

CORONARY ARTERY DISEASE (CAD):
The narrowing or blockage of coronary arteries.

However, clients with coronary heart disease (CHD) who participate in regular exercise increase their life expectancy, decrease the risk of future coronary heart disease-related events, reduce symptoms of CHD, and lessen the physical response to exercise exertion. Positive health behaviors, such as exercise, help clients manage their health and take an active role in their recovery from a heart attack.

HEART DISEASE

Coronary artery disease is the most common type of heart disease in the US and is a result of a buildup of plaque (cholesterol) in the wall of the arteries. This gradual process is called atherosclerosis. Over time the arteries narrow and become less elastic, making it more difficult for the heart to pump blood to the body and for the blood to return to the heart. Atherosclerosis is a silent condition. Eventually, the heart doesn't get enough blood, and the individual experiences chest pain or discomfort.

Table 16.4 Other Heart-Related Conditions

CONDITION	DESCRIPTION
Arrhythmia	This is an irregular or unusually fast or slow heartbeat. Two types of arrhythmia include ventricular fibrillation, which may lead to death if not treated right away with an electrical shock, called defibrillation, and atrial fibrillation, which may cause a stroke.
Cardiomyopathy	The heart becomes enlarged or stiff. This makes it harder for the heart to pump blood to the rest of the body.
Heart failure	Also called congestive heart failure, this is when the heart is too weak to pump blood to meet the body's needs. Fluids build up in the lungs, liver, gastrointestinal tract, arms, and legs.
Peripheral arterial disease	The blood vessels in the arms and legs become narrowed or stiff—usually the cause of atherosclerosis—and blood flow is low or fully blocked.

ANGINA:
A condition marked by severe chest pain.

Angina is the most common symptom of CAD and progressively weakens the heart muscle, leading to an arrhythmia or even heart failure. In many cases, a heart attack is the first symptom an individual with heart disease experiences.

RISK FACTORS

Almost half of all Americans have at least one key risk factor for developing heart disease. These include hypertension, high cholesterol, and smoking. Other conditions and behaviors that contribute to increased risk are being overweight, obesity, diabetes, poor diet, inactivity, and excessive alcohol consumption.

Obesity

Having excess body fat contributes to bad cholesterol and lowers good cholesterol. It leads to HBP and diabetes, which are risk factors of their own. Consuming a diet high in saturated fats, trans fat, and cholesterol is linked to heart disease.

Physical Inactivity

Being inactive leads to unhealthy weight gain and fat buildup in the arteries. This causes damage to the blood vessels and leads to cardiovascular disease. It is important for clients to achieve at least 30–60 minutes of aerobic exercise three to four times per week.

High Blood Pressure

HBP puts extra stress on coronary arteries. Hypertension becomes a major risk factor for heart disease when a buildup of plaque becomes present. This plaque is a buildup of fat, cholesterol, and other substances in the blood and leads to atherosclerosis.

Smoking

Cigarette smoking also increases the amount of plaque buildup in blood vessels. The narrower the arteries become, the more blood clots present. This leads to HBP and is a major risk factor for heart disease.

Diabetes

High blood sugar damages the nerves that control the heart. Those with diabetes are more likely to have HBP and other health conditions that contribute to the risk for heart disease. A buildup of sugar in the blood can damage blood vessels and increase the force of blood through the arteries.

PROGRAM DESIGN

If a client has heart disease, it is likely they have had a CAD-related event and participated in a cardiac rehabilitation (CR) program. The CR program has four phases: acute phase, subacute phase, intensive outpatient therapy, and independent ongoing conditioning. This program may last 12 weeks or more and is beneficial in the recovery process. However, less than half of all patients eligible for outpatient programs enroll after discharge from acute care.

Clients who have had a cardiac event but have not completed their CR should be advised to do so before exercising on their own or with a personal trainer. If a client has completed the first three phases of a CR program and is now in phase four—independent ongoing conditioning—the personal trainer can proceed as usual by collecting the physician's approval letter and initial intake paperwork and conducting fitness assessments.

Aerobic exercise intensity should gradually increase until the client can participate in the following recommendations:

- 150 minutes of moderate-intensity aerobic activity per week, or
- 75 minutes of vigorous-intensity aerobic activity per week, or
- any combination of the two.

Low exercise capacity contributed more to early death from a heart attack than other major risk factors. Clients with low exercise capacity—those who are afraid to begin an exercise program because they are weak or deconditioned—benefit most from exercise programs. These clients can see improvements in exercise capacity from 16 to 46 percent after moderate-intensity and vigorous-intensity exercise programs, respectively. Improved exercise capacity protects against the incidence of heart attack and improves chances of survival after a first episode. Clients should be closely monitored during exercise sessions for signs and symptoms of a heart attack.

SPECIAL CONSIDERATIONS

In a 2005 survey, only one in four respondents were aware of all the major symptoms of a heart attack. When working with clients with a history of heart disease, it is essential the personal trainer know the signs and symptoms of a heart attack and how to respond. All ISSA certified trainers are required to maintain a current CPR with AED and first aid certification.

The signs and symptoms of a heart attack include the following:

- Chest pain or discomfort
- Upper-body pain, such as in the arms, back, neck, jaw, or upper stomach
- Shortness of breath
- Nausea, lightheadedness, or cold sweats

If some, or all, of these symptoms are present, the fitness professional should immediately call 911.

The Henry Ford Exercise Testing Project tested the exercise capacity of nearly 30,000 men and women around the age of 53 and then followed up with participants 11 years later. What they found was not that the major risk factors—hypertension, hyperlipidemia, obesity, diabetes, and smoking—were associated with the deaths of participants (almost 7 percent had died during the study). Rather, low exercise capacity contributed more to the risk of death after the first heart attack.

Educating clients on the importance of exercise and diet is part of the personal trainer's job, but the trainer should help clients develop the skills necessary to maintain or improve their health. Clients who feel in control of their health outcomes are more likely to adhere to healthy lifestyle habits, such as exercise and eating a heart-healthy diet, than clients who do not feel in control.

Those who do not participate in exercise say they feel too tired, lack motivation, don't like the soreness or discomfort associated with exercise, feel that exercise is boring, say they have no time, or are afraid they are too weak or deconditioned to start a fitness program. For these clients, simply providing instruction is not enough. Coaching should increase the client's readiness for change, build self-efficacy, enhance self-motivation, and gradually build adherence to long-term healthy habits.

EXERCISE AND ASTHMA

Asthma is a chronic respiratory disease that afflicts roughly 300 million people worldwide. Scientists expect another 100 million cases by 2025. Asthma is characterized by airway inflammation, airway **hyperresponsiveness**, and reversible airway obstruction. Unfortunately, in most cases, doctors don't know the causes of asthma; however, having a family history of the disease increases the likelihood someone will have it.

ASTHMA: A respiratory condition marked by spasms in the bronchi of the lungs, causing difficulty in breathing.

HYPERRESPONSIVENESS: The acute, early phase of an asthma attack.

What most people associate with this condition is asthma attacks. Asthma attacks are triggered by irritants that cause the airway to constrict. **Triggers** are different for each person, but some common triggers include the following:

TRIGGERS: Any chemical, irritant, or allergen that causes an inflammatory response of the airways.

- Tobacco smoke
- Dust mites
- Outdoor air pollution
- Cockroach allergen
- Pets
- Mold
- Smoke from burning wood or grass
- Infections such as flu

Other less common triggers may include physical exercise, some medicines, cold and dry air, some foods, food additives, and fragrances. Even strong emotions such as stress, anxiety, or fear may lead to **hyperventilation** and an asthma attack.

HYPERVENTILATION: To breathe at an abnormally rapid rate, increasing the rate of loss of carbon dioxide.

Asthma can be controlled by medicine. Some medicines are inhaled while others are taken in pill form. Quick-relief medications control the symptoms of asthma attacks, and long-term-control medications help to reduce the number and severity of attacks but are not helpful during an asthma attack.

Another method of controlling asthma is exercise. Sedentary lifestyles and deconditioning play key roles in the development of symptoms in obese clients with asthma. However, exercise has been proven to improve airway hyperactivity, psychosocial factors, and health-related quality of life. Exercise also reduces airway inflammation.

RISK FACTORS

Once someone is diagnosed with asthma, they have it forever, and asthma attacks may happen at any time. The airways resemble a tree with many branches, with the airways getting smaller the further out they branch. When an asthma attack occurs, the sides of the airways swell and shrink. Less air gets in and out of the lungs, and mucous created by the body clogs the airways further. There are many risk factors that increase the signs and symptoms of an asthma attack. Signs and symptoms include **wheezing**, shortness of breath, tightness in the chest, and coughing. Some attacks may resolve on their own, while others will require the help of medication.

WHEEZING: Breathing with a whistling or rattling sound in the chest.

Sex

Asthma occurs in children and more often in boys than girls. Young males often have smaller airways than young females. As children grow older and reach age 20, the numbers for males and females who have asthma become closer. At age 40, more females have adult asthma than males.

Family History

Genetics increases the risk of asthma. According to the CDC, if a person has a parent with asthma, they are three to six times more likely to develop asthma than someone who does not have a parent with asthma.

Allergies

Indoor allergies and outdoor allergies are risk factors. Dust mites, mold, and pollen can trigger acute asthma. Triggers are different for each person, but environmental factors are known to trigger signs and symptoms of asthma.

Smoking

Any exposure to cigarette smoke in the prenatal and postnatal stages increases the risk of a child getting asthma. Smoking creates inflammatory responses in the lungs and airways. This puts excessive stress on lung function and obstructs airflow.

Obesity

Obesity is a risk factor for asthma because it increases leptin (a hormone that inhibits hunger) in the body. This produces a pro-inflammatory response in the lungs. Excess weight around the chest can constrict the lungs and make it difficult to breathe. Fat tissue leads to asthma in clients.

ASTHMA CONDITIONS

Overweight and obese clients are 38 and 92 percent more likely to develop asthma, respectively, than clients with a healthy BMI. Obesity also makes disease management much more difficult. Clients with asthma who are also obese report worse clinical control of their symptoms, poorer quality of life, reduced lung function, reduced response to **corticosteroids**, and more psychosocial (behaviors influenced by social factors) symptoms. However, weight loss improves asthma symptoms, improves management and control over the disease, and reduces the need for medication.

Table 16.5 Asthma Conditions

Condition	Description
Exercise-induced bronchoconstriction (EIB)	Exercise-induced asthma, also called **exercise-induced bronchoconstriction (EIB)**, is diagnosed as a 10 percent or more reduction in FEV1 (forced expiratory volume) after exercise. This may sometimes be the only sign that a client has asthma.
Gastroesophageal reflux disease (GERD)	Clients with **gastroesophageal reflux disease (GERD)** are more likely to develop asthma than healthy clients, and between 50 and 80 percent of clients with asthma report symptoms of GERD. The trainer and client must also be aware that medications may increase GERD-related symptoms.
Chronic obstructive pulmonary disease (COPD)	**Chronic obstructive pulmonary disease (COPD)** may coexist with asthma, especially in clients who have asthma and smoke. However, the symptoms of COPD and asthma are similar and hard to distinguish and should be properly diagnosed by a medical professional.

CORTICOSTEROIDS: A group of natural and synthetic steroid hormones produced by the pituitary gland.

EXERCISE-INDUCED BRONCHOCONSTRICTION (EIB): Asthma attack triggered by doing sports or physical activity.

GASTROESOPHAGEAL REFLUX DISEASE (GERD): A condition in which acidic gastric fluid flows backward into the esophagus, resulting in heartburn.

CHRONIC OBSTRUCTIVE PULMONARY DISEASE (COPD): A lung disease characterized by chronic obstruction of lung airflow that interferes with normal breathing and is not fully reversible.

Other side effects related to asthma include muscle dysfunction and reduced functional capacity. Clients with asthma are more likely to be inactive because of disease symptoms. Disuse leads to deconditioning and further disuse. Because asthma influences the amount of oxygen taken into the body, fatigue is a common side effect, especially in the lower extremities. Clients may not feel like they are having an asthma attack but may feel like they need to stop exercising because their legs are tired.

PROGRAM DESIGN

When designing a training program for the client, the training environment should be free from allergens and pollutants that could trigger the client's asthma. Checking outdoor air quality before a training session should dictate whether a client will train outside on the track or inside on the treadmill. In cold, outdoor environments, clients should wear a mask or scarf. Choosing sports with intermittent bouts of activity, such as tennis, volleyball, softball, or baseball is ideal. Clients should stay properly hydrated and allow for both a warm-up and a cooldown.

When it comes to resistance training, assessments can be used to determine appropriate training loads. The personal trainer can assess the client's target heart rate before beginning aerobic training, beginning at 50–60 percent of VO_2 max and increasing slowly, about 5 percent every two weeks. Clients with asthma should not exercise in excess of 80 percent VO_2 max.

Using a heart rate monitor is ideal, but clients may also use the Borg RPE scale to share perceived level of exertion. Sixty percent of VO_2 max is about equal to 12 or 14 on the Borg scale. Throughout the exercise session, the personal trainer can ask clients to rate leg discomfort and difficulty breathing.

Clients with asthma benefit from exercise and should be encouraged to be more active. The program and disease management will get easier with time, but realistic expectations should be set, and appropriately trained staff should be available in case of respiratory emergencies.

ACTION PLAN:
A set of individualized written instructions, designed with a doctor, that details how a person with asthma should manage their asthma at home.

SPECIAL CONSIDERATIONS

In some situations when working with clients with chronic conditions, including clients with asthma, it is necessary to collect the **action plan** they created with their physician. The fitness trainer and relevant personnel should have copies of this document and know where to find the client's medications and how to use them. Information found on the action plan includes the client's symptoms, broken down into green, yellow, and red categories. There should also be a list of medicines, along with how much the client should take and when to take them. Emergency contact numbers should also be listed.

Athletes

Athletes seem to have a higher prevalence of asthma than the general population. Sometimes, however, athletes will have respiratory symptoms similar to asthma without actually having asthma. It is important, then, that clients who report having asthma provide a letter from their physician with their diagnosis and action plan.

Symptoms vary during different periods of life. Athletes may not have had asthma in childhood and may not have any symptoms following their sport career. Children with asthma may not experience symptoms during adolescence, but symptoms may return later in life. If a client has been diagnosed with asthma but hasn't had symptoms in a while, they still have asthma and must have an action plan and medications available during exercise sessions.

Medications

Certain asthma medications can alter muscle fiber size and type. High doses of **glucocorticoids** cause muscle atrophy and loss of strength, a side effect called **steroid myopathy**. This impacts the muscle contractile system and may lead to reduced motor function and ventilatory performance.

Psychosocial

Anxiety, depression, and panic disorders are more frequent in clients with asthma than the general population. It is important to note that a client who has been diagnosed with both asthma and depression may not adhere to exercise programs or asthma treatment programs in follow-up visits with health care providers to ensure the successful management of the disease.

GLUCOCORTICOIDS:
A group of corticosteroids involved in the metabolism of carbohydrates, proteins, and fats.

STEROID MYOPATHY:
Weakness primarily to proximal muscles of the upper and lower extremities and neck caused by treatment with corticosteroids.

CHAPTER 17

LIFESPAN POPULATIONS

LEARNING OBJECTIVES

1 | Explain effective exercise methods for youth based on their age and development stage.

2 | Name common fitness-related health considerations for older adults.

3 | Describe effective elements of fitness for senior populations.

4 | Discuss exercise and fitness options for women during pregnancy.

5 | Define adaptive fitness and the ways a fitness professional can make fitness more accessible.

Designing individualized training programs for every client is key to a personal trainer's long-term success. However, the needs of a client vary by individual, and those needs also change throughout the different stages of life. Therefore, it is essential for a fitness professional to understand the mental and physical differences of the various stages of life to effectively program and coach clients.

EXERCISE AND YOUTH

Children are naturally active in most cases, but they can still benefit from regular exercise. Active children can handle the physical and emotional challenges of childhood, may experience fewer physical injuries as their bodies grow, and may sleep better, which supports healthy development. Unfortunately, not all children are as active as they should be to experience the benefits and build lifelong healthy habits as they grow. In fact, research has found a number of alarming conclusions concerning exercise and youth:

OBESITY:
An abnormal or excessive accumulation of bodyfat that may cause additional health risks.

SCREEN TIME:
The time spent using a device such as a computer, television, smartphone, or games console.

- Worldwide, childhood **obesity** rates have tripled since the 1970s.
- 17 percent of children (ages 6–11) are classified as obese (United States).
- Over 21 percent of adolescents (ages 12–19) are obese (United States).
- Only 5 percent of American adolescents are meeting recommendations for sleep, exercise, and **screen time**.
- Only 3 in 10 children and 1 in 10 adolescents meet daily recommendations for physical activity and screen time.
- 30 percent of children and 50 percent of adolescents do not meet the recommendations for either physical activity or screen time.

In many cases, an inactive (sedentary) lifestyle and technology advances that make it easier for children to remain inactive have been named as primary causes of the declining health status of youth. Poor eating habits are another major contributor to the rise in childhood obesity. There are many consequences to inactivity and obesity, but these consequences can be minimized with the introduction of physical activity. A child with excess bodyfat can experience health complications, including:

- hypertension,
- high cholesterol,
- type 2 diabetes,
- coronary heart disease,
- stroke,
- osteoarthritis,
- cancer,
- sleep apnea and breathing problems, and
- depression, anxiety, and other mental disorders.

According to data from the Centers for Disease Control and Prevention (CDC) in the United States, any elementary school classroom likely has at least one child with hypertension and another three children with elevated blood pressure. Similarly, type 2 diabetes was once considered a condition that developed in adulthood but is now seen more frequently in young children with a 21 percent increase in youth diagnoses between 2001 and 2009.

Childhood obesity and poor health related to physical inactivity can also decrease quality of life, impact brain structure and function, and negatively impact motor function and coordination. In healthy kids, play and socialization opportunities help children develop **motor skills**—the ability to learn and manage the process of moving their bodies in a coordinated way. When a child is unable to develop the correct motor skills and meet developmental milestones at a young age, they may experience physical setbacks as they mature.

In addition to the physical challenges, being overweight or obese often leads to mental stumbling blocks. Children who are obese may become victims of **social stigmatization**, discrimination, and **bullying**. These detrimental interactions can increase the likelihood of anxiety, depression, **dysfunctional eating patterns**, and low self-esteem for young people.

BENEFITS OF EXERCISE

Science has identified many positive effects of exercise in youth. We know that children and adolescents need at least one hour of physical activity each day, including two to three days per week of high-intensity aerobic activity, resistance training, or bone-strengthening exercises. Research has also found that

- children who participate in physical fitness programs have higher self-concepts than those who are inactive;
- children who participate in aerobic exercise programs have the potential to increase their self-efficacy, creativity, self-esteem, internal locus of control (belief that the individual is responsible for their own success), test scores for **cognitive functioning**, and classroom behavior;
- adolescents who follow a muscular strength program benefit from a 20–35 percent reduced risk of premature mortality;
- physically stronger adolescents were 15–65 percent less likely to have psychiatric (mental health) problems; and
- adolescents who participate in resistance training can reduce their risk of suicide by 20–30 percent.

MOTOR SKILLS:
The ability to learn and manage the process of moving the body in a coordinated way.

SOCIAL STIGMATIZATION:
The disapproval of, or discrimination against, a person based on perceivable social characteristics.

BULLYING:
An unwanted, aggressive behavior among school-aged children that involves a real or perceived power imbalance.

DYSFUNCTIONAL EATING PATTERNS:
May include behavior commonly associated with eating disorders, such as food restriction, binge eating, and purging.

COGNITIVE FUNCTIONING:
An intellectual process by which one becomes aware of, perceives, or comprehends ideas.

The benefits of strength training in youth populations include:

- increasing muscle endurance and strength,
- improving bone density,
- reducing risk of physical injury,
- improving self-esteem, and
- improving athletic performance.

Strength has been shown to improve with both high- and low-load resistance training, although muscular size gains are not significant during childhood. Much of these improvements may be due to neuromuscular improvements as muscles are recruited more efficiently and more muscle fibers are engaged in movement patterns. For this reason, load should only be increased once proper exercise form and technique have been learned and demonstrated.

Children between the ages of 6 and 10 years of age can support strength development by incorporating resistance training into games (play) and simple exercises or movement patterns. However, children can begin low-volume, low-intensity strength training with an emphasis on foundational exercises and proper form as young as 7 or 8 years old. When children reach the ages of 11 to 14, they can begin to implement circuit training and strength exercises using light free weights with low to medium volume and low intensity. By the ages of 15 to 18, adolescents can begin specialized training for specific sports and athletic endeavors. By this age, training volume and intensity can be increased, and more equipment variety can be introduced.

There are also benefits of cardiorespiratory training for youth, including:

- improving heart and lung capacity and function,
- reducing excess bodyfat,
- reducing the risk of depression,
- reducing the risk of general diseases (heart disease, cancer, type 2 diabetes, etc.), and
- promoting healthy blood pressure.

Endurance cardiorespiratory training for young children should have an emphasis on fun and games such as relays and races to keep children engaged. Once children reach **puberty**, their hormones begin to change, as do their bodies and physical capabilities. At this life stage, children can experience greater improvements in endurance training and can begin to specialize their training to promote skill development specifically. For example, research suggests that athletes progressing through puberty can physiologically endure longer-duration activities and drills such as sprinting and interval training.

PUBERTY:
The period of hormonal change in an adolescent where they reach sexual maturity.

Plyometrics aims to increase muscular power and is often the focus of youth training. When proper form and technique are coached, plyometrics can have many benefits for kids, such as:

- improving speed and agility,
- improving explosive power,
- improving sport-specific skills, and
- reducing sports-related injuries.

Flexibility training is an aspect of fitness that is important for growing children as their bones and muscles often grow at different rates. It also improves muscle pliability and can help improve neuromuscular control and coordination in kids. The benefits of flexibility training in youth include:

- improved joint health and mobility,
- improved range of motion, and
- reduced risk for injuries.

Injury Prevention for Youth

When children are exercising, it is imperative to remember that proper form, proper use of the equipment, and proper supervision are essential. While many strength training–related injuries are due to misuse of equipment, there are many other considerations to protect youth clients during exercise.

A personal trainer should focus on the following considerations when working with youth clients:

- ensuring proper instruction and form at all times,
- using proper training progression,
- adjusting exercise intensity to meet the child's physical capabilities,
- always including a warm-up and cooldown,
- always supervising children during the entirety of a training session,
- using appropriate equipment and making sure the client knows how to use each piece correctly,
- requiring proper attire and shoes for training,
- ensuring adequate rest during exercise sessions and promoting rest on off days,
- using cross-training to prevent injury and keep children engaged, and
- encouraging optimal hydration and nutrition before, during, and after exercise.

Sleep is also an important aspect of a training program to promote physical recovery. However, for kids, sleep is also necessary for brain development, improving memory and learning, and optimal physical development.

TEST TIP!

General recommendations for sleep:

- Children aged 3 to 5 years need 10 to 13 hours of sleep
- School-aged kids between the ages of 6 and 12 require 9 to 12 hours of sleep
- Adolescents aged 13 to 18 years should get 8 to 10 hours of sleep each night

CHILDHOOD DEVELOPMENT

Creating effective youth exercise programs requires a strong understanding of the growth and development processes and milestones of a child and adolescent. These include physiological and psychological components that vary based on the age and physical maturity of the child.

SENSITIVE PERIOD:
A time or stage in a person's development when they are more responsive to external stimuli and quicker to learn particular skills.

PARALLEL PLAY:
A form of play in which children play adjacent to each other, but do not try to influence one another's behavior.

SCAFFOLDING:
A process in which teachers model or demonstrate how to solve a problem, and then step back, offering support as needed.

GROSS MOTOR SKILLS:
The abilities required in order to control the large muscles of the body for walking, running, sitting, crawling, and other activities.

Young Children: Under Six Years Old

Physiology: After the rapid growth and development from birth to age two, growth slows. This age is considered a **sensitive period** for motor skills development. At this point, young children are more responsive to what they see, hear, and touch and will learn skills and movement patterns easily.

Psychology: This age group enjoys **parallel play**, and children are still learning to share, work in a team, and follow detailed instructions. Children in this stage learn new skills via **scaffolding**, or modeling behavior.

Children under six should be exposed to indoor and outdoor opportunities to play and have interactive play with their caregivers. Play and activities should be mainly unstructured but emphasize improving their balance, walking, running, and kicking with a focus on reducing sedentary times in their day.

Coaching children in this age group can be challenging, but they do learn and benefit from physical activity. When they are young, it is best for trainers to teach **gross motor skills**—the control of large muscles of the body—and help improve hand-eye coordination, muscle coordination, and balance in an environment without many rules and restrictions.

Fitness professionals should incorporate **positive reinforcement** to help children develop a love and appreciation for physical activity. They are too young to try to master skills or a sport but can focus on the processes of learning a skill instead. Professionals should focus on controlling their environment and encourage them to play and practice however they like. Coaching needs to be encouraging, fun, and loving.

POSITIVE REINFORCEMENT: Including a favorable outcome, event, or reward after a child completes a desired behavior or action.

Activities for children under six years of age may include

- freeze tag,
- duck, duck, goose,
- treasure hunts,
- T-ball,
- follow the leader, and
- kicking a ball into a goal.

Children: 6–10 Years Old

Physiology: Children have continued slow, steady growth until the **adolescent growth spurt** when they see rapid physical changes in height and weight. This is an ideal stage for both gross and fine motor skills development, and exercise can become more detailed and challenging.

ADOLESCENT GROWTH SPURT: A rapid increase in the individual's height and weight during puberty.

Psychology: Children aged 6 to 10 years can successfully join and work in a group, manage conflict, take turns, find new friends, and manage relationships. They have very high self-esteem and are eager to learn new skills. Social comparisons, when youth compare themselves to others, also begin during this stage.

Also during this stage, children are improving in their hand-eye coordination as well as the coordination of muscles. They are also improving in their balance and can pick up activities such as riding their bike without training wheels or swimming, and are improving their skills for running, jumping, and climbing. Children at this age should begin participating in more intense exercise, such as running and strengthening exercises to benefit the cardiorespiratory and musculoskeletal system.

A personal trainer should emphasize **personal development** and process goals over outcome goals for kids of this age. This includes encouraging children to practice skills and movements regularly while still emphasizing fun. Coaching should be warm and encouraging, but with more specific and directive guidance. A fitness professional may also begin to set expectations for kids between 6 and 10 years of age.

PERSONAL DEVELOPMENT: Activities that improve awareness and identity, develop talents and potential, build human capital and facilitate employability, enhance the quality of life, and contribute to the realization of dreams and aspirations.

WEIGHT-BEARING EXERCISE:
Activities that move one's own body weight against gravity.

Activities for children 6 to 10 years of age should include cardiorespiratory, flexibility, and strengthening exercises. At this age, strengthening exercise does not have to mean weightlifting. Instead, kids can focus on **weight-bearing exercise** that uses body weight only, such as:

- running and jogging,
- dancing,
- push-ups and pull-ups,
- sports activities,
- gymnastics,
- stretching, and
- climbing and wrestling.

Adolescents: 11–19 Years Old

Physiology: Adolescents will experience a growth spurt between the ages of 10 and 13 for girls, and 12 to 15 for boys. This growth spurt is accompanied by dramatic hormonal changes. Height increases faster than weight, and caloric needs are relatively high during this time of physical growth. Girls will develop wider hips as a result of hormonal changes while boys may experience fast height and weight changes as well as broadening of the shoulders.

In general, girls mature earlier and faster than boys. For this reason, girls may see greater improvements in physical performance and coordination sooner than boys early in adolescence, but their rate of improvement often slows as girls approach maturity and the rate of physical improvements in boys begins to increase.

EGOCENTRIC:
Thinking only of oneself, without regard for the feelings or desires of others.

IMAGINARY AUDIENCE:
An individual imagines and believes that multitudes of people are enthusiastically listening to or watching them.

Psychology: Adolescents in this age range often think and behave in their own best interest (**egocentric**) as they begin to discover their personal identity. They tend to think everyone is watching them (known as having an **imaginary audience**) and may become embarrassed quite easily if they fail or blunder social tasks. Youth in this age range also may take unnecessary risks such as skipping school, fighting, substance use, and illegal activities like vandalism and trespassing.

In this age group, youth can begin learning specialized motor skills such as those pertaining to sports. Adolescents who have consistently played sports during childhood are ready to refine movement patterns they have already learned. At this age, a trainer can use visuals to assess and refine movements and begin to identify physical strengths and weaknesses to be trained. These young adults also may benefit from progress tracking and assessments to help them improve their fitness level.

A fitness professional should understand that not every child is involved in athletics from a young age. The learning and skill development process happens in a stepwise manner regardless of age. If the adolescent is new to sports or physical activity, they should be coached as a beginner to the skills and movements. Coaches should encourage newer athletes to choose a sport they enjoy and that matches their levels of skill and coordination.

DIFFERENCES BETWEEN CHILDREN AND ADULTS

Thinking physiologically, children differ greatly from adults. The many differences will impact how children exercise, the way they move, their physical abilities, and their needs regarding nutrition, hydration, and physical recovery. There are some differences between children and adults that a fitness professional should be aware of:

- Children have less blood volume than adults. Blood volume during exercise is reduced due to sweating and salt (electrolyte) loss naturally, so this can make children more susceptible to dehydration. Lower blood volume can also affect temperature regulation and make children more likely to experience **hyperthermia**, or excessively high body temperature, during prolonged exercise.
- Children and youth have smaller airways with more soft tissue than adults. This physical limitation may limit the lung capacity and, thus, training intensity possible for younger children.
- Children have faster respiratory rates and heart rates than adults. Babies under one year of age breathe 30 to 60 breaths per minute, children 1 to 11 years average 12 to 20 breaths per minute, and youth up to 19 years average 12 to 18 breaths per minute at rest. The average adult takes 12 to 16 breaths per minute. Infant heart rates range between 100 and 160 beats per minute, children 1 to 11 years average 70 to 120 beats per minute, and teens up to 19 typically have a resting heart rate of 60 to 100 beats per minute. The average adult has a resting heart rate between 60 and 90 beats per minute as well. A faster resting breathing and heart rate for children means that the increases in both metrics during exercise may limit their potential training intensity and duration without overtaxing the cardiorespiratory system.
- Children have more skin surface area in relation to weight than adults. This can make youth more susceptible to excessive fluid loss and dehydration during prolonged exercise or activity in hot, humid environments.
- Children have less muscle mass and fat mass than adults. This can make a child more

HYPERTHERMIA:
The condition of excessively high body temperature.

vulnerable to injury, bruising, or blunt trauma (especially during contact sports) than an adult. It can also have implications for musculoskeletal coordination and control.

- A child's vision doesn't fully develop until the age of eight. Depth perception is often developed by the age of two, but youth may still be developing hand-eye coordination and the ability to see sharply until they are well into school age. This can affect their ability to execute tasks and play games with fast-moving objects like ball sports and games.
- Children going through puberty have poor coordination and balance. This is mostly due to their rapid physical growth that changes their center of gravity. For adolescents in this life stage, specific skills like ball handling, agility, speed, and coordinated movement can be affected.

EXERCISE PROGRAMMING FOR YOUTH

PRESIDENTIAL YOUTH FITNESS PROGRAM: A comprehensive school-based program that promotes health and regular physical activity for America's youth.

FITNESSGRAM: A noncompetitive standard performance assessment to measure aerobic capacity, muscular strength and endurance, flexibility, and body composition.

Children and adolescents ages 2 to 19 should get at least 60 minutes of physical activity per day. The **Presidential Youth Fitness program** suggests any activity that impacts the whole child is beneficial. This means that aerobic capacity, muscular strength and endurance, flexibility, and body composition are all important factors to consider when developing a program for a young client. These are also key areas of fitness to assess before initiating a training program with a youth client.

Youth Fitness Assessments

FitnessGram, based upon the scientifically established Healthy Fitness Zone from the Cooper Institute, is a noncompetitive standard performance assessment to measure each of these areas of fitness. As with any client, children must have their current fitness level determined, and the FitnessGram is the most current standard to use.

Table 17.1 FitnessGram Youth Fitness Assessments

AREA OF FITNESS	PERFORMANCE ASSESSMENT
Aerobic capacity	PACER test, one-mile run, or walk test
Body composition	Skinfold, bioelectrical impedance (BIA), or body mass index (BMI)
Flexibility	Back-saver sit and reach, shoulder stretch
Muscular strength and endurance	Curl-up, trunk lift, 90-degree push-up, modified pull-up, flexed arm hang

The PACER test is a cardiovascular assessment with multiple stages that gets progressively more difficult as the assessment continues. It challenges children to run laps of either 15 or 20 meters to the sound of a beep that gets faster as time goes on. They continue to run until they can no longer stay with the beep. The maximum number of laps can then be entered into the FitnessGram software to receive a score along with the assessments for body composition, flexibility, strength, and endurance.

More on the PACER test can be found at:

www.fitnessgram.net/pacertest/

And more on the FitnessGram software can be found at:

www.fitnessgram.net/software

Acute Training Variables for Youth

The acute training variables to consider for a youth exercise program are like those for adult programming. They include training volume, load, exercise choice and order, rest, velocity, range of motion, and training frequency. Similarly, the training cycles within a periodized program also apply to youth exercisers and will prevent boredom, promote adaptation, and reduce injury risk. Since children are growing and experiencing spurts of physical development, the length of the training cycles will likely need to be modified accordingly.

Much research has been done to support the fact that resistance and strength training are acceptable and, in most cases, desirable for children. Periodized and appropriate resistance training has been found to protect muscles and connective tissue from injury, improve physical performance, increase bone density, and improve coordination and movement patterns in children of all ages. It has also been noted that the timing of puberty will affect strength and plyometric improvements in adolescents as the levels of anabolic hormones such as testosterone will expedite physical adaptations during this life stage.

EXERCISE AND OLDER ADULTS

Senescence is the process of aging, and it presents differently in every person. Physical activity is a key factor in graceful aging and retention of strength and balance—two very important aspects of injury prevention and longevity in older adults. **Chronological age**—or the number of years a person has lived—does not necessarily equate to physiological age or actual **functional capacity** of the physical body.

SENESCENCE:
The process or state of growing old.

CHRONOLOGICAL AGE:
The number of years a person has lived.

FUNCTIONAL CAPACITY:
The capability of performing tasks and activities that people find necessary or desirable in their lives.

According to the American Heart Association, living a sedentary lifestyle is a major risk factor for many chronic health conditions for adults. It is also a risk factor that is completely controllable. Exercise has been found to slow the physical and, in some cases, mental decline associated with aging. It can decrease the severity of functional limitations that aging can create, such as joint stiffness and poor flexibility, and improve quality of life. As adults grow older, it is more important to be able to perform **activities of daily living** like bathing, cooking, walking, and standing than it is to perform the nonfunctional task of squatting 300 pounds. Many older adults pursue fitness so they can maintain or improve their level of fitness, move well and with less pain, improve their quality of life, and maintain their social and physical independence.

ACTIVITIES OF DAILY LIVING:
The tasks usually performed in the course of a normal day in a person's life, such as eating, toileting, dressing, bathing, or brushing the teeth.

All activities of daily living are related to an exercise movement pattern. Standing up from a chair and climbing in and out of a car mimic a squatting movement. Lifting small children, a laundry basket, or groceries from the trunk are essentially deadlift movements. Picking up and placing a box of old photos onto a high shelf for storage is like a clean and press. Recognizing these movement patterns makes creating functional and effective exercise programs simpler for the older adult client.

EXERCISE AND CHRONIC HEALTH CONDITIONS

By 2030, it is estimated that the number of American adults aged 65 or older will be close to 70 million out of a projected 360 million population. There is sure to be high demand for the health care system to care for this vast demographic as they age, especially for those who do not remain healthy and active. Although aging naturally causes some declines in health and function, the severity of the declines can be greatly reduced by living a healthy lifestyle. Several key indicators have been measured and found to decline between the ages of 20 and 80:

- Maximal oxygen uptake: declines by approximately 50 percent
- Maximal cardiac output: declines by approximately 25 percent
- Maximal heart rate: declines by approximately 25 percent
- Maximal stroke volume: declines by approximately 15 percent

The average rate of decline (per decade) for adults over the age of 50 has also been measured:

- Loss of muscle mass or **sarcopenia**: declines by approximately 6 percent
- Reduction in muscle strength or **dynapenia**: declines by approximately 12 to 14 percent
- Reduction of bone mass: declines by approximately 10 to 15 percent

SARCOPENIA:
The degenerative loss of skeletal muscle mass.

DYNAPENIA:
The age-associated loss of muscle strength that is not caused by neurologic or muscular disease.

Baby boomers (those born between 1946 and 1964) may suffer from additional health complications with age as well. This may include **metabolic syndrome** which is a collection of factors that increase the risk of type 2 diabetes and heart disease.

Frailty affects one's ability to recover from illness and injury, increases the risk of hospitalization, falls, requiring daily assistance, and premature mortality. It is characterized as an increased vulnerability that can be caused by conditions such as sarcopenia and dynapenia in older adults.

Having excess weight in the form of bodyfat can also lead to health issues such as asthma, diabetes, hypertension, orthopedic complications, cardiovascular disease, high cholesterol, **sleep apnea**, and depression.

In many cases, an adult or senior with one chronic health condition will often have additional health conditions that are related to or caused by the first. About 80 percent of people aged 65 years and older are living with at least one chronic health condition, and approximately 50 percent are living with two chronic health conditions. These are known as **comorbidities**, which are disorders or diseases that often appear together. For instance, a client may suffer from cardiovascular disease, hypertension, obesity, and **Parkinson's disease**.

Another condition that senior clients may be at risk for is **osteoporosis**. This common condition affects more than 3 million adults (mostly elderly) in the United States annually. The body is constantly absorbing and replacing bone tissue, but when bone is absorbed and not created to replace itself, the skeleton becomes weak and brittle. Osteoporosis is often asymptomatic until a bone break or fracture occurs. Fractures most commonly occur in areas of the body that bear most of the load or are exposed during a fall, such as the wrists, spine, and hips.

Load-bearing exercise is strongly recommended by medical professionals as a preventative measure for osteoporosis along with a healthy diet and, for some individuals, medications. Resistance training has been shown to increase bone density and stimulate bone remodeling and repair due to the tension created by muscle action and tendonous tension directly on the bones. However, high-impact exercise and exercises that heavily compress the spine are contraindicated for those with osteoporosis.

THE ROLE OF FITNESS PROFESSIONALS IN HEALTH CARE

Until recently, health and health care have been focused on the symptoms that accompany an ailment or disease instead of the prevention of the condition over the life span. The medical community is placing a new focus on the person as a whole, considering not only symptoms but lifestyle factors

BABY BOOMERS:
A person born in the years following World War II, when there was a temporary marked increase in the birth rate.

METABOLIC SYNDROME:
A cluster of at least three biochemical and physiological abnormalities associated with the development of cardiovascular disease and type 2 diabetes.

FRAILTY:
An increased vulnerability resulting from aging-associated decline in reserve and function across multiple physiologic systems.

SLEEP APNEA:
A disorder of breathing during sleep.

COMORBIDITIES:
The simultaneous presence of two chronic diseases or conditions in a person.

PARKINSON'S DISEASE:
A progressive disease of the nervous system marked by tremor, muscular rigidity, and slow, imprecise movement.

OSTEOPOROSIS:
A skeletal condition that results in weak or brittle bones.

that contribute to overall health. This is a new concept to many seniors who are used to visiting several health care specialists such as the endocrinologist for their diabetes, rheumatologist for their arthritis pain, and primary care physician for treatment and monitoring of their hypertension.

Fitness professionals now have a larger role in health care and preventative care. A personal trainer should be aware of the needs of an older demographic to design effective exercise programs that support a well-balanced fitness lifestyle. Before creating a fitness program for seniors, it is important for fitness professionals to obtain medical clearance from their new client's primary care physician and to collect client intake paperwork. It is then necessary to discuss their chronic health conditions and create two separate lists:

1. **Long-term mortality risk:** for instance, a client with heart disease, as well as osteoporosis, should focus on managing the more severe condition. In this case, that would be heart disease.
2. **Symptom limitations:** if a client is suffering from osteoporosis, their associated limitations will impact their exercise training and acute training variables.

The health condition that poses the greatest risk to the client's health must be prioritized without overlooking the limitations placed on the client as the result of comorbidities.

TEST TIP!

- Maintenance of a fitness level is considered a successful intervention for a senior client.
- For example, if a 65-year-old client has been working out for five years but experiences no change in their cardiorespiratory fitness, they have prevented normal decline and have, therefore, been successful!

SENIOR FITNESS TESTS

Fitness assessments and evaluations should be conducted once a senior client is approved to engage in exercise. Evaluations in the form of fitness tests allow a fitness professional to create an overview of a client's health and current fitness level. Senior fitness tests differ slightly from traditional objective and movement assessments since strength assessments like the 1RM tests are generally not applicable to this population.

Rikli and Jones created the **Functional Fitness Test for Seniors**. This is a safe alternative to traditional assessments that modifies the physical demands and is a good starting place for testing older clientele. These simple and easy-to-use assessments include the chair stand, back scratch test, and two-minute step test. Normal range of scores for men and women are provided, with the word normal being defined as the middle 50 percent of the population for each respective category. Those who score above the provided ranges should be considered above average for

FUNCTIONAL FITNESS TEST FOR SENIORS: A simple, easy-to-use battery of test items that assess the functional fitness of older adults.

their age, and similarly, those who score below should be considered below average for their age.

Table 17.2 Senior Fitness Assessments

FITNESS TEST	EVALUATE	HOW TO PERFORM	AT RISK
30-second chair stand	Lower-body strength for activities of daily living (ADL) such as getting out of a chair, gardening, or navigating stairs.	With arms folded across chest, count the number of stands that can be fully completed within 30 seconds.	Less than 8 unassisted stands for men and women
Arm curl	Upper-body strength that measures ADL such as carrying groceries, lifting grandchildren, or putting dishes away.	Count the number of biceps curls that can be completed within 30 seconds while holding a hand weight (5 lb. or 2.27 kg for women; 8 lb. or 3.63 kg for men).	Less than 11 curls for men and women
Two-minute step test	Stamina for activities such as shopping, traveling, or yard work.	Count the number of full steps completed within two minutes. Each knee must be raised to point midway between the kneecap and hip bone. Only the number of times the right knee reaches required height is scored.	Less than 65 steps for men and women
Chair sit and reach	Lower-body flexibility for preventing lower-back pain, balance, posture, and falls.	While seated at the front of a chair and with one leg extended, reach toward the toes with the hands. Count the number of inches between fingers and tip of toe.	Minus four inches or more for men Minus two inches for women
Eight foot up and go	Speed, agility, and balance to help in activities such as walking through crowds or playing at the playground with grandkids.	Count the number of seconds needed to get up from a seated position, then walk eight feet (2.44 m), turn, and return to a seated position.	Greater than 9 seconds for men and women
Back scratch test	Flexibility in the upper body, which may affect the ability to reach up high, change a light bulb, or open the refrigerator.	Begin standing. Place one hand behind the back and slowly move it up the spine toward the head. The opposite hand is placed behind the neck and is slowly moved down the spine with the goal of bringing both hands as close together (or overlapping) as possible. Repeat with the opposite hands (switch hand placement).	N/A

Table 17.3 Normal Ranges for Men

	AGE-RANGE						
	60–64	**65–69**	**70–74**	**75–79**	**80–84**	**85–89**	**90–94**
Chair stand (no. of stands)	14–19	12–18	12–17	11–17	10–15	8–14	7–12
Arm curl (no. of reps)	16–22	15–21	14–21	13–19	13–19	11–17	10–14
Two-min step (no. of steps)	87–115	86–116	80–110	73–109	71–103	59–91	52–86
Sit and reach (inches)	-2.5–+4.0	-3.0–+3.0	-3.5–+2.5	-4.0–+2.0	-5.5–+1.5	-5.5–+0.5	-6.5– -0.5
Eight foot up and go (seconds)	5.6–3.8	5.7–4.3	6.0–4.2	7.2–4.6	7.6–5.2	8.9–5.3	10.0–6.2
Back scratch (inches)	-6.5–+0.0	-7.5– -1.0	-8.0– -1.0	-9.0–2.0	-9.5– -2.0	-10.0– -3.0	-10.5– -4.0

Table 17.4 Normal Ranges for Women

	AGE-RANGE						
	60–64	**65–69**	**70–74**	**75–79**	**80–84**	**85–89**	**90–94**
Chair stand (no. of stands)	12–17	11–16	10–15	10–15	9–14	8–13	4–11
Arm curl (no. of reps)	13–19	12–18	12–17	11–17	10–16	10–15	8–13
Two-min step (no. of steps)	75–107	73–107	68–101	68–100	60–91	55–85	44–72
Sit and reach (inches)	-0.5–+5.0	-0.5–+4.0	-1.0–+4.0	-1.5–+3.5	-2.0–+3.0	-2.5–+2.5	-4.5– -1.0
Eight foot up and go (seconds)	6.0–4.4	6.4–4.8	7.1–4.9	7.4–5.2	8.7–5.7	9.6–6.2	11.5–7.3
Back scratch (inches)	-3.0–+1.5	-3.5– -1.5	-4.0–+1.0	-5.0–+0.5	-5.5–+0.0	-7.0– -1.0	-8.0– -1.0

DESIGNING A SENIOR FITNESS PROGRAM

When programming for a senior client, the health condition that places a coach's client at the greatest risk for mortality should be the primary focus of exercise interventions. However, trainers may introduce modifications to work around or accommodate for any secondary conditions and limiting factors.

Each client is unique and may require a high degree of monitoring to be successful. Therefore, it's important for personal trainers to be flexible in their program design and allow for modifications in acute variables such as frequency, intensity, types of exercise, and time (to include duration, rest, and time of day). For example, trainers should consider modifying workouts to decrease the exercise volume or intensity during an arthritis flare-up. It might also be beneficial for a client to have their workout moved from the gym to the pool for relief of weight-bearing symptoms. If pain or fatigue are too much for the older client on a given day, the trainer should reschedule the session to another day when the limiting symptoms are less restrictive.

Periodization rules for the general population still apply to seniors, but, as with youth, the length of training cycles is likely to be abbreviated based on the client's needs and abilities.

Heart and Respiratory Fitness

Research has identified minimum standards for cardiovascular exercise in seniors for improved health and to prevent the risk of developing heart disease. These guidelines include

- 150 minutes per week of moderate-intensity aerobic exercise (30-minute workouts five times per week),
- 75 minutes per week of vigorous-intensity aerobic exercise (30-minute workouts three times per week), or
- any combination of the two.

Seniors with a long history of being sedentary, or who have limiting factors such as arthritis or asthma, may need to start off with only 10 to 15 minutes of moderate-intensity activity at a frequency that fits into their lifestyle. In addition to the subjective information collected during initial assessments with a client, the data from the two-minute step test will determine a valid starting point and the goals a trainer will help a client set. General guidelines for the acute variables of frequency, intensity, and time have been established for common chronic health conditions.

Table 17.5 Acute Variables for Chronic Health Conditions

CONDITION	FREQUENCY	INTENSITY	TIME
Arthritis	3-5 days/wk	40% to <60% HRR	20-30 min/day
Cardiac Disease	4-7 days/wk	40% to 80% HRR	20-60 min/day
Dyslipidemia	≥ 5 days/wk	40% to 75% HRR	30-60 min/day
Hypertension	≥ 5 days/wk	40% to <60% HRR	30-60 min/day
Obesity	≥ 5 days/wk	40% to <60% HRR	30-60 min/day
Osteoporosis	3-5 days/wk	40% to 60% HRR	30-60 min/day
Type 2 Diabetes	3-7 days/wk	50% to 80% HRR	20-60 min/day

For aerobic activity, a client's cardiovascular health and joint health must be taken into consideration. The fitness professional can identify specific exercises that will produce the greatest adaptation without creating undue stress or physical pain. Rowing, recumbent cycling, aerobic stepping, and upper-body ergometers are reasonable alternatives to the treadmill, upright bike, or walking for clients with joint or cardiovascular limitations.

Muscle Strengthening

The same considerations should be made when it comes to muscle strengthening. Fitness professionals should identify exercises that will produce the greatest desired adaptations but do not elicit pain. Strength training for seniors is a critical component to healthy aging and is safe and effective when done properly. However, oftentimes senior clients will not do well with bodyweight exercises without first addressing mobility. A shuffling gait (walking pattern), reduced range of motion, or poor posture will limit an older client's ability to correctly perform some movement patterns. Safe equipment modifications in these cases include resistance bands, changing body position (sitting instead of standing), or using exercise machines.

Coaches can start with closed kinetic chain exercises to support the joints, such as balancing on one leg or squats and shoulder taps, then gradually progress to open chain exercises such as seated knee extensions, leg curls, and bench press with a focus on balance and stabilization exercises in all three planes of motion.

Depending on each client's abilities, acceptable methods of strength training for this population include the use of bands, machines, free weights, and calisthenics. Exercise intensity should follow a certain set of guidelines:

- One set of 8–10 repetitions for exercises working the major muscle groups on two to three nonconsecutive days of the week.
- The trainer should ask the client to rate their exertion on a scale of 0 to 10, with a 0 equating to no movement and 10 to an all-out effort.
- Moderate-intensity exercise (a perceived effort of 5 or 6) should allow the client to perform 12–15 repetitions, and high-intensity exercise (a 7 or 8 on the scale) should permit between 8 and 10 repetitions.

It has been shown that resistance training with higher volume is associated with larger improvements in lean body mass for seniors as well. Contraindications are relative and dependent on the health conditions of each senior client. For example, clients with osteoporosis should avoid excessive loading of the spine as can occur during a leg press exercise. Nevertheless, most clients with preexisting conditions can safely begin a muscle-strengthening program by performing loaded exercises that involve little to no movement of the spine and then progress within the client's limits.

Flexibility Training

Older adults aged 55 to 86 years of age may see a decrease in flexibility of the shoulder and hip joints by approximately six degrees per decade. At the age of 70, this decline may naturally become even more severe. Although flexibility training in older adults increases range of motion, it is still unclear how daily functional movements are impacted. Regardless, senior clients should engage in flexibility training to promote optimal biomechanics and posture. Light, static stretching of the major muscle groups at least twice per week can improve the quality of life in older adults, and daily stretching can be an integrated part of their fitness lifestyle. Flexibility exercises are best done after a thorough warm-up and may even be done immediately after walking, or directly after a hot shower to improve muscle pliability.

Balance Training

Balance training is essential for senior populations because it helps prevent falls and associated injuries and challenges the body's ability to sense its position in space and time. The ability to balance will decrease with advancing age, making seniors more susceptible to common injuries like tripping while walking or stepping off a sidewalk, or slipping on a wet or uneven surface. When this ability degrades, the body can become unstable, especially with movement.

Balance training can easily be integrated into various parts of a workout, but it works best during the warm-up or during the workout since it can be taxing on the neuromuscular system. It is recommended that balance training be performed three days per week for about 10 to 15 minutes per session. Proprioceptive components are critical for this type of training and include training on unstable or uneven surfaces and closing the eyes during movement to challenge the sense of feel without visual information.

Safety is always of utmost priority, so a personal trainer should always be close by to assist or provide a support during balance exercises. Balance exercises should progress in the same manner as exercise in general—from standing on a stable surface such as the floor, to balancing on one leg, as well as using a bench or chair with arms, before progressing to exercises with a Swiss ball.

Mental Training

Physiological decline is inevitable with age, but mental activity, social involvement, and physical activity have been found to improve memory function, focus and clarity, and mental sharpness.

Science supports the fact that genetics determines about half of the human's memory capacity. That leaves another 50 percent that can be challenged and improved. Lifestyle and habits including nutritional habits, exercise habits, and level of education can contribute to how the other half of one's memory will function.

Physiological age and chronological age are considered separate measures of aging. Another recent study found that people in their 70s may have as many young neurons—essential to learning and memory—as teenagers. This is contrary to findings just 20 years ago when research supported the idea that it was not possible to grow new neurons as humans age. Other studies have also discovered that reducing sedentary behavior may improve brain health for those at risk for progressive mental degeneration conditions such as **Alzheimer's disease**. Both cognitive and physical training have positive effects on the brain, and it has been found that moderate-intensity exercise can improve brain structure and function and may reverse neural decay in older adults.

ALZHEIMER'S DISEASE:
A progressive mental deterioration that can occur in middle or old age, due to generalized degeneration of the brain.

EXERCISE AND PREGNANCY

It is commonly asked whether pregnant females can exercise safely. The general answer is that those who were active prior to pregnancy should be able to continue their regular activity unless advised otherwise by a physician. However, it is never too late for women who are inactive prior to becoming pregnant to begin an exercise program. In fact, exercise is highly recommended for preparing a woman's body for carrying and delivering a child and for improving the health of the unborn baby. Starting an exercise program may also help a pregnant woman reduce or prevent feelings of anxiety, tension, fear, and panic about childbirth.

Many physicians believe that **prenatal** exercise should be a critical part of a woman's pregnancy. It is recommended that pregnant females do at least 150 minutes of moderate-intensity exercise and three days of resistance training each week. However, it is estimated that fewer than one in four pregnant women meet the minimum recommendations for physical activity during pregnancy. Exercise can help a pregnant woman connect to her mental and emotional state and enjoy a more balanced, healthful pregnancy and **postpartum** period.

PRENATAL:
Occurring or existing before birth.

POSTPARTUM:
The period of time following childbirth.

PHYSIOLOGICAL AND ANATOMICAL CHANGES DURING PREGNANCY

A woman's body goes through many changes during pregnancy, and these changes impact nearly every organ system in her body. It is critical for fitness professionals to understand these physiological changes at a high level so that they can create the most beneficial and effective exercise program.

Pregnancy is divided into three trimesters, and each trimester is approximately 12 weeks. Many of the major physiological and anatomical changes will happen within the first and second trimesters alone.

In the first trimester of pregnancy, important hormonal changes occur. At the time of pregnancy, **progesterone** levels increase to develop the lining of the uterus, which supports the fertilized egg as it implants to grow. Also, levels of the hormone **relaxin** are released from the corpus luteum in the ovary and eventually the placenta, and this hormone will reach its highest levels during this time. Relaxin, as its name suggests, relaxes the wall of the uterus in preparation for pregnancy and eventually relaxes the ligaments of the pelvic region.

PROGESTERONE:
Female hormone that regulates the menstrual cycle and is crucial for pregnancy.

RELAXIN:
A sex hormone that facilitates birth by causing relaxation of the pelvic ligaments.

Other joints can also become more flexible, which can limit the body's ability to stabilize itself. There is an increase in the elasticity of muscles and tendons, which can lead to reduced muscle actions during exercise. In addition, there will be an increase in the elasticity and size of the heart, veins, and arteries, leading to dilation of blood vessels. This, in turn, can cause vascular underfill of the heart where blood vessels have expanded, but because the amount of blood in the body has not increased, there is not enough blood to fill up the heart. This can cause a drop in blood pressure and create feelings of fatigue and dizziness known as orthostatic hypotension with changes in position such as getting up from lying on the floor.

During the second trimester, biomechanical changes will create new challenges. As the baby grows within the uterus, there is a significant shift in a woman's center of gravity, causing the pelvis to tilt forward and increasing lumbar lordosis. This may encourage poor posture and create low-back pain in some women. A woman's weight will naturally increase with the growth of the baby, and there may be a need to urinate more frequently as the uterus presses on the bladder. Weight gain, changes in the alignment of the pelvis, and changes in hormones contribute to **hypermobility** from joint laxity, which can lead to postural compensations such as flat feet from fallen arches or feet that appear externally rotated from overpronation. These uncontrollable physical changes will need to be carefully monitored by a fitness professional with modification and adjustments to variables such as body position and exercise selection made when appropriate.

HYPERMOBILITY:
The condition of having excessive amounts of range of motion in a joint or joints.

In the third and final trimester of pregnancy, dramatic physiological changes slow, but the increase in body weight will likely continue to affect the client. A growing baby may compress the major blood vessels that run to and from the heart when the client is lying in a supine position, causing a drop in blood pressure, feelings of lightheadedness, as well as a reduction of blood flow to the baby. For this reason, it is recommended that pregnant women limit the amount of time in back-lying positions. A woman may also experience shortness of breath, swelling, backaches, and insomnia during the third trimester, making exercise, progress, and physical recovery from activity more challenging. There is also an inherent risk of **diastasis**—or the separation of the large abdominal muscles—as the abdomen becomes distended or during core exercises such as crunches and sit-ups.

DIASTASIS:
The separation of the large abdominal muscles during pregnancy.

Table 17.6 Physiological and Anatomical Changes during Pregnancy

BODY SYSTEM	OBSERVABLE CHANGES
Cardiovascular system	• Resting heart rate increases • There is a 45 percent increase in blood volume • Stroke volume and cardiac output increase • Respiratory rate may increase up to 50 percent • There is a 15–20 percent increase in oxygen consumption during exercise • Lung capacity decreases • There is a decrease in oxygen availability • Risk for orthostatic hypotension
Musculoskeletal system	• Bodyweight increases, placing more stress on joints • Elasticity of muscles, tendons, and ligaments increases • The center of gravity changes, causing issues with balance • Postural changes contribute to compensations
Endocrine system	• Levels of relaxin and progesterone increase • Thyroid-stimulating hormones released more often • Insulin resistance is increased due to a continuous supply needed for the fetus • More lipid (fat) use leading to ketogenesis

In many cases, there are significant differences in weight gain between those who exercise during pregnancy and those who do not. Postpartum BMI is lower for women who exercise than for those who do not, and women who enter pregnancy overweight and do not exercise may experience a more difficult delivery. By continuing or beginning a fitness program during pregnancy, women may improve their general health and physical function, reduce bodily pain, have more energy to participate in fun social activities, and enjoy pregnancy.

SPECIAL CONSIDERATIONS FOR PREGNANCY

Women experience many changes during pregnancy, and many of these changes are expected. However, there are instances where exercise is contraindicated, and special considerations must be made. For this reason, it is important for all clients to obtain clearance from their doctor before continuing or beginning an exercise program while pregnant. Contraindications can be relative, meaning they are dependent on certain conditions. Contraindications can also be absolute, meaning there are no exceptions, and a woman should discontinue or avoid exercise while pregnant. If a client shows any signs or symptoms that are unusual, trainers should talk to them about the issue immediately and refer them to their doctor.

Absolute Contraindications

Absolute contraindications for a pregnant client mean the client's physician will diagnose these conditions. Coaches should not continue with the exercise program if the client presents with any of the following conditions:

PLACENTA PREVIA:
A condition in which the placenta partially or wholly blocks the neck of the uterus, thus interfering with normal delivery of a baby.

PREECLAMPSIA:
A condition in pregnancy characterized by high blood pressure, sometimes with fluid retention and proteinuria.

- Incompetent cervix
- Persistent vaginal bleeding
- **Placenta previa** after 26 weeks gestation
- Premature labor
- **Preeclampsia**
- Uncontrolled diabetes or other systemic disorder

Relative Contraindications

If a pregnant client presents with certain conditions, coaches must refer them to their physician or request a letter from their physician to continue exercising:

- Severe anemia
- Extreme morbid obesity
- Extremely underweight
- Poorly controlled hypertension, seizure disorder, or thyroid disease
- Orthopedic limitations
- Maternal cardiac arrhythmia

GESTATIONAL DIABETES:
A condition characterized by an elevated level of glucose in the blood during pregnancy, typically resolving after birth.

With obesity on the rise, another major concern during pregnancy is the condition of **gestational diabetes** - also called gestational diabetes or GDM. This is the temporary condition of diabetes that only occurs in a pregnant female during her pregnancy. Between 2 and 10 percent of pregnancies result in GDM, which can increase the risk for complications during pregnancy and increase the risk for the child to develop diabetes later in life. A fasting blood glucose test is administered by a medical professional between 24 and 28 weeks into the pregnancy to detect and diagnose GDM. This condition can be managed by proper nutrition, but, in some cases, insulin is needed to manage blood sugar for the duration of the pregnancy. For those who require insulin, exercising will reduce the amount of insulin needed to manage their GDM compared to women who do not exercise.

PROGRAM DESIGN FOR PREGNANT CLIENTS

In a normal and healthy pregnancy, exercise has not been found to negatively affect fetal birth weight, size, or gestational age. Rather, exercise can help ease pregnancy-related symptoms, maintain glycemic control, and reduce or maintain pregnancy and postpartum body weight. Controlling these variables provides beneficial outcomes for the unborn baby as well.

Exercise during pregnancy should be based on the client's previous exercise level and preferred exercise methods and should be considered in the context of pregnancy symptoms and current health status. Women who were not exercising before becoming pregnant should start slowly and progress gradually. Provided there are no contraindications, the goal of the prenatal exercise program should be to eventually achieve moderate-intensity exercise for 20 to 30 minutes on most days of the week. Fitness goals for a pregnant client should not include weight loss or performance improvement. Instead, exercise should focus on the maintenance of current health status.

Acute training variables such as frequency, resistance, tempo, and type can be modified as normal for pregnant clients. However, coaches should pay special attention to physical reactions during and after exercise to ensure there are no complications being caused. Clients who exercised regularly before pregnancy may continue their exercise programs, although, as pregnancy progresses, some modifications may be necessary (for example, removing supine exercises after the first trimester). Clients should not start new or more intense exercise programs during any stage of pregnancy.

Core Training

Stability of the core and pelvic floor is an important part of a prenatal strength training program. The core and pelvic floor help to protect the pelvis and the lumbar spine. Fortunately, there are alternatives to core training besides traditional supine crunches that a pregnant client can take advantage of. Abdominal training options for the prenatal client can include deliberate pelvic tilts (anterior and posterior), core bracing and isometric holds, quadruped exercises like the bird dog, and some plank variations.

EXERCISE AND ADAPTIVE FITNESS

A **disability** is any condition of the body or mind that makes certain activities more difficult for the individual with the condition. **Impairment**, **activity limitation**, and **participation restrictions** are types of disabilities defined by the CDC.

DISABILITY:
A physical or mental condition that limits a person's movements, senses, or activities.

IMPAIRMENT:
The state of being diminished, weakened, or damaged, especially mentally or physically.

ACTIVITY LIMITATION:
The quantitative and qualitative measure of disability referring to difficulties experienced by an individual in executing a task or action.

PARTICIPATION RESTRICTIONS:
A problem experienced by an individual in involvement in life situations.

The Americans with Disabilities Act (ADA), signed by President George W. Bush, was modeled after the Civil Rights Act and section 504 of the Rehabilitation Act. This legislation protects the rights of people with disabilities to include equal employment opportunities, rights to purchase goods and services, and participation in state and local government programs and services.

For the fitness industry and other physical activity areas such as local parks and recreation, the ADA brought about the need to create tools and facilities that made exercise in these spaces more accessible for people with disabilities. The focus then became **inclusion** - understanding the relationship between the way people function (physically or mentally) and how they participate in society. A disability should not determine the activities a person can or cannot participate in. Rather, activities should accommodate all different abilities and desires so that everyone may enjoy every aspect of life.

INCLUSION:
The act of including into a group, involvement and empowerment, where the inherent worth and dignity of all people are recognized.

ADAPTIVE PHYSICAL FITNESS:
The art and science of developing, implementing, and monitoring a carefully designed physical fitness program for a person with a disability.

Adaptive physical fitness programs help bridge this gap and bring into the fold those persons with vision, movement, thinking, remembering, learning, communicating, hearing, mental health, or social disabilities. Though there are a wide range of needs and each person is affected differently by their disability, adaptive fitness programs offer opportunities for anyone to fall in love with and enjoy the benefits of a fitness lifestyle.

MAKING EXERCISE ACCESSIBLE

Unfortunately, those with disabilities do not have the same access to health care as others without disabilities. Women with disabilities are less likely than women without disabilities to have had a mammogram during the past two years. It is thought that limited access to health care can increase the occurrence of chronic conditions such as heart disease, stroke, diabetes, or cancer. It is important for fitness professionals to understand the scope of work ahead before diving into the details of serving this demographic.

Table 17.7 Inactivity by Disability Type

DISABILITY TYPE	PERCENTAGE OF POPULATION THAT DOESN'T GET EXERCISE	ESTIMATED NUMBER OF PEOPLE
Mobility Dysfunction	57 percent	34,770,000
Cognitive Disability	40 percent	24,400,000
Vision Disability	36 percent	21,960,000
Hearing Impairment	33 percent	20,130,000
No disability	26 percent	84,682,000

Source: Centers for Disease Control and Prevention

Roughly three out of five people with a mobility issue do not get any aerobic activity. Most of the time this is because of limited access to facilities or resources. Disabilities can be caused by any number of factors:

- Disorders in single genes such as Duchenne muscular dystrophy.
- Disorders of the chromosomes such as Down syndrome.
- The result of a mother's exposure to teratogens during pregnancy such as alcohol, cigarettes, or the disease Rubella.
- Related to developmental conditions like autism spectrum disorders.
- Related to an injury such as a traumatic brain injury.
- The result of a chronic condition such as vision loss, nerve damage, or loss of limb due to complications from diabetes.

An impairment can be structural such as the complete loss of a body component (amputation) or it can be functional such as the complete or partial loss of a body part, such as a joint that no longer moves. In any of these cases, it is rare that an individual is 100 percent disabled. Whatever abilities a coach's clients have, that coach should help them find a sport, game, or activity that they enjoy, that challenges them, and that helps improve their overall health.

SPECIAL CONSIDERATIONS

Around 25 percent of Americans have a condition that disables them, and that number sits around 15 percent worldwide. When a person identifies as disabled and accepts that identity as positive and affirming, outcomes are beneficial: one study reported that persons with multiple sclerosis who identify positively with their condition report less depression and reduced anxiety.

Those born with a disability (**congenital**) report higher life satisfaction than those who acquire a disability later in life. Perhaps this is because an individual born with a disability knows no other outcome and develops their personality and character within the context of that disability, whereas an individual who loses an extremity, for example, may feel as though they have lost their identity and now has to relearn their body and the way they participate in society. It's important for fitness professionals to allow clients to grieve their disability in whatever way they need to. But it's also important that fitness professionals help clients see that there is still a world of opportunity for these individuals. An essential component of this process requires an understanding that it is not the fitness professional's job to tell the client when they're ready to try new things, but instead to listen to the client and their needs. These psychological considerations should be front of mind for a personal trainer, but it is not within their scope to diagnose or treat them.

CONGENITAL:
Relating to a disease or physical abnormality present from birth.

The benefits of fitness do not discriminate between an amputee and a person with all four extremities. The same physiological benefits available to a 25-year-old male with no intellectual disability are the same benefits available to a peer with Down syndrome or a traumatic brain injury. Fitness is for everyone and helps to:

- reduce the risk of heart disease, stroke, diabetes, and some cancers;
- improve self-confidence and autonomy;
- reduce feelings of depression;
- increase quality of life and life satisfaction scores;
- increase longevity; and
- reduce some symptoms of chronic medical conditions.

Fitness programming is fundamentally similar for clients with disabilities and those without. The fitness professional needs to be aware of cardiovascular fitness, muscular strength, muscular endurance, flexibility, balance, agility, speed, neuromuscular coordination, and body composition management in each program but also understand that some clients' disabilities may require alterations or subtractions in these areas.

PROGRAM DESIGN

In general, when designing a fitness program for a client with a disability, it is important for trainers to get the client engaged in the amount and type of activity that is right for them. Find opportunities for them to increase their activity in ways that meet their needs and abilities and start slowly but encourage their client to stay active since any activity is better than none.

All acute training variables can be manipulated for clients with disabilities. However, as with pregnant women, their physical reactions during and after exercise should be monitored to ensure no complications are being created.

When a fitness professional is working with children with disabilities, their number one factor in choosing a healthy activity should be enjoyment. They should help the child develop a love for fitness by creating an environment in which they feel accepted, successful, accomplished, and competent. They should also help the child to make friends, develop motor skills, and learn independence, as well as allow them to choose how they want to participate—as an individual or on a team. Coaches should encourage them to interact with peers with and without disabilities.

Recommendations for cardiovascular fitness and muscular strength and endurance exercises are similar to those suggested for general populations.

General recommendations for cardiovascular fitness may include:

- 30 minutes of moderate-intensity aerobic activity five times per week,
- 25 minutes of vigorous-intensity aerobic activity five times per week, or
- any combination of the two.

Recommendations for muscular strength and endurance include moderate- to high-intensity exercises, moving all the major muscle groups, on two or more days per week. Children and adolescents should engage in 60 or more minutes of physical activity per day, such as playing at the playground, riding bicycles, and playing sports. Other components of the physical fitness program will be dependent upon the client's current fitness level, stated goals, and abilities.

Benefit of Competitive Sports

The Working Wounded Games is an adaptive fitness competition open exclusively to those with disabilities. Not surprisingly, the athletes who participate in this and similar programs are thriving. A recent study examined program participation feedback and perceived improvements in fitness, mood, and self-confidence of those who participated in this type of event. Sixty percent of participants reported an improvement in muscular strength, muscular endurance, flexibility, balance, mood, and self-confidence. These benefits weren't limited to participants' physical performance—many reported improvements in cognition, affect, and social skills as well.

Researchers believe the supportive and encouraging community environment helps to further enhance the adaptive athlete's social well-being. The Special Olympics, serving those with physical and intellectual disabilities, is now in its fifth decade and offers multiple opportunities for athletes to participate in sports competitions around the world. The Paralympics, started in 1948, is for athletes with various physical disabilities and is so named because it occurs in tandem or shortly after the International Olympic Games. Athletes can compete in sports such as alpine skiing, athletics, badminton, basketball, bocce, bowling, cricket, cross-country skiing, cycling, equestrian, figure skating, flag football, floorball, floor hockey, golf, gymnastics, handball, judo, kayaking, netball, powerlifting, roller skating, sailing, snowboarding, snowshoeing, soccer, softball, swimming, table tennis, tennis, triathlon, and volleyball.

The American Association of Adapted Sports Programs (AAASP), started after the 1996 Paralympic Games, gives disabled students the opportunity to experience school sport participation like their nondisabled peers do. They partner with school districts along with state and national agencies and have helped to develop standardized competition rules and seasons, safety guidelines, coaches, and official training and guidelines for compliance and inclusivity. The AAASP can be a great resource for fitness professionals and facilities for information on creating and operating sports programs for the disabled. Specific fitness programming for the athletes may require additional education specific to their needs.

CHAPTER 18

BUSINESS AND MARKETING

LEARNING OBJECTIVES

1 | Differentiate between the most common styles of personal training.

2 | Explain the purpose and components of a business plan for a fitness professional.

3 | Describe the stages of the client life cycle.

4 | Explain the types of marketing a fitness professional can use to communicate with current and potential clients.

Personal training is a relationship business. Much of the success of a trainer is dependent on their ability to build rapport with clients and prospective clients, communicate effectively, and understand and cater to the needs of each individual client.

Personal trainers often work for corporate gyms and health clubs. However, opportunities exist to work in many other locations, including community centers, fitness studios, independent gyms, schools, physical and occupational therapy offices, and assisted-living facilities, or as **independent contractors**. An independent contractor works for themselves and is contracted to provide services for a company as a nonemployee.

INDEPENDENT CONTRACTOR: Someone who works for themselves and is contracted to provide services for a company as a nonemployee.

Regardless of where a personal trainer is employed, the personal trainer is essentially running their own small business. Starting and growing a fitness business requires the consideration of important business aspects, including the following:

BUSINESS PLAN: Outlines the structure, marketing, and growth of a new business.

- The style of personal training sessions to offer
- A **business plan** to lay out "how" a personal training business will be operated
- Attraction and conversion of clients and customer referral acquisition
- Client retention
- Marketing and brand creation
- An understanding of one's financial needs and how much work and revenue generation is necessary to meet those needs

STYLES OF PERSONAL TRAINING

The styles of personal training generally describe how a training session is conducted and with how many clients. The following are the common styles of training:

- In-person training
- Virtual training
- Hybrid training
- Buddy training
- Small group personal training
- Group exercise

Each style of training requires foundational fitness knowledge in subjects such as anatomy, biomechanics, programming, and **cueing**, but there are unique elements to consider with each style of training. For example, training a large group requires different communication and cueing skills than one-on-one training.

CUEING: A communication that prompts a client to engage in a movement pattern or conveys proper technique.

IN-PERSON TRAINING

In-person training is done face-to-face in a live setting and can include one-on-one training with a client and a trainer or be executed in larger groups. The benefits of live, in-person fitness instruction include greater clarity and understanding and the ability to correct a client's form and interact with them directly. Many clients prefer having live instruction, especially if they are relatively new to exercise, since they can ask questions and receive instant feedback.

IN-PERSON TRAINING:
Live, face-to-face fitness training done individually or in small or large groups.

VIRTUAL TRAINING

Online or **virtual training** is growing in popularity with both trainers and clients. Sessions can be conducted via websites, phone applications, or social media platforms. Training formats can include videos, livestreaming interactions, and chat forums. Virtual training allows a fitness professional to reach a larger client base and meet the client in their environment.

VIRTUAL TRAINING:
Remote training sessions conducted via website, phone applications, or social media platforms.

Conducting training sessions online requires specific equipment for a high-quality experience. A personal trainer will need to consider the following aspects of how they conduct online sessions:

- **Virtual platform:** There are many platforms, such as Zoom, video calls, and Google Meet, for conducting virtual meetings. A personal trainer should select a platform that is easy to use, is accessible to all clients, and has the features they will need. Features to consider include screen sharing, chat capability, and the ability to record sessions as well as send and receive attachments while in the call.
- **Camera:** For quick video calls, a phone can suffice. However, for longer or more regular sessions, a personal trainer may consider investing in a high-quality camera or a computer with high camera quality. Having better image quality during a video call can enhance the training relationship and promote engagement in the virtual session.
- **Lighting:** Many virtual personal trainers neglect lighting when on a call. However, having a well-lit space can ensure clients can clearly see the personal trainer—this is essential when demonstrating proper form. Ring lights attached to a device or a computer are commonly used to illuminate a trainer's face and space for a video. Lights do not have to be expensive to be effective.
- **Space and appearance:** The space where a trainer sets up for an online training session matters. The background should be clean, free of clutter, and free of distractions. Setting up in a space that is similar to where an in-person session

would be held is ideal. Even though the session is on video, a personal trainer should also be dressed professionally and appropriately for the activities that will be performed.

- **Exercise equipment:** Virtual training is typically conducted with no or minimal exercise equipment. Programming will have to be practical to meet the requirements of the camera view and available equipment.

A website or app is another essential tool for a virtual fitness professional. This allows clients to log in for communication and to access resources as needed. A website or app can also include scheduling for live consultations, client handouts, progress tracking, payment options, helpful education, and a library of blogs and videos.

Figure 18.1 Virtual Personal Training

HYBRID TRAINING

HYBRID PERSONAL TRAINING:
A training approach that utilizes in-person and virtual training styles to allow for easier, more frequent access to the fitness professional.

A relatively new style of training is **hybrid personal training**. Hybrid training is a combination of in-person and virtual training. A personal trainer will work with a client in person at a frequency that meets the client's needs. Then when they are not together physically, the fitness professional can connect with the client virtually to provide exercise guidance and nutrition guidance, answer questions, and conduct progress evaluations and assessments. Hybrid training makes holding clients accountable to their program and their progress easier since the fitness professional can touch base with the client as often as necessary.

BUDDY TRAINING

In fitness, **buddy training** is when a personal trainer works with two clients at the same time. This training style can make individualized exercise instruction more affordable for participants since the cost per hour is often divided between both participants. Exercising with a partner can also increase motivation, accountability, and exercise compliance for all participants. Buddy training can also provide a safe and comfortable environment for those clients who may have anxiety in social settings. Working out with a spouse or trusted friend can provide the motivation and accountability they need.

BUDDY TRAINING:
Exercise instruction between a personal trainer and two clients at the same time.

Figure 18.2 Buddy Training

SMALL GROUP PERSONAL TRAINING

Small group personal training is exercise instruction delivered to two to four clients at once. Similar to buddy training, this training style can make individualized instruction more affordable for participants, as the cost of an hour of the trainer's time is less per participant but offers the trainer an opportunity to make more per hour as well. For example, a trainer who charges $60 per hour for one-on-one training may charge $30 per hour per participant for small group training. With six participants, that means the trainer is making $180 for the hour—three times their regular hourly rate.

SMALL GROUP PERSONAL TRAINING:
Exercise instruction delivered to two to four clients at the same time.

Small group personal training can increase client motivation, accountability, and adherence to an exercise program when rapport is built between the trainer and all participants. This style of training also allows the trainer to maintain a high level of contact and interaction with each participant to offer an individualized training experience.

Figure 18.3 Small Group Personal Training

LARGE GROUP TRAINING

Large group training expands the concepts of small group training to much larger groups. Common examples are boot camp–style classes, running or adventure racing groups, and strength and conditioning sports camps. With groups ranging from 20 to 50 participants and possibly beyond, it is often necessary to add additional instructors to ensure the quality of the experience.

Some large group offerings are seasonal in nature, such as sports camps and large outdoor boot camps. It is important that the planning and marketing of these seasonal offerings are done several months ahead of the start date. Fitness professionals should consider having rates that include drop-in pricing as well as pricing for the entire session. An example of this is a one-month outdoor boot camp that has 10 workouts in the month. A monthly rate of $150 would equal $15 per workout. A suggested drop-in rate (paying for a single class) might be $20.

TRAINER TIP!

With small group personal training, a fitness professional will need to consider the following:

Space and equipment: Specifically how much space and what equipment is available to support all participants. This is part of what determines how many people can properly participate in this group.

Exercise programming: With small groups, it is important to keep all participants engaged. Exercise programming must specifically consider the goals and abilities of each participant, and exercise selection should also consider the space, format (circuit, timed rounds, etc.), and modifications needed for the session.

Observability: When programming exercise for a small group, the fitness professional will attempt to watch all participants at the same time. This is challenging. To minimize injury risk, the trainer should program one to two exercises at a time that require observation while keeping other exercises that are happening simultaneously simpler. For example, in a small group of three clients, one client is doing a back squat, one is doing push-ups, and the other is doing a plank. The back squat is the exercise the trainer will spend most of their time correcting and observing, while the other two exercises are less likely to need as much correction.

The larger the small group, the more challenging programming becomes. Small group trainers must master the skills of verbal cueing, precise exercise demonstration, motivating others, and attention to detail (e.g., exercise form, proper movement patterns, how to properly modify exercises, etc.) to be successful.

GROUP EXERCISE

Group exercise is a form of large group training that is often offered in a choreographed group format. Spin classes, kickboxing classes, interval-based group workouts, step aerobics classes, barre, Pilates, and many yoga classes are forms of group exercise. These classes are typically taught by **certified group fitness instructors** as opposed to the certified personal trainers in the previous styles of training. Group exercise classes often begin with a group warm-up and end with a group cooldown. During the workout session, all participants are doing the same thing in most cases (or may be split into groups doing the same exercises).

GROUP EXERCISE: Large group training that is often choreographed and where all participants are executing the same exercises simultaneously.

CERTIFIED GROUP FITNESS INSTRUCTORS: Fitness professionals certified in delivering large group fitness classes. These classes are often choreographed and require specific training in a particular class format.

Figure 18.4 Group Exercise Class

STARTING A PERSONAL TRAINING BUSINESS

When setting up a business, a fitness professional must consider the legal structure. A business's structure will determine who is involved in the business, each involved party's role in the business, when and how profits and expenses are divided, and how taxes will be paid. The structure also determines how liability is shared among the business and the responsible parties.

BUSINESS STRUCTURES

There are several common business structures a personal trainer can choose from. The ideal structure will be based on the number of individuals involved in the business and the needs of these parties. The four primary business structures are as follows:

- Sole proprietorship
- Partnership
- Limited liability company (LLC)
- Corporation

Sole Proprietorship

According to the **Small Business Administration (SBA)**, the **sole proprietorship** is the most common business structure in the United States. Businesses using this structure include coaching businesses, home-based companies, and retail businesses. In this format, the owner of the business has full control over the company's operations.

Sole proprietors are responsible for paying their own taxes and keeping business and financial records. The owners are also personally responsible for the debts and financial obligations of their business.

Partnership

As the name suggests, a **partnership** structure joins two or more people together to run a business. Each partner has an equal stake in the business's losses and profits. Each party is also responsible for paying taxes and record keeping.

A drawback of a partnership is that each partner is also personally responsible for the losses and financial obligations of the business and the actions of the other partners. To avoid communication issues, all agreements and changes to a partnership business should be documented in writing, legally reviewed, and signed by all parties.

Limited Liability Company

The **limited liability company (LLC)** is a relatively new business structure. LLCs can operate like partnerships, with multiple stakeholders that are referred to as members. As the name suggests, the members in an LLC are limited as to their liability for the financial obligations of the business. This makes the structure appealing for many business owners. However, some business types, such as banks and insurance companies, are restricted from forming LLCs for this reason.

SMALL BUSINESS ADMINISTRATION (SBA):
A US government agency established in 1953 to promote economic growth by helping new and existing small businesses and providing advice, financial assistance, counseling, and tips for sustainable business growth.

SOLE PROPRIETORSHIP:
The most common business structure, in which the single owner has complete control over and liability for a business.

PARTNERSHIP:
A business structure with two or more people running the business who share liability and responsibility for the business's performance.

LIMITED LIABILITY COMPANY (LLC):
A corporate structure in the US limiting the liability of the owner; it combines aspects of corporations and sole proprietorships.

CORPORATION:
A business structure in which the owners and operators are separated from the liabilities of the business.

Corporation

The **corporation** is the most complex of the four business structures. Owners and operators are shielded from liability in this business structure, and they are regulated by the local laws where they operate. Corporations have separate tax rates from other business structures, and the owners and operators within a corporation pay their own taxes.

The following are the two subchapters within corporations:

- **C corporations:** The business itself is liable for the tax burdens of financial losses and gains of the corporation.
- **S corporations:** The shareholders are responsible for the tax burdens of losses and gains.

WRITING A BUSINESS PLAN

Planning is an important stage in the process of starting a small business. It includes learning about competing businesses, the available market, and accessing funding. A business plan outlines the structure, marketing, and growth of a new business.

The SBA is an organization available to all small business owners and anyone interested in starting a business. The SBA offers resources such as consultants and business loans. Business experts help small business owners plan, launch, manage, and grow their operations. Most major cities have a local office.

According to the SBA, there are two types of business plans. The traditional business plan is detailed, time consuming, and useful for any new business owner looking to secure funding. It should provide detailed information about growth and financial projections so investors or banks can make funding decisions. A lean business plan is shorter and contains less detail. It is generally used internally for planning and is not shared externally with investors.

Traditional Business Plan

The traditional format is great for detail-oriented individuals looking for a comprehensive overview and plan for a new business. The following are the elements of a traditional business plan:

MISSION STATEMENT:
A short statement of why a business exists and their overall goal for operating.

- The executive summary includes the what and the why of the business. It should outline the basics of the financials, **mission statement**, vision, and products or services offered. It is an introduction or an abstract.

- A detailed company description and **market analysis** should be included and will explain the business's **target market** and give an in-depth look at local competitors. This should highlight the personal trainer's experience and anything that sets them apart from the rest of the market.
- The business plan should describe the business organization type. Many small businesses with just one or two owners are LLCs. The plan should describe the ownership structure and whether there will be employees or independent contractors.
- A comprehensive description of services offered should also include an estimate of **customer life cycle**.
- Marketing is also important in a business plan. All planned strategies for marketing should be outlined here.
- A traditional business plan is generally used to get funding, so it must include financial projections and funding requests. This part can be complicated and requires some specialized knowledge. It may be a good idea to work with an accountant or the SBA to determine how to develop this section. The financial projections must be based on data and be reasonable and attainable to secure funding from investors or loans from a bank.

MARKET ANALYSIS:
A qualitative and quantitative assessment of a business market that examines product and service volume, buying patterns, regulations, and business competition.

TARGET MARKET:
The particular group(s) of consumers that a product or service targets.

CUSTOMER LIFE CYCLE:
The steps a customer goes through when considering, buying, and using a product or service, including awareness, engagement, evaluation, purchase, experience, and bonding and advocacy.

Lean Business Plan

A lean business plan will include most of the same information as a traditional business plan but with much less detail. This type of plan is used primarily for the owner and any other employees to organize the structure, finances, and plans for future growth.

A lean format is appropriate for smaller businesses that will be starting quickly and offering few services. It should establish the products and services offered, the values of the company, how customers will find the business, marketing plans, and a brief study of the market and target audience.

Regardless of type, a business plan is an important step in starting a small business. It helps with planning and organization. New trainers should take advantage of resources during the planning process, including the SBA or a local chamber of commerce.

MARKETING A BUSINESS

Once a business has been structured and its ideal clientele has been identified, marketing the business is imperative. Marketing is essential for bringing awareness to a new business and attracting new clients. The first component of marketing is the creation of a business name, brand, and logo. Creating a name and look for a new business is a great time to also start considering the goals and a mission statement to help clarify the brand and goals. This is just the beginning of what a personal trainer needs to consider to market and grow a business. In fact, a large portion of any new fitness professional's extra time is spent marketing and attracting new clients.

In the initial stages of a fitness business, details such as these must be established:

- What are the business's services?
- Who is its target market?
- How does it offer its services (in person, online, or both)?
- What is the price for each service offered?
- How do people pay the business owners?
- Where will the fitness professionals train their clients (if applicable)?

TRAINER TIP!

Creating a Mission Statement

Every trainer should have a mission statement. It's a short explanation of who they work with, what they offer, and why they are unique—kind of like an elevator pitch. That's a short description that can be given to anyone who asks, "Why do you do what do you do?" or "What's your purpose?" The following are examples:

Nordstrom: to give customers the most compelling shopping experience possible.

Tesla: to accelerate the world's transition to sustainable energy.

A fitness professional: to deliver quality, effective, goal-focused fitness and wellness services.

Creating a Vision Statement

A vision statement is slightly different but just as important. It states the desired outcome that results from the business achieving its mission. The following are examples:

LinkedIn: to create economic opportunity for every member of the global workforce.

Facebook: to connect with friends and people across the world.

A fitness professional: to educate clients and improve longevity and quality of life through fitness.

HOW TO IDENTIFY THE TARGET MARKET

As the fitness industry continues to grow, it is crucial that trainers have a clearly defined target market. This will help set them apart from others in the industry. Creating a **client persona** is an important first step in identifying the target marketing and understanding the client life cycle. By understanding their ideal client, a trainer can do a better job marketing to these individuals based on who they are, where they live, their household income, and more. When developing a client persona, trainers should ask the following questions:

- Is this person male or female?
- How old is this person?
- What does this person do for a living?
- How much money does this person make?
- Is this person a parent?
- What is this person's current fitness level?
- What is this person's goal? To increase strength? Lose fat? Train for an event?
- What are this person's biggest challenges?

Here is an example of a client persona:

Mary is a 35-year-old woman. She is a new mom who works part-time at the local fabric store. Her husband is a high school teacher. Prior to pregnancy, Mary spent two days/week at the gym lifting weights. She ran outside for 30 minutes three days/week. Mary has spent 12 weeks on maternity leave and would like to lose the "post-baby tummy" and train for her first half marathon.

With this information, one would gather that the trainer likely specializes in postpartum fitness and fat loss for moms of middle-class income. Now that the trainer has put thought into who their ideal client is, they can make a plan to find and market to people who match their ideal client.

CLIENT PERSONA:
A fictional person that represents the key characteristics of a trainer's preferred clientele.

CREATING A BRAND

Defined as selecting a logo or symbol that is easily identifiable, **branding** is more than a graphic. A brand can elicit feelings from consumers. It can create anxiety or promote innovation. It can also differentiate one fitness professional from another.

In the fitness industry, and all industries, there are familiar brands that mean something. It may be a brand associated with bodybuilding culture or one that is closely tied to at-home fitness. This branding creates familiarity and an expectation. Those looking for a bodybuilding gym will know where to go and expect a bodybuilding look, feel, and culture.

BRANDING:
A name, logo or symbol that identifies and differentiates a product from other products.

Much consumer testing has been done to determine how people react to shapes, colors, and logos. Technically speaking, curves on a logo often are viewed as having a feminine connotation, while hard-edged shapes like triangles and squares denote stability and balance. Straight lines give the feeling of professionalism and organization.

When deciding on a logo, design specialists recommend the following:

- The brand should be defined "first."
- The competition's designs should be analyzed.
- A style and color scheme should be chosen (and stuck with).
- A font should be chosen and used consistently.

SOCIAL MEDIA AND ONLINE PRESENCE

Social media and a website are the hallmarks of modern marketing. They are necessary for a business to have success and growth. These are likely to be the two main pathways that lead customers to new businesses. As the owner of a small business, it can be tempting to combine existing personal sites and profiles with those of the company. Doing that should be avoided; it's better to keep separate accounts, websites, and social media profiles.

CALLS TO ACTION:
Marketing statements that demand an immediate response from the recipient—for instance, "Sign up now" or "Click here to learn more."

Business profiles and marketing materials must include frequent engagement opportunities through blogs, photos, teaser articles, informative posts, and **calls to action**. Calls to action are statements that encourage immediate action. These keep businesses relevant and in front of potential clients.

Business social media sites must be active with regular followings and linked to potential clients and relevant businesses and influencers. Using **hashtags**—social media tags that aid in online searches and finding content with a certain theme—and other fitness and wellness profiles can help a fitness professional connect with the target market.

HASHTAGS:
Social media tags users can create to help others find messages and posts with a specific theme or content.

Relevant and high-traffic social media platforms that personal trainers should consider using include the following:

- YouTube
- LinkedIn
- Pinterest
- Instagram
- Facebook
- Snapchat
- TikTok

Each platform offers a unique way to share credentials and services. They can also showcase results and client testimonials. These are typically free platforms that are small business friendly. Many also have paid options for accounts that provide opportunities for greater visibility, advertising, and targeting of potential clients.

POSITIVE SHAREABLE MARKETING MATERIAL

Using positive client reviews—with the reviewers' permission—is a great way to prove the value of a fitness professional's services and create inspirational and effective marketing content. Testimonials from clients, before and after photos, and client stories are effective attention-capturing tools for reaching new potential clients on social media and through a business website.

After a trainer has worked with a client long enough to build a relationship and for the client to see results, the trainer should consider asking them to leave a public review on a platform such as Facebook or Google. These online reviews provide credibility that will be visible to others who are in the early stages of the client life cycle.

A testimonial and **social proof** are great marketing tools in fitness. Testimonials can be written or in video form and detail a client's success or story with a trainer and their program. Social proof is a success story of a program or something similar to prove that the style of training works.

SOCIAL PROOF:
A success story of a program or something similar to prove that the style of training works.

With a client's permission, before and after photos or testimonials may be able to be used in marketing material and online outlets. Building a bank of testimonials is a good idea to establish trust in a brand and make sure people will recognize that brand as an authority.

Marketing materials and posts using client testimonials and stories should be positive, informative, colorful, and engaging. Trainers should encourage comments, discussions, and questions for these kinds of posts and reply promptly.

EMAIL MARKETING

PROSPECT:
A person who has shown interest in a product or service and is a potential customer.

Especially if a fitness professional offers online or virtual training, email is a huge communication and marketing tool. Emails can be sent to people in any stage of the client process, from inquiring to **prospect** to client. They can also be used to send and receive intake forms and various assessments like photos or weekly measurements.

The look and branding of a personal trainer's email communication should be in line with their logo and the definition of their brand. The colors, layout, and diction used should be consistent. Personal trainers can use email communication as a way to provide helpful information, nurture potential clients toward taking the next step (purchasing a product or service), and keep current and potential clients engaged. If a trainer isn't a fan of fad diets, they shouldn't trash them. Instead, they should offer valuable information and articles that support the eating patterns they know are successful.

Not every email should ask for something other than a reply. The most common email communication mistake is treating email as a one-way conversation. Trainers should invite replies with catchy subject lines and questions that require a response. The more a trainer can get someone to interact via email, the more engaged and interested that person will be.

Email Frequency and Length

What is sent via email is more important than how often it's sent. It's important to try different types of content and track what is most valuable and engaging to potential and future clients. Examples of content include informative content, blog articles, details pertinent to each client and their goals, and information answering a question a trainer may have received from a prospect. This type of email communication is what gets opened and read.

Although the content is most important, it is still imperative for a personal trainer to consider the frequency of their emails. Generally, two to three emails a week is optimal. But a few different email cadences should be trialed to determine what is most ideal for the fitness professional and their clientele.

Much marketing research has been completed to determine the optimal email length for effective communications. On average, an email with 50–125 words is ideal. Emails are long enough to offer something valuable but short enough to remain concise and not be visibly overwhelming. Even the subject lines matter. About 40 characters (not 40 "words") is the recommended length for an attractive email subject line. The text should be catchy and, in many cases, include a directive such as "New Video: The Hip Thrust Explained!"—36 characters.

Relationship Emails

Whether engaging with a current client for the 50th time or a prospect for the first time, effective email communication seeks to build a relationship. These emails are conversational, with the goal of delivering information or answering questions. Since many clients will often have the same questions, these emails can be easily made into templates and then customized before being sent, including, for example, questions regarding what to eat before and after a workout or information on posture assessments and how the trainer uses the results to tailor the client's program.

Short, concise text with minimal headers and graphics is best. People will begin to look forward to emails if they know they will be useful and pertinent to them. **Relationship emails** feel like sending a note to a friend.

RELATIONSHIP EMAILS:
Emails used to engage with clients and prospects and build a relationship.

Strategic Emails

Strategic emails explain why a fitness professional does what they do—training philosophies, program structure, the value a trainer provide to a client, and more about themselves. This is an ideal communication method for prospects and new clients. Without preaching to the reader, a trainer can outline their education and training strategies to better connect with the goals and needs of each client. This is a way to establish oneself as an authority in one's discipline and build trust.

STRATEGIC EMAILS:
Email communications that explain why a trainer does what they do, training philosophies, and more about themselves.

This email type is also easily templated for convenient access and use. A trainer should create a brief email that explains who they are and why they do what they do and keep it handy. Branding should be included for easy recognition. A trainer can also copy and paste bits of their philosophy email into other emails, such as promotional and reengagement emails, for consistency.

PROMOTIONAL EMAILS:
An email communication series that presents an offer or promotion for a limited time.

Promotional Emails

Just as the name implies, **promotional emails** present a product or service, build value in it, and then incentivize someone to purchase it. The most effective promotional emails are set up as a series of three to five emails sent over as many days. The initial email will present the promotion and generate excitement. The following emails will reinforce the promotion, solicit a response and questions, and highlight the end date of the promotion.

The request for a response and the end date are two of the most important aspects of a promotional email. When asking for a response, a fitness professional is offering to answer any questions a client may have. These questions may be the only thing stopping a potential client from signing up to train with them. Email does not have to be a one-way conversation. Prospects and clients who reply are often the most interested and closest to making a purchase.

The end date is important for several reasons. First, no promotion is infinite. The sense of exclusivity is lost if the promotion is always running. Second, it creates a sense of urgency. The psychological concept of the fear of missing out is real. Many people will rush to purchase something if there is a chance they will miss it. Finally, having an end date helps warrant the multiple emails that will be sent over a short period. Each email builds urgency and reminds the prospective client of what is being offered.

Then, when the promotion ends, fitness professionals should stay firm on the end date. The email series for that offer will end, and services and prices will return to normal.

Onboarding Emails

ONBOARDING EMAILS:
A series of email communications that gather the required documentation and assessments to begin a training program.

The onboarding process happens in multiple steps: paperwork, assessments, programming, then training. So, too, will **onboarding emails**. These emails should be set up as a series and always be authentic. The trainer should infuse their voice, philosophies, and personality into these emails. For those who train online, this may be the first and only way some clients interact with the fitness professional.

First, if there was a deliverable promised, it should be delivered in the initial onboarding email—for example, a free written workout, free session, video, or piece of content. Clients want to know that a trainer will deliver what was promised. These free sessions or pieces of content are at times used to create interest for those that have not made a purchase yet and to capture their contact information. This initial email is the ideal place to ask prospective clients such as these to make a purchase as well. Trainers should share promotions, if available, and ask for the sale. It is possible to turn onboarding emails into promotional emails over a few days if a prospect has not committed or purchased yet.

Once a client has made their purchase and is ready to train, the intake process should begin. When doing this by email, fitness professionals should send the required forms and information in smaller emails as opposed to one long email with several attachments. For example, over three business days, the following may be sent:

- Day 1: Client intake form, health history questionnaire, PAR-Q, and dietary log; the trainer should ask for them back by a specific day and request the client begin food logging for a specified number of days.
- Day 2: Training policies and client/trainer expectations; the trainer should clarify any questions.
- Day 3: Schedule assessments (video format or in person) as soon as possible; the trainer should communicate when the program will start and, after assessment, begin program design and delivery.

Ideally, this process will not take longer than a week. Clients are likely to be excited and ready to begin as soon as they make their purchase, and a trainer must capitalize on this urgency. However, outlining clear expectations and timelines in the initial emails will help clients understand the process. For example, explaining training philosophies will help a new client understand what the forms are for, what the trainer gathers from assessments, and why injury prevention and effective programming are both important.

Reengagement Emails

It is important not to forget about previous clients or **leads**. Some clients may leave a trainer if they deem their services were not effective for them. For others, it may simply be timing. They might have moved, changed jobs, or had some other circumstance out of their control. **Reengagement emails** reach back out to former clients and prospects a trainer has lost touch with to see if they are interested in rejoining.

LEADS: Potential clients not yet using a professional's services.

REENGAGEMENT EMAILS: An email communication method to reach out to former clients and prospects and encourage a reply.

Use short emails that ask for a response. Here is an example:

Subject Line: Hey, Brian! Are you still training?

Body: Hey, Brian!

It's Sarah from Monner Training! I'd love to have you back in the training group on Saturdays! Are you interested?

Yours in health,

Sarah Monner

This communication is short, is to the point, and asks for a reply. If the recipient is interested, they will likely reply with an affirmative and ask for more information. If they are not interested, they will likely reply with a no or not reply at all. There is no harm in asking. If the timing was not right or the recipient is still interested, this email will help reengage them back into dialogue. For those not ready to commit, a trainer can reenter them back into their list of emails they send periodically—informational, strategic, or promotional.

COLLABORATING WITH INFLUENTIAL PEOPLE

Just as a trainer works to build relationships with their clients, it is also important to build relationships with people in the community. Introducing others to a brand authentically, in nontraditional marketing ways, offers many benefits. For example, a hairstylist at a high-end salon talks with many people every day. If these are affluent people who are willing to spend time and money on their appearances and luxury services, they may also be interested in hiring a personal trainer. A trainer should consider offering an occasional complimentary session to someone who's influential, such as a hairstylist. Trainers should actively connect with other professionals who share a similar target market. The following examples generally have client crossover with the fitness industry:

- Hairstylists
- Chiropractors
- Physical therapists
- Nutritionists

Similarly, by hosting a complimentary group exercise class for this individual and their clients, a trainer will have the opportunity to connect with several potential clients. It will be a win-win for the hosting professional (a free class for their clients) as well as the personal trainer.

THE CLIENT LIFE CYCLE

A fitness professional must understand the steps the average client goes through when considering, buying, and using personal training services—the client life cycle. Each step is important for attracting and converting potential clients, providing them with a positive and productive fitness experience, and keeping them engaged and motivated to continue to employ a trainer's services.

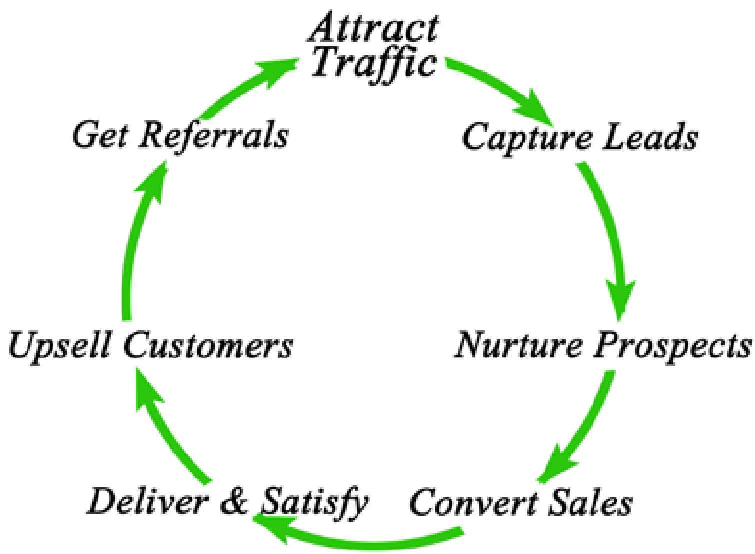


Figure 18.5 Perfect Customer Lifecycle

ATTRACT NEW POTENTIAL CLIENTS

The fitness industry is seasonal, and there are expected ebbs and flows in the business. For example, many new clients hire fitness professionals in January as they set and commit to health-related New Year's resolutions. Conversely, many personal trainers will see a reduction in client sessions completed, income, and training interest during November and December, as there are several holidays at this time of year when clients may be traveling or less available. Similarly, dips in business may also be seen in May and June, as this corresponds to many children getting out of school for the summer and an increase in family travel.

Finding potential new clients, also known as leads, can be a daunting challenge. There are many different ways to market, and when starting a business, marketing budgets are generally small yet manageable. Many trainers likely cannot afford to create television or online advertisements to market themselves. However, social media apps now have less expensive but highly effective advertising options available.

To combat the seasonality of the fitness industry, a personal trainer should always be looking for and working to attract new potential clients. This can be done with marketing and advertising both in-person and online, reaching out to interested individuals to set up initial training sessions (often free of charge), or encouraging paying clients to bring or refer their friends and family. **Client referrals** are a powerful tool for building and growing a personal training business.

CLIENT REFERRALS: A method of marketing where current or former clients refer friends and family to a professional for services by word of mouth.

CAPTURE LEADS

There are many ways to generate leads. From websites and social media to in-person events and trade shows, fitness professionals encounter prospective clients all the time. If a trainer is not generating leads, there is a good chance their business is “not” growing.

Many leads that a fitness professional will encounter will not sign up to train with them immediately. When a trainer meets new leads, the key is to collect their information so they can be contacted about the trainer’s services. Email lists, referrals, and business cards from the leads should be used to collect the contact information of people who are interested in the trainer’s services (or whom the trainer feels could benefit). Then it’s easy to reach out with offers, information, and valuable content to establish the fitness professional and what they do. This is the first step in nurturing leads.

NURTURE AND CONVERT LEADS

Once leads are collected, the nurturing process begins. In marketing for any industry, nurturing leads is the process of building and reinforcing a relationship with a buyer (or potential buyer) throughout the sales process. Specifically, before the lead purchases anything from the trainer, they can be nurtured with periodic contact via phone, text, or email and sent valuable (and free) information that applies to their goals or invitations to seminars, workout sessions, or workshops. The goal of nurturing leads is to ensure they understand what services the fitness professional offers and allow the lead to interact with the trainer, ask questions, and see value in their services. The goal is lead conversion—a lead moving from someone who’s interested to someone who purchases something from the fitness professional. They may complete a one-time purchase or commit to an ongoing training program based on what they have found value in.

HOW TO CREATE VALUE

Creating value is an essential component of a successful business, regardless of the industry. Potential clients are considering whether they should invest their time, money, and attention in return for an anticipated result. It’s important for a personal trainer to share their personal story and their “why” behind what they do—a client who resonates with that will want to know more.

But more importantly, how does what the trainer does and why the trainer does it help the potential client? What does the client get out of it? What can the trainer do for the client that is worth the investment? The trainer should consider the following:

What is the tangible value of working with a trainer?

- I am hiring an expert.
- I am hiring someone who has experience leading others to a similar goal.
- I am hiring someone who can develop a plan for me.

What are the issues working with a trainer helps solve?

- I do not feel comfortable working out by myself.
- I cannot seem to hold myself accountable for healthier habits. I've tried many times and failed.
- I do not have a person in my life who encourages a healthier lifestyle.
- I try to eat well and work out, but I don't know what I am doing.

The way a personal trainer communicates this information in their marketing resources and when communicating with potential clients is one of the keys to their lead conversion.

INITIAL ASSESSMENT

When the client is ready to commit to the program, the initial assessment can take place. Client forms (subjective assessments) will be provided to the client during the initial assessment. During this assessment, it is also important for a fitness professional to spend time getting to know a client and learning their goals. This allows trainers to create programming that's customized and based on someone's personality, likes, and dislikes. The more thorough the initial assessment is and the more information that's gathered about the client, the more customized the program will be. Fitness assessments are an important part of establishing a baseline fitness level and should include the following:

- How the client heard about the program
- Health history questionnaire
- Liability waiver
- PAR-Q
- Physician's release, if necessary
- Fitness assessments
- Goal setting

This is also a good time for the personal trainer to set expectations for the program. For example, a trainer should be sure a new client understands their refund policy (if applicable), their cancellation policy for training sessions, and how and when to contact the trainer during the program.

DELIVER SERVICES

Once the lead has become a paying client and expectations have been set, the trainer can add the client to their schedule and deliver their services. It is important that any promises made during the nurture and conversion processes are fulfilled promptly. For example, if a trainer offers a free written workout or a free shirt upon signup for 12 training sessions, they should ensure it is delivered immediately upon the client's enrollment into the program.

UPSELL CLIENTS

UPSELL:
A sales technique where a client is encouraged to purchase additional services, products, or add-ons to generate more revenue.

Throughout the client life cycle, the trainer has an opportunity to **upsell**. An upsell is a technique used in sales where a client is encouraged to purchase additional services, products, or add-ons to generate more revenue—for example, selling supplements, apparel, or other services such as nutrition guidance or physical recovery sessions to clients once they have begun their program. Upselling is an opportunity to present additional options, products, and services that provide value to the client and their goals. These extra offerings also serve to increase a client's commitment to their program since they are investing additional money toward it.

FOLLOW-UP ASSESSMENT

Follow-up assessments should happen throughout the program and are a valuable component of the personal training experience. Not only is this helpful for tracking progress, but by revealing and discussing the outcomes with a client, the trainer also increases the likelihood that a client will renew their package. Follow-up assessments should include the following:

- Revisiting existing goals
- Fitness assessments
- Setting new goals
- Action plan
- Recommitment
- Reinvestment

GET REFERRALS

A referral is an important and valuable way to build a personal trainer's clientele. When a current or past client refers friends or family for services, it means they trust the trainer and value the services they offer. Referrals may even come from someone who has never been a client but had a positive interaction with a fitness professional at a workshop, the gym, or a seminar, for example. All interactions a personal trainer has with current clients or leads are important. Even those interactions that do not end in an immediate sale could lead to a referral.

When to Ask for Referrals

Any time can be good to ask for a referral or testimonial. But people are most excited about a trainer's services when they are seeing results and making effective lifestyle changes. It is advantageous for a trainer to leverage that excitement to get a quote or review for marketing or to ask for a referral. The client may have family or friends who admired their progress and showed an interest in the fitness professional's personal training services.

A trainer can ask for more information about the people a client knows so they can create offers targeted at those who are interested. For instance, if a client talks about a friend struggling with losing weight and setting goals, a personal trainer may ask more about the situation and offer an opportunity to bring a friend for free on a future training date. This can allow the personal trainer an opportunity to make a connection with the friends of their clients and provide a unique offer that encourages those friends to sign up.

Some trainers find success in offering rewards for referrals. It could be as simple as an entry into a monthly drawing for apparel or gift cards or a free session if the referral makes a purchase. A reward can be an effective, an inexpensive, and a motivating way to drive the referral process.

Quick follow-up with referrals is essential to act on interest in the moment. People are easier to talk to—and objections are easier to overcome—when they are excited and highly motivated to change.

Promoters versus Detractors

When building a reputation, personal trainers and small business owners encounter two types of people:

- Promoters are those who had positive experiences with a fitness professional and their services. They are happy with their results and will likely refer friends or family.
- Detractors are unsatisfied with their interactions with or services provided by a fitness professional. Detractors will usually make themselves known quickly. It is important to directly reach out to any detractors as quickly as possible to hear their concerns, empathize with them, and, if possible, offer a solution.

Conducting periodic surveys of current, past, and potential clients can provide useful information on the effects of marketing materials, a fitness professional's social media presence, and client satisfaction.

THE IMPORTANCE OF CLIENT RETENTION

Trainers must invest time and attention with each potential and existing client. The effort it takes to recruit a new client is greater by far than the effort it takes to maintain an existing one, given the trainer is fulfilling their role and the expectations of the client. Consistently creating value and creating a positive experience for clients are key components in retaining clientele.

CLIENT ACCOUNTABILITY

Accountability is one of the main reasons a client hires a personal trainer. Putting together an amazing health and fitness game plan is part of the experience when working with a trainer. But the results come from executing and following through with the plan. It has been shown that having a coach in most any endeavor will improve results. This is true in personal training. Whether a client is meeting with their trainer virtually or in person, showing up for another person is a big step that will become easier over time and with a trainer who brings value.

RELATIONSHIP BUILDING

Putting the “personal” in personal training creates rapport and builds trust between the trainer and client. A trainer’s work goes beyond a 30-minute workout. During this time, clients tend to open up about their work life, homelife, what stresses them out, and what they do for fun. The following tips provide value and will strengthen the relationship, leading to long-term commitment and client retention:

- Listen actively.
- Say and do things that reflect the client was heard.
- Recognize their birthday.
- Email articles and tips that are of interest to them.
- Perform weekly check-ins through text or email.

RENEWING CLIENT PROGRAMS

When a client is nearing the end of their package of sessions or subscription (in the case of a month-to-month contract), there are multiple ways a trainer can encourage a renewal. It is not the client’s responsibility to ask what the next steps are. Instead, a personal trainer should be actively selling the renewal before the final session. Additionally, it is a good business practice to plant the seed of a potential renewal to give clients time to plan their finances accordingly.

One way to pique a client's interest in additional training is to reference the progress they've made. Recognizing their hard work reinforces that the sessions are effective and that their financial investment, along with their time, has been well spent. Using future-based language and referencing what they will be doing "next month" or "in another eight weeks" will help them set their sights on future goals and future progress and make the necessary financial arrangements to continue investing in their trainer. Periodic reassessments can reinforce the value of working with their trainer. Knowing they performed two push-ups at the start of the program and now they can do six push-ups is extremely valuable. Trainers should spend time recognizing their progress and giving an overview of what that means for the next several weeks.

MANAGING A PERSONAL TRAINING BUSINESS

Selling and servicing personal training sessions are what a personal trainer does when they are working the business. Tracking the finances of the business, documenting client contracts, marketing their programs, and evaluating their business as a whole is what a personal trainer does when they are managing their business. Being a proactive and organized manager of the business will ensure continued success and growth along with a positive customer experience.

SCOPE OF PRACTICE

One of the most important components of a personal training business is understanding and staying within the **scope of practice**. Throughout their careers, trainers will come upon various scenarios that may be outside their scope of practice. Trainers should familiarize themselves with their scope of practice in this role. Stepping outside their role as a trainer can put them at risk of becoming responsible for the information or advice they shared. The following are common conditions that are present in the personal training setting. If personal trainers encounter a client or potential client with any of these conditions, they should not give advice or make a diagnosis but refer them to the appropriate professional.

- Injuries
- Medical concerns
- Eating disorders
- Mental illness, including depression
- Specific meal planning

SCOPE OF PRACTICE:
The practices, procedures, and actions a personal trainer is permitted to undertake in keeping with their professional certification.

TRACKING TRAINING SESSIONS

Just as each trainer has a unique training style and approach, their preferred tracking method should be what works best for them. There are various options when it comes to tracking sessions, all of which help maintain organization. The simplest method includes using a pen and paper. Websites, apps, and software programs can be highly useful, particularly as the business grows. This makes it possible to track sessions or client notes on one's smartphone or tablet. Software programs can also help trainers manage their revenue, costs, and expenses, which can be developed into a **profit and loss statement** (P&L statement).

PROFIT AND LOSS STATEMENT:
A financial statement summarizing revenues, costs, and expenses in a given time period.

FINANCIAL CONSIDERATIONS

Regardless of how great a trainer is at building relationships and bringing value to their clients, if they are not financially savvy, their business will struggle. Personal trainers must consider their expenses when establishing client rates. The following expenses are often overlooked and should be considered early in the business's startup:

- Paid social media ads
- Time spent marketing
- Time spent preparing client sessions
- Equipment (resistance bands, weights, mats, etc.)
- Certification renewal
- Continuing education
- Cardiopulmonary resuscitation (CPR)/automated external defibrillator (AED) and first aid certification
- Rental space
- Paying to park during sessions
- Liability insurance
- Business license

SALES

While not everyone is comfortable "selling," it's a skill that can be improved with practice. Going into a sale with a financially focused mindset can provide additional drive and determination. However, there's more to it than financial motivation. Here are the three ways a personal trainer can improve their ability to sell:

One: Focus on bringing value. Rather than asking "What's in it for me?" a trainer who emphasizes service, value, and quality will have a strong foundation of credentials that increases the likelihood of a client purchasing packages.

Two: Don't use high pressure. Just as a trainer wouldn't expect a new client to perform 60 seconds of burpees on day one, they also shouldn't expect someone to purchase a package right away either. As indicated in the customer life cycle, it takes time to convert a lead into a client. People want to learn more about a trainer's services before they sign up with them. Talking with the client, answering their questions, and showcasing one's expertise will warm them to the idea of purchasing a package.

Three: ASK! If someone hasn't purchased a package yet, it doesn't mean they aren't ready to. Sometimes life happens and their schedule, family, or work matters take over. Stay in touch, and when all else fails, a trainer should take the assertive approach and ask for the sale. A simple "Let's get started. When are you available for the first session?" might be all the encouragement they need to seal the deal.

As the sale is made, fitness professionals should have a professional contract ready for the client to sign. The contract is a way for both the trainer and the client to agree to the terms of the program. These terms can include the following:

- Cost of the services
- Number of sessions purchased
- Cancellation policy
- Future payment dates (in the case of a payment plan)

CONSIDER OTHER PRODUCTS AND SERVICES

When it comes to personal training, the possibilities are endless. From one-on-one training to group exercise and virtual workouts, the fitness industry continues to grow. The following are additional revenue streams that trainers can tap into while sharing their expertise and building credibility:

- Collaborating through paid social media posts with fitness and wellness brands
- Contributing blog content to fitness and wellness brand websites
- Creating fitness programs for clients to do on their own (this is an affordable way to introduce them to the programming, which may lead them to purchase a full one-on-one package)
- Writing and selling an e-book
- Writing and selling a recipe book
- Selling online courses
- Hosting fitness retreats or camps
- Hosting workshops

PERSONAL TRAINING BEST PRACTICES: ADVICE FROM SEASONED FITNESS PROFESSIONALS

Becoming a personal trainer means learning the science of the human body to be able to act as an expert in the field of human movement. A personal trainer can go so far as to obtain a PhD in exercise physiology or biomechanics. This level of subject matter expertise can serve a personal trainer well, as it is this knowledge that can create expert-level exercise programming. This is only part of the equation when it comes to the success of most personal training careers. There is more to the job than just subject matter expertise. Other pieces of knowledge, skills, and abilities lend themselves to career success in this field. This section highlights some of those that are common among successful professionals.

BE ORGANIZED AND USE A SCHEDULING TOOL

Many of the best trainers are organized trainers. These trainers typically have systems they use to keep themselves organized. A filing system for current and potential clients (hard copy or virtual) allows for good record keeping. This can help a trainer manage the long-term plan related to the client's fitness goal and keep track of potential or new clientele. Creating a plan for each day and each training session is necessary so every session is personalized and thought out. Minimally, a general outline of the day's workout should be prepared.

Time management is key as a personal trainer. Using a scheduling tool becomes a necessity as one becomes busier and is juggling several appointments daily. Examples of scheduling tools range from simple appointment books to more technology-based websites or mobile phone applications. Trainers must manage the scheduling of their appointments with clients along with scheduling time to dedicate toward developing their business. A growing business does not happen accidentally, so using a tool to schedule time for finding new leads, following up with old leads, and marketing oneself is also necessary. It's important for fitness professionals to also manage the parts of their lives that are outside their businesses. Using a scheduling tool to set aside time for meals, workouts, dentist appointments, and so on helps trainers ensure that time in their businesses and lives is organized, without conflict, and accounted for.

TRACK CLIENT RESULTS

Clients, in general, hire a personal trainer to achieve goals. Many of those goals are measurable goals. As covered in the Assessments chapter, a personal trainer can assess and track metrics such as weight, bodyfat percentage, circumference, strength, and endurance. While working with a client, the personal trainer should also track how clients perform during their workouts, if they are completing other tasks related to their program (such as completing a daily walk), or if they are doing their workouts at all.

All this information plays an important role for the trainer and the client. For the trainer, it acts as a tool to coach the client, track progress, or indicate that changes need to be made. For the client, it can confirm that their hard work is paying off or help them see they are not holding themselves accountable to the process.

BE ON TIME

Being on time is not only an expectation clientele and employers will have, but it is also a necessity for the personal trainer to ensure preparedness and organization. If a trainer has an appointment starting at 8:00 a.m., on time does not mean 8:00 a.m. for the trainer. They should be present and preparing beforehand. If this 8:00 a.m. client expects to have the session completed and move on with their day by 9:00 a.m., then on time also means completed on time. To be prepared and organized, many employers will recommend a 10- to 15-minute buffer prior to starting a personal training session. If a trainer has several appointments scheduled back to back, it becomes more important that the trainer is prepared for their clientele before the start of those sessions. Additionally, it's critical that the trainer manage each session so they end with time to spare to prepare for their next client.

MEET AND NURTURE LEADS

A common misstep personal trainers make in growing their business is failing to manage their leads. Often, trainers in a health club setting will meet new members (potential new clients) and set complimentary appointments with them to discuss goals and possibly take them through a workout. Things may go well, but the new member may not be ready to hire the trainer. This is where the mistake happens: lack of follow-up. The trainer has spent time and energy starting a relationship but then does nothing to nurture and further the relationship. Potential clients become actual clients when they trust the trainer enough to pay for their services. Sometimes that trust must be built over more than just one complimentary session.

The personal trainer must have a system in place for keeping track of their leads. Minimally, as they meet new potential clients, trainers will want to track their names, contact information, and results of their last contact with them. Over time this list can become long, and in terms of building a business, it is in the best interest of the personal trainer to be able to follow up with people they have already interacted with and have some level of rapport with. The alternative is continually meeting new people and never speaking with them again.

PRACTICE SELF-CARE

As a professional in the health and fitness industry who will be coaching clientele toward a healthy and fit lifestyle, the personal trainer must practice what they preach. This does not necessarily mean big muscles, a low bodyfat percentage, or impressive athletic feats. What it does mean is a lifestyle that includes a healthy personal exercise practice, nutrition that helps the trainer feel their best, and rest and recovery that lets them show up every day ready to serve their clients. This can lend itself to their credibility as a professional. Additionally, managing their hygiene and appearance play a role in how clients and potential clients may perceive them. Trainers are often viewed as sources of inspiration and people who set a high standard of health and fitness. Managing how they present themselves to the public can have a significant influence on how they appear to potential clients.

CONTINUING EDUCATION AND PERSONAL DEVELOPMENT

The health and fitness industry has evolved greatly over the years, and so has our understanding of the science involved in optimizing human health and performance. Because of this, the personal trainer must continue their education to not only broaden their understanding but also stay current with the latest industry developments.

Continuing education can offer trainers the ability to specialize within the profession. Some personal trainers specialize in strength and conditioning, golf performance, rehab-based training, and youth exercise. Continuing education can also offer personal trainers the opportunity to become better businesspeople, learning leadership and management along with entrepreneurial topics.

As the industry continues to evolve, more and different opportunities are becoming available. Those who seek education and evolve with the industry will be those most suited to succeed. Industry newsletters, conferences, and educational companies such as ISSA are some of the best resources for staying up to date.

PERSONALIZING THE TRAINING EXPERIENCE

Excellent customer service should be a consistent component of the personal trainer's role with current and potential clients. Being prepared and on time are the minimal standards of customer service. To further improve the customer experience for clients, adding a personal touch is highly recommended. Here are some examples of how to personalize the training experience:

- Acknowledge special occasions
    - Birthdays or holidays (special themed workouts, birthday cards)
    - 100 sessions completed
    - Achieving a goal
- Have items on hand for clients (especially if they forget to bring them)
    - Water
    - Towels
    - Hair ties

MAINTAINING APPROPRIATE RELATIONSHIP BOUNDARIES

The relationship between a trainer and their clients can at times be a close personal relationship. First and foremost, it is a professional relationship. This professional relationship entails the communications and interactions relevant to the goals of the client and the trainer's role. Maintaining a clear separation between the professional relationship and anything more personal is the responsibility of the trainer. Preserving this boundary helps the trainer maintain a professional reputation and keeps them protected from any potential liability. Some additional tips that can help personal trainers set and maintain appropriate boundaries include the following:

- Establishing appropriate avenues and times for client communication
- Being mindful of discussing sensitive or personal subjects
- Being clear about and enforcing established policies
- Staying within the scope of practice
- Maintaining appropriate levels of privacy if sharing personal life details

CODE OF ETHICS

CODE OF ETHICS:
A set of guiding principles that drives the actions of a professional.

A **code of ethics** is a set of guiding principles that drives the actions of a professional. It identifies the best practices for honest, fair, and equitable service for all parties involved—the coach and the client.

The code of ethics covers standards from each of these five categories:

- **Integrity:** being straightforward, honest, and transparent
- **Objectivity:** remaining unprejudiced and avoiding conflict, bias, or outside influence
- **Professional competence:** committing to education and professional knowledge to improve coaching skills throughout one's career
- **Confidentiality:** protecting the privacy of clients in all forms
- **Professional behavior:** acting to build and preserve one's reputation as a health coaching professional

ISSA CODE OF ETHICS

The ISSA Certified Personal Trainer shall do the following:

- Act with integrity in relationships with colleagues, peers, and other health care professionals.
- Maintain a professional client–trainer relationship at all times. Personal training professionals have the obligation to properly assess clients, program for their needs, educate them, and provide health care referrals as needed for their best interest.
- Refrain from soliciting business from another professional's clients or students.
- Respect the client's choices and decisions about their own health and provide accurate, factual information.
- Truthfully represent their education or credential(s) to ISSA, clients, or an employer and work inside their scope of practice.
- Do not discriminate on the basis of sex, gender, race, religion, national origin, color, or any other basis deemed illegal.
- Maintain any and all primary and supplementary certifications (including CPR certification as required) that are necessary to execute their job.
- Uphold their social responsibility to promote diversity and inclusion and educate and inform within the scope of practice.
- Use their best judgment to maintain a safe training environment for clients. This includes the space being used and the recommendations being offered. At no time shall harm to others be intended.
- Accurately represent their services and what is reasonably expected from a training relationship with clients.
- Keep up to date on new developments, concepts, and practices in the wellness industry to promote professional excellence.
- Maintain a strict level of privacy and confidentiality with patient information and programs.
- Maintain a clean appearance that is consistent with good hygiene and appropriate working attire.

CHAPTER 19

SAFETY AND EMERGENCY SITUATIONS

LEARNING OBJECTIVES

1 | Explain the purpose of a CPR/AED certification for a fitness professional.

2 | Identify recommended safety equipment that should be in a fitness facility.

3 | Describe the most common emergency situations a personal trainer may encounter.

4 | Identify instances when emergency services should be called.

DISCLAIMER

Under no conditions does ISSA accept responsibility regarding any consequences that stem from the use of the information provided in this safety and emergency situations chapter.

The following information is provided as a study aid and is not intended for use as a first aid manual. The following information is intended as information for safety awareness and is in NO way to be used as a substitute for CPR, AED, or first aid training, OSHA compliance, job training, or for proper equipment use.

During exercise, remaining safe means following a proper warmup and cool down protocol, using proper form, and challenging the body with appropriate resistance and workloads. Safety also applies to the environments where exercise takes place. Fitness professionals must be aware of common and potential safety hazards and situations, how to address them, and understand their role in keeping themselves and clients safe during activity.

OWN THE FITNESS FLOOR

Fitness professionals work in a variety of environments and facilities. The area where clients exercise is often called the 'workout floor'- or 'the floor' for short. This area is where a personal trainer will spend most of their time when working with clients. When they are not training clients, they will still be out on the floor taking care of the equipment, meeting and engaging with members, prospecting for new clients, and selling products and services.

Regardless of the type of environment a personal trainer works in, there are safety and cleaning duties that need to be tended to on a regular basis. Some of these include:

- Keeping all equipment clean
- Ensuring all equipment is in working order
- Properly storing equipment that is not in use

EQUIPMENT CLEANLINESS

Fitness equipment is touched and used frequently in most cases. While most fitness facilities ask clients to clean equipment before and after use, this does not always happen. Regularly cleaning fitness equipment like weight machines, dumbbells and barbells, and mats with cleaning and sanitizing chemicals can reduce the number of bacteria, dirt, and contaminants that can make clients and employees sick. Cleaning also offers a trainer the opportunity to look at equipment and identify machines or tools that need repair or replacement.

It should be differentiated that cleaning and sanitizing are not the same thing. Cleaning can be done with soap and water while disinfecting and sanitizing require the use of chemicals. For clarity, each are defined by the U.S. Center for Disease Control and Prevention (CDC):

- **Cleaning**- Removing dirt and impurities from surfaces or objects with a detergent (like soap) and water. Cleaning does NOT kill germs, but it removes them and lowers the risk of spreading infection.
- **Disinfecting**- Killing germs and virus on surfaces or objects with the use of chemicals. Disinfecting does not necessarily remove the germs from the surface when it kills them, but it lowers the risk of infection.
- **Sanitizing**- Cleaning and killing germs on surfaces or objects enough to bring the microbe level to an acceptable range.

Sample Safety and Cleanliness Checklist for a Fitness Facility.

FACILITY FLOOR

- ☐ Clean and free of loose debris or equipment
- ☐ Wooden floor is free of dust, splinters, or protruding nails or screws
- ☐ Carpets, rubber floors or interlocking mats are secure and free of tears, gaps or bulges
- ☐ Walking paths are clear of wires (plugs for cardio), small exercise tools and other debris

WALLS

- ☐ Electrical outlets or wires are not protruding in activity areas
- ☐ Walls, mirrors and windows should be cleaned daily.
- ☐ Mirrors are not cracked or distorted and are securely fixed
- ☐ Mirrors should be at least 20 inches off the floor. Equipment should be placed at least six inches from the mirrors.

CEILING

- ☐ Maintain all light fixtures and replace any broken or non-functioning bulbs.
- ☐ Replace any missing ceiling tiles and cover exposed ducts or pipes.

EXERCISE EQUIPMENT FOR STRETCHING AREA

- ☐ Mats should be cleaned and disinfected prior to heavy use times of day
- ☐ The floor should be free of loose debris or equipment.
- ☐ Restore all equipment to its proper place.

AEROBIC OR PLYOMETRICS AREA

- ☐ The floor should be free of loose debris or equipment.
- ☐ Restore all equipment to its proper place.
- ☐ Ensure all the equipment is in working order

EQUIPMENT FUNCTIONALITY

Fitness equipment can range from simple, like a dumbbell or kettlebell, to complex, like a cable cross machine with many different parts, pulleys, and cables. For safety and functionality, it is important that all fitness equipment is kept in good working order. Loose pieces or equipment that is not operating properly can cause injuries to users and impair the function of a machine. For example, any machine that uses cables will have altered resistance if the cable coverings are torn or frayed. Similarly, a seat that has torn fabric or a dumbbell with a loose handle can pinch skin or cause cuts or lacerations during use.

Often, simple equipment maintenance and the identification of needed repairs falls on the fitness professional. More complicated repairs, reupholstering, and parts replacements are typically handled by a maintenance team, or a professional fitness equipment care company.

Many fitness facilities will have a reporting process for broken or damaged equipment. For example, entering the equipment number, a description of the damage, and the date it was first identified into a log that maintenance or a manager checks daily. If a trainer is working for themselves, they will need to establish their own processes for identifying, replacing, and repairing broken fitness equipment.

EQUIPMENT STORAGE

Exercise equipment should be stored appropriately with the goal of minimizing safety or trip hazards and prolonging the life of the equipment. This means storing smaller equipment in a safe, appropriate location like a hook on a wall, a designated weight rack, or in a basket. This also applies to the storage positions for larger, stationary equipment like treadmills, large machines, and stationary bikes for example. Larger equipment should be set to the off position (turned off or unplugged if preferred) with all accessories stored properly.

In the case of a stationary bike, for example, many facilities prefer the seat and handlebars to be set to the lowest position and gears released for manual bikes. This neutral position takes tension off the gear system and makes use easier for the next person.

For plate-loaded equipment, all plates should be stored on the appropriate weight trees when not in use. Plates should not be left on the floor, in walkways, or leaning against equipment where they pose a trip hazard or could fall and smash a foot.

Fitness professionals who work in a facility will often be tasked with walking the gym floor and picking up stray fitness equipment. Every opportunity on the floor is a chance for a personal trainer to prospect for new clients regardless of the tasks they are completing. In many cases, a trainer will also clean any dirty equipment they come across and take time to engage with members, clients, and guests as they pick up and store equipment.

CARDIOPULMONARY RESUSCITATION (CPR): An emergency procedure involving chest compressions and, often, artificial ventilation to circulate blood and preserve brain function in an individual in cardiac arrest.

AUTOMATED EXTERNAL DEFIBRILLATOR (AED): A portable electronic device that can identify and electrically correct heart arrythmias, ventricular fibrillation, and tachycardia.

CARDIAC ARREST: An electrical malfunction of the heart that causes irregular heartbeat.

CPR CERTIFICATION

It is a basic requirement for a certified personal trainer to have a certification in **cardiopulmonary resuscitation (CPR)** which is often combined with training on how to use an **automated external defibrillator (AED)**. A CPR and AED certification teaches a personal trainer how to identify risk factors for emergency health situations like **cardiac arrest** or injuries. It also prepares a fitness professional to provide potentially life-saving aid in the event of an emergency in the fitness setting. This requirement is necessary upon initial certification and for the renewal of a Certified Personal Trainer (CPT) certification.

Figure 19.1 Chest Compressions for CPR

CPR is an emergency procedure used to manually preserve respiration and heart function in an individual who is in cardiac arrest. It involves chest compressions and, in some cases, artificial ventilation (breathing) to keep the victim's blood oxygenated and circulating.

An AED is a portable device that is used before or during CPR to diagnose the status of the heart. Specifically, an AED can identify if someone is experiencing a life-threatening arrythmia (irregular heartbeat), ventricular fibrillation (rapid fluttering of the ventricles), or tachycardia (rapid heartbeat). Many businesses, schools, and office buildings have at least one AED on site. When working in a fitness facility, it is important to identify (1) if the facility has an AED and (2) where it is located in case of emergency.

Figure 19.2 Automated External Defibrillator (AED)

Many organizations offer CPR courses, including ISSA. In the U.S., The American Heart Association and the Red Cross are common CPR course administrators. Contact your local CPR administrator for more information on in-person and online CPR courses offered near you that will meet your individual needs.

www.redcross.org

www.americanheart.org

THE GOOD SAMARITAN LAW

The **Good Samaritan Laws** are legal protections offered for people who provide reasonable assistance to someone who they believe to be injured, ill, or incapacitated. These laws are applicable in most of the United States and some areas of Canada. In many other countries, these laws and protections do not exist. The challenging part is that these legal protections vary by local jurisdiction. However, in all instances, the four basic components of the Good Samaritan Laws are:

1. Permission can be given by the injured or ill person if possible.
2. Assistance or care was provided in an appropriate manner (not recklessly).
3. The person protected by the Law was NOT the person who caused the accident.
4. Care was provided because it was an emergency and trained aid had not yet arrived.

Under these protections, the individual providing aid cannot be sued for additional injuries

GOOD SAMARITAN LAWS:

Legal protections offered in much of the U.S. and Canada that protect an individual who offers assistance, CPR, or first aid to someone else in an emergency situation before trained help arrives.

caused during a rescue attempt. For example, broken ribs that are a result of chest compressions during CPR are relatively common. If a victim sustains broken ribs from a rescuer providing CPR, the rescuer may be legally protected from liability for this additional injury. This policy is in place to encourage people to help one another in emergencies without the fear of repercussions. This is not intended as legal advice and should not take the place of advice from a qualified legal professional.

INJURY PREVENTION

ACUTE INJURY:
Describes a type of injury or an illness that is of rapid onset and progression.

CHRONIC INJURY:
Refers to an injury, illness, or disease that develops slowly and is persistent and long-lasting.

Part of ensuring a positive and safe experience for clientele is taking the proper steps to prevent injury. **Acute injury** describes a type of injury or an illness that is of rapid onset and progression. These types of injuries are usually the result of a specific impact or trauma to the body. **Chronic injury** refers to an injury, illness or disease that develops slowly and is persistent and long-lasting. Many chronic injuries have mild symptoms, sometimes referred to as cumulative trauma or overuse. Both acute and chronic injuries can be made less likely when the personal trainer takes the following steps:

- Always ensure a proper warm-up.
- Show students correct technique and alignment as well as proper posture and body position for each exercise.
- Show clients the proper use of exercise equipment and machines
- In complex movement or exercise patterns, establish the correct movement or pattern before adding speed.
- Create exercise programming that builds in rest and recovery to avoid overtraining.
- Offer modification to accommodate different fitness levels.
- Control the number of repetitions performed in one given set.
- Always ensure a proper cool-down and stretch.

EMERGENCY EQUIPMENT AND PROTOCOLS

A fitness professional may need to utilize emergency equipment at one time or another. Outside of the AED, a first aid kit is commonly accessed for necessary items ranging from bandages to tweezers. The first thing to be aware of is where all emergency equipment is located in a workplace or building should it be needed quickly.

FIRST AID KIT

First aid is a term that describes the first and immediate aid given to someone with a minor or serious injury, illness, or condition. The goal of first aid is to prevent the issue from worsening, promote recovery, and, in extreme cases, preserve life.

A **first aid kit** is a compact box that is pre-stocked with supplies for general medical interventions. They can be purchased fully stocked or a kit can be made with the appropriate items. Like the AED, most businesses, office buildings, and schools have at least one first aid kit available. Typical items you will find in a first aid kit include:

- **Adhesive bandages**- these are available in various sizes and are ideal for minor cuts, abrasions, and puncture wounds.
- **Butterfly closures**- these help close open wounds and hold the edges of skin firmly together.
- **Rolled gauze**- gauze is a wrap that allows freedom of movement and is recommended for securing dressings or pads.
- **Nonstick sterile pads**- these are soft, absorbent pads that cover wounds and create an optimal environment for wound healing. They are recommended for bleeding, burns, and infections.
- **First aid tape**- these tapes come in a variety of thicknesses and are often waterproof. They can be clear, cloth, or paper-based for different degrees of rigidity or adhesiveness.
- **Tweezers**- these can be used to remove debris from a wound like dirt, pieces of glass, or splinters.
- **Thermometer**- a thermometer is used to measure body temperature. While oral thermometers are more accurate, they are not as hygienic as a digital thermometer that measures the temperature at the temple or in the ear canal.
- **Ice packs**- ice packs in a first aid kit are inactive until the inner packaging is punctured, and the contents are mixed together. These are ideal for acute injuries like strains, sprains, localized swelling, or muscle pain.
- **Analgesics**- these are a classification of drug that provides relief from pain. They can be oral such as ibuprofen or topical in gel or cream form.

Some commercial first aid kits may also include antacids, burn cream, latex gloves, a CPR mask, items to make a small splint, and eye patches as well.

FIRST AID:
The first and immediate aid given to someone with a minor or serious injury, illness, or condition.

FIRST AID KIT:
A compact box that is pre-stocked with supplies for triage and general medical interventions.

Figure 19.3 Example First Aid Kit

EMERGENCY EXIT PLAN

EMERGENCY EXIT PLAN:
A visual plan of how and where to exit a space in the event of an emergency.

In every location where exercise is performed, there should be an **emergency exit plan**, or emergency evacuation plan, in place. This includes outdoor spaces, gyms, studios, homes, schools, and other buildings. It will clearly identify how to evacuate a building or space in case of emergency. An emergency exit plan is a written and visual tool often hung on a wall in plain sight that:

- Includes a drawn floorplan of the space.
- Clearly labels all exit and entry doors, stairwells, and elevators.
- Visually identifies the location of the viewer on the floorplan.
- Clearly identifies the exit routes from the current location.
- Identifies where to go in case the elevators are not operational (if applicable).
- Clearly identifies a designated meeting place outside of or away from the facility or space.

Figure 19.4 Example Emergency Evacuation Plan

Other important considerations for an effective emergency exit plan include:

- Identifying when an emergency exit is necessary (fire, earthquake, etc.)
- Identifying a clear chain of command during an emergency for employees, clients, and visitors.
- Determining a way to account for all employees, guests, and visitors after an evacuation has taken place.

Most fitness facilities will have an emergency exit plan in place and will share it with all employees. However, if you are a fitness professional with your own space or working with in-home clients, this information may need to be created or discussed for safety.

SAFETY SUPPLIES

There are several other safety supplies that every fitness space should have. These include, but are not limited to:

- **Flashlights**- flashlights may be needed in the event of a power outage.
- **Toolbox**- tools will be necessary to fix many pieces of equipment and general repair an upkeep in a building. Common tools to have on hand include screwdrivers (power or manual), pliers, a wrench set, Allen wrench set, a hammer or mallet, and additional screws, nails, washers, nuts, and bolts of various sizes.
- **Wet floor signs**- in case of a spill, a wet floor sign will highlight the potential slip hazard.
- **Safety vests**- these valuable tools make the wearer more visible. They can be used in emergency evacuations or any other situation where someone needs to be seen easily (taking out the trash in the dark, power outage, cleaning or work crews, etc.).

- **Fire extinguisher**- in case of a small, manageable fire, the fire extinguisher is useful and should be placed in an easy-to-access location. Depending on building size, many buildings have more than one.
- **Disposable gloves**- gloves can be used for cleaning, first aid, and any other situation where the wearer needs to be shielded. It is recommended to have an additional box of gloves outside of those that may be in a first aid kit as they are a high use item.
- **Bloodborne pathogen cleanup kits**- used for safe and sanitary fluid and blood spills
- **Mop and broom-** these are used for daily cleaning, but also for emergency spills or debris cleanup.
- **Cleaning towels**- towels will likely be used for cleaning equipment, surfaces, and spaces. It is important to distinguish cleaning towels from towels intended for use on the body. If possible, cleaning towels should be a different color and stored in a separate location.
- **Cleaning and sanitizing solutions**- these are used frequently to clean and sanitize equipment, surfaces, and spaces like the restrooms and offices. Extreme care should be taken with all chemicals and every chemical in the building should have a material safety data sheet (MSDS) available. An MSDS provides information about hazardous ingredients, health risks, chemical reactions, handling precautions, and exposure limitations for a chemical product.

INCIDENT REPORTING

As a business practice, personal trainers and fitness facilities must document incidents concerning first aid or emergency situations. The information that should be gathered includes:

- Person's name
- Contact information
- Injury or illness
- How the injury occurred
- Site of incident
- Witnesses and their contact information

These reports can serve the trainer and facility in several ways. Learning from the incident and creating strategies for the future can help to avoid the same incident from happening again. They can provide detailed information for a medical or legal professional. They can also act as a document that contains follow up details for the trainer or facility manager.

FIRST AID SITUATIONS

First aid situations refer to the care given to a person that is injured or ill until medical treatment is available. In some cases, such as minor injuries, first aid care may be enough. In other cases, a condition may escalate or may be more serious and advanced care may become necessary.

Blisters

Blisters can appear as redness from friction accompanied by production of fluid under affected area. Because they can be uncomfortable or painful, continued exercise may not be recommended without proper treatment. If punctured, the blister should be cleansed and protected with pad and dressing.

Fainting

Fainting is a temporary loss of consciousness. Light headedness, dizziness, paleness, and light sweating are common symptoms that often precede fainting.

Assume anyone found unconscious to have a possible head injury and do not give the victim anything by mouth. Do not move the victim unless absolutely necessary. Look for an emergency medical ID around neck or wrist that could suggest a cause for unconsciousness and keep the victim prone and quiet if they regain consciousness. Check to ensure a clear airway, breathing, and circulation.

Hypoglycemia

Hypoglycemia, or low blood sugar, can often be caused by diabetes treatments. Dizziness, weakness, blurred vision, excessive hunger, and cool, moist skin are common symptoms. There is the possibility of seizure, confusion, headache, and anxiety. Victims should consume fluids with sugar (fruit juice) or candy bar, if they are conscious. If the victim is unconscious, call 911 immediately.

Flu or Fever

Flu and fever often are accompanied by a combination of swollen glands, high temperature, fatigue, and congestion. Advise clients to go the doctor, rest, and DO NOT EXERCISE!

Heat Cramps

Cramps are a painful involuntary contraction of a muscle or group of muscles. They can be caused by overuse, dehydration or the loss of minerals due to excessive sweating. Generally, rest, gentle stretches, ice, and of course rehydrating can help to alleviate the pain.

Heat Exhaustion

Heat exhaustion is a progression from heat cramps and can include pale clammy skin, a rapid weak pulse, weakness, headache or nausea, and cramps in the abdomen or limbs. The victim should lie down with their head level or lower than the body. If possible, move the victim to cool place, but protect them from getting too cold. They should rehydrate with water and electrolytes as soon as possible.

Heat Stroke

Heat stroke is a very serious heat-related condition where the body has become unable to regulate its temperature. It can be identified by symptoms such as the cessation of sweating, a rapid strong pulse, and flushed, hot skin. Loss of consciousness may occur and it is important to call 911 immediately. Cool the body with a cold, wet towel.

Lacerations and Abrasions

Lacerations and abrasions or cuts and scrapes of the skin may cause bleeding and should be tended to before continuing with exercise. In some cases, depending on the severity and location of the laceration or abrasion it may not be recommended to continue with exercise. The wound and surrounding skin should be cleansed immediately to prevent infection. A sterile pad should be held firmly over the wound until bleeding stops before changing the pad and bandaging the area loosely.

Contusions

A contusion (bruise) is a region of injured tissue or skin where blood capillaries have been ruptured. Discoloration is likely at the contusion site with continued color changes during the healing process. Applying ice is recommended.

Shock

Shock is an acute medical condition brought on by a sudden drop in blood flow and blood pressure through the body. Cold, clammy skin, a pale face, nausea or vomiting, and shallow breathing are common symptoms. The victim may be chilled or shaky. Correct the cause of shock (bleeding), if possible. The victim should remain lying down, with a focus on staying warm, keeping their airway open and their legs elevated. They should consume fluids if they can swallow.

FRACTURES, SPRAINS, STRAINS, AND DISLOCATIONS

Fractures, sprains, and strains may be difficult for a fitness professional to tell apart. For this reason, first aid treatment of any of these conditions should be treated as though they were a fracture. Signs and symptoms of any of these conditions may include a grating sensation of bones rubbing together, pain, tenderness, swelling, bruising, and an inability to move the injured body part. First aid for any of these conditions should control bleeding (if present) and care for shock.

Sprains are injuries to the connective tissue in a joint or group of joints. The ankle and wrist are common locations for sprains. A strain occurs in a muscle. Strains can happen anywhere but are most common in the low back, neck, shoulders, and hamstrings. A relatively high amount of trauma is usually necessary for a joint dislocation to occur. The most common in a fitness setting would be shoulders and fingers. It is not advised for the personal trainer to attempt resetting the joint.

Cold packs can also help to reduce swelling and relieve pain. Only trained rescue workers should move victims with traumatic injuries. Head, neck, and back injuries are serious and require special care for movement and transport.

R.I.C.E.

All victims with fractures, dislocations, sprains, and strains require professional medical attention. However, if a client cannot get medical care until a later date, the R.I.C.E. method can help reduce pain and inflammation from an injury.

- **R**- REST: Ensure the individual is in a safe location and minimize movement.
- **I**- ICE: Apply ice or a cold pack to the injured area. This is usually done in ten to 20-minute intervals for several hours after an injury or until medical attention is received.
- **C**- COMPRESSION: Wrap the injured area with clothing or bandage and apply pressure.
- **E**- ELEVATION: Elevate the injured body part above the level of the heart.

WHEN TO CALL EMERGENCY SERVICES

The above first aid situations sometimes require additional and sometimes immediate professional medical care. There are also other general circumstances when a fitness professional should call emergency services as soon as possible to ensure timely medical attention. These include:

- **Chest pain**- specifically, chest pain lasting more than a few minutes.
- **Loss of consciousness**- for any reason. A medical professional can help determine the underlying cause.

- **Shortness of breath**- especially when it occurs abruptly, seek medical help right away to determine the cause and prevent further complications.
- **Head injuries**- these can range from mild to severe and may cause concussions. Contact help especially if accompanied with other symptoms like seizure, headache, nausea or vomiting, slurred speech, confusion, weakness, or a loss of coordination.
- **Broken bones**- more than basic first aid cannot be offered by anyone other than a medical professional for broken bones.
- **Heart conditions**- specifically, heart attack or arrythmias that cause chest pain, loss of consciousness, or shortness of breath should be attended to by a medical professional.
- **Abnormal vision or dizziness**- blurry vision, double vision, and loss of vision may be symptoms of a more serious medical condition.
- **Vomiting**- if there is blood in the vomit or it is accompanied by other symptoms like a headache, abdominal pain, or a fast heartrate, it can be a symptom of a greater condition.
- **Deep cuts**- more severe cuts and lacerations will need to be closed with sutures and may affect major blood vessels.
- **Severe abdominal pain**- a medical professional would need to determine the cause. It could be as simple as gas or as serious as an inflamed or ruptured appendix which would require an operation immediately.

BLEEDING

Major bleeding may be life-threatening and will require immediate attention. Bleeding can be internal or external and come from three sources:

- An artery
- A vein
- A capillary

Arterial bleeding is characterized by spurts of blood with each beat of the heart, is bright red in color (though blood darkens when it contacts the air) and is usually severe and difficult to control. Arterial bleeding requires immediate medical care.

Venus bleeding is characterized by a steady flow and the blood is often darker in color. Venus bleeding is easier to control than arterial bleeding. Capillary bleeding is generally slow and oozing in nature and has a higher risk for infection than other types of bleeding. Controlling the bleeding with a sterile pad can prove useful until emergency services arrives.

NOSE INJURIES

Severe nosebleeds can be frightening and lead to **shock** if enough blood is lost. In the event of a nosebleed, the client should sit down, pinch the nostril shut, and lean forward. This will prevent blood from running into the throat and can slow the bleeding.

SHOCK:
An acute medical condition brought on by a sudden drop in blood flow through the body.

Once the bleeding has stopped, the victim should rest quietly until it can be confirmed that the bleeding has ended. Talking, walking, or blowing the nose may disturb the blood clot and cause the bleeding to resume. All uncontrolled nosebleeds require prompt medical attention.

DIABETIC EMERGENCIES

Sugar is required for energy production and insulin is the primary hormone that helps the body regulate and use sugar. When the body does not produce enough insulin or cannot regulate blood sugars, diabetes can result. Individuals with diabetes can have two types of emergencies:

- Insulin Shock
- Diabetic Coma

Insulin Shock

Insulin shock occurs when there is too much insulin in the body. This condition rapidly reduces the amount of sugar in the blood and cells in the brain can be damaged as a result. Insulin reactions can be caused by taking too much medication, failing to eat, heavy exercise, and emotional factors.

INSULIN SHOCK:
A medical condition caused by too much insulin in the body that results in stark drops in blood glucose.

Signs and symptoms of insulin shock may include:

- Fast breathing
- Fast pulse
- Dizziness
- Weakness
- Loss of consciousness
- Vision difficulties
- Sweating
- Headache
- Hunger
- Numb hands or feet

A person in insulin shock needs sugar immediately. If the person is conscious, they should consume sugar in any form- candy, fruit, juice, or a soft drink. Monitor the victim carefully and seek additional medical assistance.

Diabetic Coma

DIABETIC COMA:
A comatose state resulting from excessively high blood sugar levels.

A **diabetic coma** occurs when there is too much sugar and not enough insulin in the body. In this case, the cells cannot take up glucose well and will not be able to function effectively. This condition can develop over the course of several days. Diabetic comas can be caused by eating too much sugar at once, failure to take a prescribed medication, stress, and infections.

Signs and symptoms of a diabetic coma include:

- Drowsiness
- Confusion
- Deep and fast breathing
- Thirst and dehydration
- Fever
- Loss of consciousness
- Sweet or fruity-smelling breath

People with symptoms of a diabetic coma may still be conscious. If there is suspicion of the condition, first ask if they have eaten or if they have taken their medications. If they have eaten but are having symptoms, it may be a diabetic coma. If they have not eaten, but did not take their medications, they may be experiencing insulin shock. Monitor the victim carefully and seek additional medical assistance.

STROKE

STROKE:
When the blood flow to the brain is interrupted long enough to cause damage.

Stroke can occur when the blood flow to the brain is interrupted long enough to cause damage. This can be caused by a blood clot in an artery in the brain, a clot that is carried to the brain in the blood stream, a ruptured brain artery, or the compression of an artery in the brain. First aid for this condition consists of recognizing the signs and symptoms and seeking medical attention. Signs and symptoms of a stroke include:

- Weakness or numbness in the face, arm, or leg (often on one side of the body only)
- Dizziness
- Confusion
- Headache
- Ringing in the ears
- Mood changes

- Difficulty speaking
- Unconsciousness
- Uneven sized pupils
- Difficulty breathing or swallowing
- Loss of bladder control

If you suspect a person is having a stroke, have them stop all activity and rest while you immediately seek professional medical assistance. Observe the victim while help is on the way and be prepared to administer CPR if needed (and if trained to do so).

SEIZURE

A **seizure** is a burst of uncontrolled neural activity that causes temporary abnormalities in muscle movements or muscle tone, behaviors, or sensations. Often, people will become stiff, twitch, or go limp when having a seizure. Seizures are common and are caused by other conditions like insulin shock, infections, head injuries, or drug reactions.

SEIZURE:
A burst of uncontrolled neural activity that causes temporary abnormalities in muscle movements or muscle tone, behaviors, or sensations.

Many individuals will feel a warm sensation before the onset of a seizure. People who have seizure conditions may recognize the impending episode and physically move themselves out of danger. Seizures can range from mild to severe with mild episodes lasting a few seconds. Sever seizures can be prolonged and involve uncontrollable muscle spasms, rigidity, loss of consciousness, loss of bladder or bowel control, or, in extreme cases, breathing may stop temporarily.

If someone is having a seizure:

- Immediately call for professional medical help
- Clear the area of other people or other objects that may cause injury
- Do not attempt to restrain the person and do not put anything in their mouth.
- Their clothing should be loosened and someone should stay with the person to monitor them until assistance arrives.

3-Day Dietary Record - A common fitness and nutrition intake form that allows clients to log their food consumption for three consecutive days to observe their habits - ***205***, ***207***

A

Abdominal Bracing - Activation of the trunk muscles to support the spine - ***266***

Abnormal Pain Perception Processing - An increase in the subjective interpretation of discomfort due to abnormal sensory processing in the central nervous system - ***615***

Acceleration - The rate of change of velocity - ***142***, ***143***

Accessory Exercises - Supplementary focused movements or exercises that strengthen synergist and supporting muscles to help a person better perform a primary movement - ***286***

Acetylcholine - The neurotransmitter released by an action potential at the neuromuscular junction - ***73***, ***74***

Acidosis - When the kidneys and lungs cannot keep the body's pH in balance due to excess acid in body fluids - ***593***

Actin - The thin filaments of muscle myofilaments where myosin binds to contract muscles - ***71***, ***72***

Action Plan - A set of individualized written instructions, designed with a doctor, that details how a person with asthma should manage their asthma at home - ***628***

Action Potential - An explosion of electrical activity caused by a neural impulse - ***69***

Activation Exercises - Low-intensity exercises that bring on additional blood flow and activate the nervous control of a muscle. Often used as part of a specific warm-up or as part of corrective exercise programming - ***495***

Active Listening - Paraphrasing or stating in one's own words what someone has just said - ***453***

Active Range Of Motion - A muscle or group of muscles contract to create a range of motion - ***315***

Active Recovery - Low-intensity exercise or activity that can promote and accelerate muscular and metabolic recovery - ***291***

Active Stretching - A muscle actively contracting to stretch another - ***314***

Activities Of Daily Living - The tasks usually performed in the course of a normal day in a person's life, such as eating, toileting, dressing, bathing, or brushing the teeth - ***71***, ***642***

Activity Level Factor (ALF) - Multipliers that reflect varying levels of activity - ***196***

Activity Limitation - The quantitative and qualitative measure of disability referring to difficulties experienced by an individual in executing a task or action - ***655***

Acute Injury - Describes a type of injury or an illness that is of rapid onset and progression - ***704***

Acute Training Variables - The components that specify how an exercise is performed - ***284***, ***373***

Acyclic Activities - Activities that incorporate different movement patterns throughout - ***408***

Adaptive Physical Fitness - The art and science of developing, implementing, and monitoring a carefully designed physical fitness program for a person with a disability. - ***656***

Added Sugars - Any type of sugar that is added to a food or beverage when it is processed. This is compared to natural sugars found in whole foods, such as fruit or milk - ***539***, ***545***

Adenosine Diphosphate (ADP) - An organic compound essential to the flow of energy in living cells - ***187***

Adenosine Triphosphate (ATP) - An energy-carrying molecule used to fuel body processes - ***186***, ***417***

Adhesion - Area of scar-like tissue that causes organs and tissues to stick together - ***314***

Adolescent Growth Spurt - A rapid increase in the individual's height and weight during puberty - ***637***

Advanced Peripheral Neuropathy - A result of damage to peripheral nerves that often causes weakness, numbness, and pain - ***613***

Aerobic Capacity - A measure of the ability of the heart and lungs to get oxygen to the muscles - ***394***

Aerobic Energy Pathways - Cellular energy pathways that require oxygen for energy production - ***190***

Aerobic Exercise - Exercise that improves or is intended to improve the efficiency of the body's cardiorespiratory system in absorbing and transporting oxygen - ***368***, ***393***, ***394***, ***395***

Aerobic Glycolysis - The breakdown of glucose to ATP in the presence of oxygen - ***190***

Afferent Neurons - Sensory neurons sending information from a stimulus to the CNS - ***66***

Agility - The ability to accelerate, decelerate, stabilize, and change direction with proper posture - ***272***

Agonist - The primary muscle used for a mechanical movement - ***160***, ***161***

All-Or-None Principle - The principle stating the strength of a neural electrical signal is independent of the magnitude of the stimulus so long as the neural threshold is achieved - ***69***

Alpha Motor Neurons - Motor neurons originating in the brain stem and spinal cord that initiate muscle contraction - ***68***

Altered Arthrokinematics - Altered movement of joint surfaces - ***451***

Altitude Training - Training at altitudes greater than 2,500 meters above sea level with the goal of increasing the blood's oxygen carrying capacity - ***410***

Alzheimer's Disease - A progressive mental deterioration that can occur in middle or old age, due to generalized degeneration of the brain - ***537***, ***650***

Amenorrhea - The absence or cessation of a menstrual cycle in females - ***210***

American Heart Association (AHA) - A nonprofit organization that funds cardiovascular research and educates consumers on healthy living and good cardiac care - ***519***, ***547***

Amino Acids - Simple organic compound known as the building block of proteins - ***111***, ***508***, ***523***, ***568***

Anabolic - The process of creating larger molecules from smaller units - ***116***

Anabolic-Androgenic Steroids (AAS) - Synthetic variations of the male sex hormone testosterone - ***592***

Anabolism - The building of complex molecules in the body from more simple, smaller molecules - ***508***, ***585***

Anaerobic - Without or not requiring oxygen - ***188***, ***189***, ***190***, ***192***

Anaerobic Exercise - Short-duration muscle contractions that break down glucose without using oxygen - ***390***, ***426***

Anaerobic Glycolysis - The anaerobic energy system converting glucose to lactate when oxygen is limited - ***189***

Anaerobic Threshold - The point at which the body switches from aerobic metabolism to primarily anaerobic metabolism - ***190***

Anatomical Position - The anatomically neutral body position facing forward with the arms at the sides of the body and palms and toes pointing straight ahead - ***130***

Anemia - A condition marked by a deficiency of red blood cells or of hemoglobin in the blood resulting in extreme fatigue - ***569***

Angina - A condition marked by severe chest pain - ***622***

Angiogenesis - The development of new blood vessels - ***394***

Angular Displacement - The change of location of an object that is rotating about an axis - ***147***

Angular Motion - Rotation around an axis - ***147***, ***149***, ***150***

Animal Products - Any material derived from the body of an animal, including dairy products, eggs, honey, and gelatin - ***554***

Antagonist - Muscle(s) opposing the mechanical movement of a prime mover - ***160***, ***161***

Antibodies - Blood proteins that combine with other substances in the body to recognize foreign bodies as part of the immune response - ***106***, ***107***

Anticatabolic - Properties that protect muscle mass from being broken down - ***588***

Antioxidants - Substances that protect the body from free radicals and the cellular damage they cause - ***508***, ***537***

Aorta - The main artery in the body that supplies oxygenated blood to the circulatory system - ***97***, ***99***, ***101***

Appendicular Skeleton - The bones of the shoulder girdle, pelvic girdle, and limbs - ***80***

Arteries - Blood vessels carrying oxygenated blood away from the heart and to the tissues - ***96***, ***101***

Arterioles - The smaller branches of the arteries leading to the capillaries - ***98***

Arthrokinematics - The broad term meaning joint motion that can be used in reference to all joint motions - ***89***

Articular Capsule - The envelope surrounding a synovial joint - ***88***

Articular Cartilage - A form of hyaline cartilage located on the joint surface of bones - ***93***

Articulation - The ability to pronounce distinctly—to enunciate - ***454***

Ascending Pyramids - Lighter weights are used to start the workout, and they get progressively higher with subsequent sets - ***444***

Asthma - A respiratory condition marked by spasms in the bronchi of the lungs, causing difficulty in breathing - ***625***, ***626***, ***627***

Atherosclerosis - The buildup of fats, cholesterol, and other substances in the artery walls - ***604***, ***622***

ATP/CP Energy Pathway - The anaerobic energy system that provides rapid energy using creatine phosphate to generate ATP - ***188***, ***193***

Atrioventricular (AV) Node - The nerve node between the right atrium and right ventricle that propagates the electrical signal from the SA node to more distal heart nerves that cause ventricular contraction - ***102***

Atrioventricular (AV) Valves - Valves between the atria and ventricles preventing the backward flow of blood during cardiac contractions - ***100***

Atrium - One of the two upper cavities of the heart passing blood to the ventricles. The plural is “atria.” - ***99***, ***100***

Atrophy - The wasting away or loss of muscle tissue - ***394***, ***425***

Auditory Cortex - The region of the temporal lobe responsible for hearing - ***64***

Auditory Learners - People who learn by hearing information - ***455***, ***456***

Autogenic Inhibition - The decrease in excitability of a contracting or stretched muscle arising from the Golgi tendon organ - ***361***

Automated External Defibrillator (AED) - A portable electronic device that can identify and electrically correct heart arrythmias, ventricular fibrillation, and tachycardia - ***19***, ***702***

Autonomic Nervous System - The part of the nervous system responsible for involuntary functions and movement - ***66***

Autonomy - The need for self-governance and control over one's own behaviors - ***32***, ***33***, ***34***, ***607***

Axial Skeleton - The bones of the head, trunk, and vertebrae - ***80***

Axis - Point of rotation around which a lever moves - ***78, 89, 147, 150, 152, 153, 154, 155, 242***

Axon - The thin tail-like structure of a neuron that generates and conducts nerve impulses - ***60***, ***69***

B

Baby Boomers - A person born in the years following World War II, when there was a temporary marked increase in the birth rate - ***643***

Balance - An even distribution of weight enabling someone or something to maintain its center of gravity within a base of support - ***6***, ***138***

Balance Training - Exercises to strengthen the stabilizer muscles and prime movers of the core and legs to improve dynamic stability - ***265***, ***266***, ***268***, ***269***

Ballistic Stretching - Uses the momentum of the body or limb to move it through and beyond a normal range of motion. This technique uses bobbing, bouncing, pulsing, or jerking to achieve a stretch - ***314***

Ballistic Training - A form of power training involving throwing weights or jumping with weights to improve explosive power - ***307***, ***308***

Base Of Support - The area beneath an object or person that includes every point of contact that the object or person makes with the supporting surface - ***138***

Behavior - An action that can be observed, measured, and modified - ***6***, ***21***, ***22***, ***23***, ***24***, ***40***, ***45***

Beta-alanine - A nonessential amino acid that is naturally produced by the body - ***584***, ***593***

Beta Blockers - One of the most widely prescribed classes of drugs to treat hypertension - ***607***

Bile - A bitter greenish-brown alkaline fluid aiding digestion, secreted by the liver and stored in the gallbladder - ***125***

Bioavailability - The amount of a substance that enters the circulation when introduced into the body and is effective - ***586***

Bioelectrical impedance Analysis (BIA) - A method for body composition measurement using a weak electrical current to measure the resistance of body tissues - ***221***

Bioenergetics - The study of how energy is transformed in living organisms - ***182***

Biological Value (BV) - The percentage of protein used by the body - ***586***

Biomechanics - The study of the mechanical laws governing movement of living organisms - ***5***, ***6***, ***11***, ***129***, ***130***, ***149***, ***150***

Bipedal Locomotion - A form of locomotion in which a person moves from one place to another using the legs - ***486***

Bipennate Muscle - Muscle fibers extending from both sides of a central tendon - ***78***

Block Periodization - Highly concentrated, specialized workloads focused on achieving maximum adaptation - ***301***

Blood Pressure - The force of blood pushing against the walls of the arteries during the two phases of the cardiac cycle - ***12***, ***104***, ***602***, ***604***

Blood Viscosity - The thickness and "stickiness" of blood and how it affects its flow through the blood vessels - ***105***

Blood Volume - The total volume of blood within the circulatory system of an individual - ***105***

Body Composition - The physical makeup of the body considering fat mass and lean mass - ***210***, ***262***

Body Density - The compactness of the body determined by dividing its mass by its volume - ***218***

Body Language - Communication of a nonverbal form with gestures or body movement - ***452***

Body Mass Index (BMI) - A predictive health measure of weight divided by height squared - ***211***

Body Weight Exercises - Movements performed with no additional load other than what the exerciser's body provides - ***442***, ***443***

Bone Marrow - The soft, spongelike tissue in the center of most bones containing stem cells of red or white blood cells or platelets - ***85***, ***86***

Botanical - Substance obtained from a plant and used as an additive - ***568***, ***597***, ***598***

Brain Stem - The trunk of the brain, consisting of the medulla oblongata, pons and midbrain that continues downward to form the spinal cord - ***62***

Branched-Chain Amino Acids (BCAAs) - A group of three essential amino acids (leucine, isoleucine, and valine) that help the body build muscle and decrease muscle fatigue - ***584***, ***594***

Branding - A name, logo or symbol that identifies and differentiates a product from other products - ***673***, ***677***

Buddy Training - Exercise instruction between a personal trainer and two clients at the same time - ***662***, ***665***

Bullying - An unwanted, aggressive behavior among school-aged children that involves a real or perceived power imbalance - ***633***

Business Plan - Outlines the structure, marketing, and growth of a new business - ***662***

C

Calls To Action - Marketing statements that demand an immediate response from the recipient—for instance, "Sign up now" or "Click here to learn more." - ***674***

Calories (Cal) - The amount of energy needed to raise the temperature of 1 kilogram of water by 1°C (4,184 joules) at a pressure of 1 atmosphere - ***194***, ***199***, ***200***

Cancellous Bone - The meshwork of spongy tissue (trabeculae) of mature adult bone, typically found at the core of vertebral bones and the ends of the long bones - ***86***

Capillaries - Fine-branching blood vessels forming a network between the arterioles and venules, where transport of nutrients and oxygen or carbon dioxide occurs on a microscopic scale - ***96***

Carb Cycling - Increasing and reducing carb intake on a daily, weekly, or monthly basis. ***560***

Cardiac Arrest - An electrical malfunction of the heart that causes irregular heartbeat - ***702***

Cardiac Cycle - The action of the heart from the start of one heartbeat to the beginning of the next - ***102***

Cardiac Muscle - Striated involuntary muscle tissue found in the heart - ***70***

Cardiac Output - The amount of blood pumped through the heart per minute - ***105***

Cardiometabolic - A combination of metabolic dysfunctions mainly characterized by insulin resistance, impaired glucose tolerance, dyslipidemia, hypertension, and central adiposity. - ***609***

Cardiopulmonary Resuscitation (CPR) - An emergency procedure involving chest compressions and, often, artificial ventilation to circulate blood and preserve brain function in an individual in cardiac arrest - ***19***, ***702***

Cardiovascular Endurance - The measure of the cardiovascular system's (heart and blood vessels) ability to perform over an extended period - ***262***, ***263***

Cartilage - Firm, flexible connective tissue that pads and protects joints and structural components of the body - ***16***, ***87***, ***89***, ***93***

Cartilaginous Joints - Moderately movable joints made of fibrocartilage or hyaline cartilage - ***88***

Catabolic - Metabolic activity involving the breakdown of molecules such as proteins or lipids - ***116***, ***585***

Catabolism - The breaking down in the body of complex molecules into more simple molecules - ***508***

Catecholamines - Hormones released by the adrenal glands into the blood as a result of stress - ***116***, ***119***

Celiac Disease - An autoimmune disorder that affects the small intestines and that is caused by gluten in the diet - ***555***

Cell Body - The core and central structure of a neuron containing a nucleus and other specialized organelles that aid in nervous system function - ***60***

Cell Proliferation - The process by which a cell grows and divides to produce new cells - ***590***

Cells - The building blocks of all living organisms - ***590***

Center Of Gravity - The hypothetical position in the body where the combined mass appears to be concentrated and the point around which gravity appears to act - ***138***, ***140***

Central Nervous System (CNS) - The part of the nervous system consisting of the brain and spinal cord - ***62***

Cerebellum - The region of the brain responsible for conscious motor coordination - ***62***

Cerebral Cortex - The part of the brain where most neural integration occurs - ***62***

Cerebrum - The uppermost and largest part of the brain consisting of a left and right hemisphere; responsible for receiving and processing sensory information and controlling the body - ***62***

Certified Group Fitness Instructors - Fitness professionals certified in delivering large group fitness classes. These classes are often choreographed and require specific training in a particular class format - ***667***

Chronic Disease - A condition lasting a year or more that limits daily activities and/or require ongoing medical attention - ***11, 210***

Chronic Injury - Refers to an injury, illness, or disease that develops slowly and is persistent and long-lasting - ***704***

Chronic Obstructive Pulmonary Disease (COPD) - A lung disease characterized by chronic obstruction of lung airflow that interferes with normal breathing and is not fully reversible - ***627***

Chronological Age - The number of years a person has lived - ***641***

Chyme - A pulpy, acidic fluid that moves from the stomach to the small intestines containing partially digested food and gastric juices - ***123***

Circuit Training - Body training that combines endurance, resistance, high-intensity interval, and aerobic training - ***386***, ***406***

Circular Muscle - Muscle fibers surrounding an opening in the body - ***77***

Circulatory System - A closed system circulating blood through the body, consisting of the heart, blood vessels, and blood - ***96***

Circumference Measurements - The measurement of the circumference of specific body regions - ***214***

Client Intake Form - A basic intake form to gather a client's or potential client's demographic information and general health history - ***205***

Client Persona - A fictional person that represents the key characteristics of a trainer's preferred clientele - ***673***

Client Profile - The collection of a client's health and intake forms, biometric measurements (physical measurements like weight, height, etc.), training plan, and liability waivers - ***208***

Client Referrals - A method of marketing where current or former clients refer friends and family to a professional for services by word of mouth - ***681***

Closed Kinetic Chain Movement - A movement keeping the distal end of the body segment in action fixed - ***236***

Closed System - A physical system that does not allow for the movement of matter into or out of the system - ***96***

Close-Packed Joint Position - The most stable joint position, when the connective tissue is taut and neighboring bones have the most contact - ***90***

Code Of Ethics - A set of guiding principles that drives the actions of a professional - ***694***

Cognitive Functioning - An intellectual process by which one becomes aware of, perceives, or comprehends ideas - ***633***

Comorbidities - The simultaneous presence of two chronic diseases or conditions in a person - ***614***, ***617***, ***643***

Compact Bone - A denser material, also known as cortical bone, making up the hard structure of the skeleton - ***86***

Competence - The basic need to feel a sense of mastery and operate effectively within the environment - ***32***, ***34***, ***35***, ***36***

Competency - The ability to do something successfully or efficiently - ***607***

Complete Protein - A food source containing all nine essential amino acids the body needs - ***523***, ***587***

Compound Exercises - Multi-joint exercises that require the use of multiple muscles or muscle groups - ***286***, ***422***

Compression Force - The force of two surfaces pressing toward one another - ***146***

Concentric Muscle Action - When the length of a muscle shortens as tension is produced - ***79***

Concurrent Training - Including both cardiorespiratory exercise and resistance training into a fitness program - ***606***

Congenital - Relating to a disease or physical abnormality present from birth - ***657***

Connective Tissue - Tissues that support, connect, or bind other tissues or organs - ***71***

Contract-Relax Antagonist Contract (CRAC) Stretching - Contracting an antagonist muscle before stretching the agonist - ***338***

Contract-Relax (CR) Stretching - Contracting a given muscle before stretching the same muscle - ***338***

Contraindications - Factors that serve as a reason to withhold training because of harm that it may cause - ***208***, ***209***

Contralateral Loading - Loading the body on the opposite side of the work being executed - ***478***

Convergent Muscle - Muscle fibers converging from a broad origin (fixed point where the muscle attaches closest to the torso) to a single tendon of insertion (fixed point where the muscle attaches furthest from the torso) - ***77***

Cooldown - Gradually slowing the body after activity to return to homeostasis or close to homeostasis - ***281***

Core Training - Refers to strengthening the musculature of the abdominals, back, and lower body that directly influence the lumbopelvic hip complex (LPHC) - ***265***, ***266***

Coronary Artery Disease (CAD) - The narrowing or blockage of coronary arteries - ***518***, ***621***, ***622***

Corporation - A business structure in which the owners and operators are separated from the liabilities of the business - ***669***, ***670***

Corrective Exercise - Exercise programming used to improve function through assessing and improving muscle imbalances ***495***

Corticosteroids - A group of natural and synthetic steroid hormones produced by the pituitary gland - ***627***

Cortisol - A catabolic hormone released in response to physical and emotional stress - ***113***, ***116***, ***118***

Countermovement - A movement or other action made in opposition to another action - ***272***

Cranial Nerves - The 12 sensory and motor nerves extending directly from the brain - ***65***

Creatine - An organic compound that aids in the recycling of ATP in the energy systems - ***417***, ***427***

Creatine Monohydrate (CM) - An organic compound that increases phosphocreatine levels and adenosine triphosphate (ATP) energy production leading to enhanced strength and power - ***584***

Creatine Phosphate (CP) - A high-energy molecule stored in skeletal muscle, the myocardium, and the brain - ***188, 417***

Cross-Training - The action of training or practice in two or more sports or types of exercise to improve fitness or performance in one's main sport - ***407***

Cueing - A communication that prompts a client to engage in a movement pattern or conveys proper technique - ***455***, ***456***, ***457***, ***662***

Customer Life Cycle - The steps a customer goes through when considering, buying, and using a product or service, including awareness, engagement, evaluation, purchase, experience, and bonding and advocacy - ***671***

Cyclic Activities - Activities that use the same movement in repetition - ***408***

Cytoplasm - The viscous fluid inside a living cell excluding the nucleus - ***182***, ***183***

D

Daily Calorie Expenditure (DCE) - The total number of calories an individual expends including their resting metabolic rate, activity level factor, and the thermic effect of food - ***196***

Daily Value (DV) - Reference amounts expressed in grams, milligrams, or micrograms of nutrients to consume or not to exceed each day - ***544***, ***571***

Deceleration - A special type of acceleration where a person or object is slowing down - ***142***

Decussation - The point of crossover of the nervous system in vertebrates located between the medulla oblongata and the spinal cord - ***63***

Dehydration - A harmful loss or removal of water in the body - ***528***

Delayed Onset Muscle Soreness (DOMS) - Muscle pain or stiffness resulting from microtearing of tissue during eccentric muscle action that is felt several days after unaccustomed exercise - ***278***

Dendrites - Rootlike structures branching out from the cell body that receive and process signals from the axons of other neurons - ***60***

Deoxyribonucleic Acid (DNA) - Self-replicating genetic material in human cells - ***183***

Dermis - Deep to the epidermis; holds blood vessels, sweat glands, and hair follicles - ***127***

Detraining - The diminishing of physical adaptations after two weeks or more of not training - ***297***

Diabetes - A condition characterized by an elevated level of glucose in the blood - ***7***, ***16***, ***510***, ***604***, ***605***, ***608***, ***609***, ***610***, ***612***, ***614***, ***623***

Diabetic Coma - A comatose state resulting from excessively high blood sugar levels - ***714***

Diaphragm - The dome-shaped muscle that separates the lungs and pleural cavity from the abdomen - ***109***

Diastasis - The separation of the large abdominal muscles during pregnancy - ***652***

Diastole - The heartbeat phase where the cardiac muscle relaxes and the heart chambers fill with blood - ***102***

Diastolic - The pressure in blood vessels when the heart rests (ventricular filling) - ***104***, ***105***, ***602***, ***604***

Diet - The foods that a person or community eats most often and habitually; a choice of regular foods consumed for the purpose of losing weight or for medical reasons - ***546***, ***547***, ***549***, ***552***, ***553***, ***554***, ***556***, ***557***, ***558***

Dietary Approaches to Stop Hypertension (DASH) Diet - A low-sodium, whole-food diet created for the treatment of hypertension - ***608***

Dietary Guidelines for Americans - Guidelines for healthy, lifelong eating habits for Americans two years of age and older - ***507***, ***511***, ***538***, ***539***, ***540***, ***545***

Dietary Ingredient - A vitamin, mineral, herb, botanical, or amino acid used to supplement a nutrition plan to increase total dietary intake of ingredients - ***568***

Dietary Reference Intakes (DRIs) - A set of standards estimating how much of a nutrient should be ingested that is used in planning eating patterns for healthy individuals - ***570***

Dietary Supplement - A product containing one or more dietary ingredients that is intended to supplement a person's nutrition plan - ***568***

Diet-Induced Thermogenesis - The thermic effect of macronutrient digestion and absorption - ***196***

Diffusion - The passive movement of molecules or particles along a concentration gradient or from regions of higher concentration to regions of lower concentration - ***109***

Digestible Indispensable Amino Acid Score (DIAAS) - Measures the amount of amino acids absorbed by the body - ***586***

Diminishing Returns - A concept stating that everyone has a set genetic limit to their potential, and, eventually, the effort put into training will no longer produce the same results - ***296***

Disability - A physical or mental condition that limits a person's movements, senses, or activities - ***655***, ***656***

Disaccharides - Any of a class of sugars with molecules that contain two monosaccharide residues - ***509***

Displacement - The distance an object is displaced from a starting point - ***147***

Distance - The total or sum of the length an object travels - ***147***

Docosahexaenoic Acid (DHA) - An omega-3 fatty acid that is a primary structural component of the human brain, cerebral cortex, skin, sperm, testicles, and retina - ***518***

Drop Set - Technique in which a set is done until failure or fatigue, the weight is "dropped" or lowered, and the exerciser continues until another failure; can continue for several rounds - ***444***

Dual Energy X-Ray Absorptiometry (DEXA) - An X-ray scanning test to determine body composition - ***222***

Dynamic Balance - The ability to remain upright and balanced when the body and/or arms and legs are in motion - ***138***

Dynamic Stretching - Movement-based active stretching where muscles engage to bring about a stretch - ***265***, ***314***, ***316***, ***317***, ***318***

Dynapenia - The age-associated loss of muscle strength that is not caused by neurologic or muscular disease - ***642***

Dysfunctional Eating Patterns - May include behavior commonly associated with eating disorders, such as food restriction, binge eating, and purging - ***633***

Dyspnea - Difficulty or labored breathing - ***222***

E

Eating Pattern - The types of food and beverages an individual consumes - ***538***

Eccentric Muscle Action - When the length of a muscle increases as tension is produced - ***79***

Efferent Neurons - Motor neurons sending information from the CNS to the muscles to generate movement - ***66***

Effort Arm - The portion of the lever arm between the applied effort and the axis - ***153***

Egocentric - Thinking only of oneself, without regard for the feelings or desires of others - ***638***

Eicosapentaenoic Acid (EPA) - A fatty acid found in fish and fish oils, which is believed to lower cholesterol, especially cholesterol bound to low-density lipoproteins - ***518***

Elastic Cartilage - Flexible cartilage present in the outer ear, inner ear, and epiglottis - ***93***

Elastin - A highly elastic connective tissue allowing many tissues to retain their shape - ***92***

Electrolyte - Minerals in the body that have an electric charge - ***114, 529***

Electron Transport Chain - A series of proteins in the mitochondrial membrane that transfer electrons and hydrogen ions across the membrane to generate ATP from ADP - ***191***

Emergency Exit Plan - A visual plan of how and where to exit a space in the event of an emergency - ***706***

Empathic Listening - The ability to understand how the clients feel and empathize with them - ***454***

Empathy - The ability to understand and share in the feelings of others - ***42***

Endocrine Glands - Ductless glands releasing hormones that remain within the body - ***111***, ***114***

Endomysium - The connective tissue covering each muscle fiber - ***72***

Endoplasmic Reticulum (ER) - A network of tubules attached to the nuclear membrane in cells - ***183***

Endorphins - Hormones that promote feelings of well-being - ***369***

Endurance Strength - The ability to sustain a submaximal activity for a longer duration - ***417***

Energy Balance - The state achieved when energy intake is equal to energy expenditure - ***195***, ***199, 583***

Energy Pathways - The chemical-reaction pathways that supply the body with energy on a cellular level - ***188***

Epidermis - The outermost layer of the skin - ***127***

Epiglottis - A piece of elastic cartilage in the throat that opens during breathing and closes during swallowing - ***93***

Epimysium - Fibrous elastic tissue that surrounds a muscle - ***73***

Equilibrium - A state in which opposing forces or influences are balanced - ***6***, ***138***

Ergogenic Aids - Substances that enhance energy production and provide athletes with a competitive advantage - ***568***, ***569***, ***595***

Erythropoietin (EPO) - A hormone with a role in the proliferation of red blood cells - ***410***

Essential Amino Acids - Amino acids that are not made by the body in the optimal amounts and therefore must be obtained through the diet - ***523***

Estimated Average Requirement (EAR) - The average daily nutrient intake level that is estimated to meet the requirement of half the healthy individuals in a specific life stage or sex - ***524***

Evaporative Heat Loss - Cooling the body and releasing heat via evaporation of water and electrolytes from the skin - ***409***

Evidence-Based Practice (EBP) - Practices, interventions, and strategies that are based on scientific evidence - ***69***, ***73***, ***93***, ***205***, ***414***, ***508***

Excess Postexercise Oxygen Consumption (EPOC) - The amount of oxygen required to restore normal metabolic status - ***194***

Excitation-Contraction Coupling - The physiological process of converting a neural impulse into a mechanical response - ***69***

Exercise Activity Thermogenesis (EAT) - Energy expended as a result of planned, structured, and repetitive movement with the goal of improving or maintaining physical fitness - ***197***

Exercise Frequency - The number of times training occurs within a specific period, or the number of times or how often an exercise is executed - ***288***

Exercise-Induced Bronchoconstriction (EIB) - Asthma attack triggered by doing sports or physical activity - ***627***

Exercise Order - The order in which exercises are completed within a training session - ***284***, ***286***

Exercise Selection - The specific exercises executed in a workout session - ***284***, ***285***

Exercise Stress Test - An assessment that usually involves walking on a treadmill or riding a stationary bike while heart rhythm, blood pressure, and breathing are monitored - ***614***

Exocrine Glands - Glands that produce and release substances through ducts or openings on the body's surface - ***111***, ***119***

Expiration - Breathing air out of the lungs - ***109***, ***110***

External Respiration - The exchange of gases between the lungs and the blood - ***110***

External Stimuli - Sensory input from external sources - ***67***

Extracellular Fluid (ECF) - Water found outside the cells and between tissues - ***529***

Extrafusal Muscle Fibers - The standard skeletal muscle fibers involved in creating mechanical work - ***68***

Extrinsic Motivation - The drive to perform certain behaviors based on external factors such as praise, recognition, and money - ***30***

F

Fartlek - A training system for distance runners that continually varies terrain and pace to enhance conditioning and eliminate boredom - ***377***, ***380***

Fasciculi - Bundles of muscle fibers; the singular is “fascicle.” - ***73***

Fasting - Abstaining from consuming food for a period of time - ***558***, ***559***

Fats - Organic compounds that are made up of carbon, hydrogen, and oxygen. Fats are a source of energy in foods and are also called lipids. They come in liquid or solid form - ***516***, ***517***, ***519***, ***540***, ***542***

Fatty Acids - The smaller, absorbable building blocks of the fat that is found in the body - ***182***, ***516***, ***518***, ***519***

Feedback Loop - The return of a system’s output as input for a future action - ***91***

Fiber - A type of carbohydrate derived from plant-based foods that the body is unable to break down - ***511***, ***514***, ***515***, ***516***

Fibrocartilage - An elastic and tough tissue containing type I and type II collagen - ***93***

Fibromyalgia (FM) - A chronic disorder characterized by widespread musculoskeletal pain, fatigue, and tenderness in localized areas - ***615***

Fibrous Joints - Joints with fibrous connective tissue joining two bones that allow for very little movement - ***87***

First Aid - The first and immediate aid given to someone with a minor or serious injury, illness, or condition - ***705***, ***709***, ***711***, ***714***

First Aid kit: A compact box that is pre-stocked with supplies for triage and general medical interventions - ***705***

FitnessGram - A noncompetitive standard performance assessment to measure aerobic capacity, muscular strength and endurance, flexibility, and body composition - ***640***, ***641***

Fitness Program Design - The systematic development of a fitness program or process using assessments, the elements of fitness, periodization, and periodic reassessment - ***284***

Flare - A sudden surge in rheumatoid arthritis inflammation - ***615***

Flat Back - An excessive lumbar flexion and posterior pelvic tilt - ***239***

Flexibility - The range of motion of a muscle and its associated connective tissues at a joint or joints - ***5***, ***6***, ***262***, ***264***, ***265***, ***311***, ***312***, ***314***, ***315***, ***316***, ***317***, ***359***

Flexibility Training - An element of fitness using stretching to increase the range of motion of a joint or group of joints and allow for increased ranges of motion - ***264***, ***265***

Food And Drug Administration (FDA) - A US federal department that regulates the production and distribution of food, pharmaceuticals, tobacco, and other consumer products - ***538***, ***569***

Force - The interaction that creates work or physical change. Its components are magnitude, direction, point of application, and line of action - ***142***, ***143***, ***144***, ***146***, ***147***, ***150***, ***151***, ***153***, ***155***, ***162***

Force Arm - The distance between the fulcrum and the force or load application in a lever - ***155***

Force-Couple Relationship - Two or more muscles acting in different directions that influence the rotation of a joint in a specific direction - ***162***

Force-Velocity Curve - A representation of the inverse relationship between force and velocity in muscle contraction - ***143***

Fortified - Having had vitamins or other supplements added so as to increase the nutritional value - ***573***, ***574***, ***575***, ***579***

Foundational Training - The basic training elements of flexibility, balance, and core training - ***301***, ***304***, ***308***

Frailty - An increased vulnerability resulting from aging-associated decline in reserve and function across multiple physiologic systems - ***643***

Free Weights - Loads that are not attached to an apparatus - ***440***, ***441***

Friction - The resistance of relative motion that one surface or object encounters when moving over another - ***6***, ***146***, ***148***

Frontal Lobe - The brain lobe involved in motor control, emotion, and language - ***63***

Frontal Plane - An imaginary line that divides the body into anterior and posterior halves - ***134***

Fulcrum - The point on which a lever rests or is supported and on which it pivots - ***152***, ***153***

Functional Capacity - The capability of performing tasks and activities that people find necessary or desirable in their lives - ***641***

Functional Fitness Test for Seniors - A simple, easy-to-use battery of test items that assess the functional fitness of older adults - ***644***

Functional isometrics - The combination of partial repetition training and isometric holds - ***439***

Fusiform Muscle - Spindle-shaped muscle - ***77***

G

Gastroesophageal Reflux Disease (GERD) - A condition in which acidic gastric fluid flows backward into the esophagus, resulting in heartburn - ***627***

General Adaptation Syndrome (GAS) - The three stages of adaptation the body goes through in response to stress—alarm, resistance, and exhaustion - ***298***

General Exercises - Foundational exercises that train overall strength - ***421***

General Warm-Up - Nonspecific, low-intensity activity including dynamic stretching and light cardiovascular activity with the purpose of increasing blood flow, respiration, and body temperature - ***265***

German Volume Training - A method in which 10 sets of 10 repetitions are done of an exercise with one minute of rest between sets - ***444***

Gestational Diabetes - A condition characterized by an elevated level of glucose in the blood during pregnancy, typically resolving after birth - ***609***, ***654***

Glucocorticoids - A group of corticosteroids involved in the metabolism of carbohydrates, proteins, and fats - ***629***

Gluconeogenesis - The generation of new glucose molecules from non-carbohydrate carbon substrates - ***183***, ***192***

Glucose - A simple sugar the body uses for energy production on the cellular level - ***115***, ***185***, ***192***, ***508***, ***535***

Gluten - A mixture of proteins found in wheat, rye, and barley and gives dough its elastic texture - ***555***, ***556***

Glycemic Index (GI) - A system that ranks foods on a scale from 1 to 100 based on their effect on blood sugar levels - ***509***

Glycogen - The stored form of glucose found in muscle tissue and the liver - ***71***, ***183***, ***185***, ***189***, ***508***

Glycolysis - The breakdown of glucose by enzymes, releasing energy and pyruvic acid - ***183***, ***188***, ***189***, ***190***

Glycoproteins - A class of proteins with a carbohydrate group(s) attached - ***184***

Goal Setting - The process of identifying the client's ideal state, determining their current state, and defining the actions that must be taken to close the gap - ***45***

Golgi Apparatus - An organelle of folded membranes responsible for packaging and transporting membrane-bound proteins - ***184***

Golgi Tendon Organ - The proprioceptive sensory organ that senses muscle tension in a tendon and inhibits muscle action - ***91***, ***314***, ***361***

Good Samaritan Laws - Legal protections offered in much of the U.S. and Canada that protect an individual who offers assistance, CPR, or first aid to someone else in an emergency situation before trained help arrives - ***703***

Gout - A disease in which defective metabolism of uric acid causes arthritis - ***615***, ***616***

Gravity - The attraction between objects and the Earth - ***138***, ***140***

Grip - Hand placement - ***433***

Grip Strength - The force applied by the hand to pull or suspend a load - ***433***

Gross Motor Skills - The abilities required in order to control the large muscles of the body for walking, running, sitting, crawling, and other activities - ***636***

Ground Reaction Force (GRF) - The force the ground exerts on a body it is in contact with - ***145***

Group Exercise - Large group training that is often choreographed and where all participants are executing the same exercises simultaneously - ***662***, ***667***

Growth Factors - Proteins that stimulate nerve cell growth and the creation of new neural pathways and connections - ***369***

Growth Hormone (GH) - A hormone released by the pituitary gland that stimulates growth in animal cells - ***112***, ***116***, ***117***

H

Handedness - The tendency to use one side of the body more naturally than the other - ***241***

Hashtags - Social media tags users can create to help others find messages and posts with a specific theme or content - ***675***

Health History Questionnaire - A detailed client intake form that gathers information on a client's present and past health and medical history - ***206***

Health Insurance Portability and Accountability Act (HIPAA) - An American legislation designed to protect the health care data, information, and payment details of patients - ***205***

Health Markers - Tools at the service of health professionals that objectively measure and evaluate indicators of normal biological processes or pathogenic processes (i.e., blood pressure) - ***370***

Heart Disease - A term used to describe several different heart conditions - ***17***, ***264***, ***608***, ***621***

Heart Rate - The number of heartbeats per minute - ***102***

Heart Rate Reserve (HRR) - Maximum heart rate minus resting heart rate - ***391***

Heart Rate Zones - Percentages of maximum heart rate associated with a desired physiological adaptation - ***278***

Hemoglobin A1c (HbA1c) - A minor component of hemoglobin to which glucose is bound - ***415***, ***611***

Herb - Any plant with leaves, seeds, or flowers used for flavoring food and medicine - ***568***

Hereditary - Relating to the biological process responsible for passing on traits from one generation to another - ***603***

High-Density Lipoprotein (HDL) - A lipoprotein that removes cholesterol from the blood. It is sometimes considered the "good cholesterol." - ***416, 518***

High-Intensity Interval Training (HIIT) - Interval training with short intervals at near maximum effort and less intense recovery periods - ***280***

Hip Hinge - A forward and backward movement of the upper body while the hips remain at the same height and move back - ***457***

Homeostasis - A self-regulating process by which the body maintains the stability of its physiological processes for the purpose of optimal function - ***64***

Hook - Gripping the thumb between the barbell and fingers - ***433***

Hormones - Chemical messengers stored, created, and released by endocrine glands - ***111***, ***112***, ***115***, ***119***

Human Leukocyte Antigen (HLA) - Genes that help the immune system distinguish the body's own proteins from foreign antigens - ***617***

Hyaline Cartilage - A transparent cartilage found on most joint surfaces and in the respiratory tract, which contains no nerves or blood vessels - ***88, 93***

Hybrid Personal Training - A training approach that utilizes in-person and virtual training styles to allow for easier, more frequent access to the fitness professional - ***664***

Hydrocarbons - A compound of hydrogen, and carbon, such as any of those that are the chief components of petroleum and natural gas - ***516***

Hydrostatic Weighing - A tool to measure body composition using water displacement and tissue density - ***222***

Hyperglycemia - Elevated blood glucose - ***609***

Hypermobility - The condition of having excessive amounts of range of motion in a joint or joints - ***313***, ***652***

Hyperresponsiveness - The acute, early phase of an asthma attack - ***625***

Hypertension - High blood pressure measuring more than 140/90 mm Hg - ***7***, ***12***, ***104***, ***105***, ***224***, ***602***, ***604***, ***606***, ***608***, ***623***

Hyperthermia - The condition of excessively high body temperature - ***639***

Hypertrophy - An increase in muscular size as an adaptation to exercise - ***285***, ***287***, ***288***, ***290***, ***292***, ***296***, ***306***, ***415***, ***430***, ***434***, ***436***, ***437***, ***445***

Hyperuricemia - An abnormally high level of uric acid in the blood - ***616***

Hyperventilation - To breathe at an abnormally rapid rate, increasing the rate of loss of carbon dioxide - ***625***

Hypodermis - The deepest layer of skin housing fat cells and connective tissues - ***127***

Hypoglycemia - The condition of lower-than-normal blood glucose - ***192***, ***510***, ***611***

Hypotension - Low blood pressure measuring 90/60 mm Hg or lower - ***104***

Hypothalamus - The region at the base of the brain responsible for maintaining homeostasis - ***64***

Hypoxia - Lack of oxygen - ***410***

I

Ideal Posture - Optimal body positioning and structural alignment - ***237***

Imaginary Audience - An individual imagines and believes that multitudes of people are enthusiastically listening to or watching them - ***638***

Impairment - The state of being diminished, weakened, or damaged, especially mentally or physically - ***655***, ***656***

Implementation Intention - A preset plan that links critical situations (e.g., anticipated obstacles or opportunities) to goal-directed responses - ***48***

Inclusion - The act of including into a group, involvement and empowerment, where the inherent worth and dignity of all people are recognized - ***656***

Incomplete Proteins - A food source that lacks one or more of the nine essential amino acids - ***524***, ***587***

Independent Contractor - Someone who works for themselves and is contracted to provide services for a company as a nonemployee - ***662***

Indirect Calorimetry - A way to measure energy expenditure by oxygen consumed and carbon dioxide produced - ***186***

Inertia - The resistance to action or change and describes the acceleration and deceleration of the human body - ***142***

Inferior Vena Cava - The blood vessel moving blood from the lower body to the heart - ***97***, ***100***

Ingredient List - A list provided on a food label of each ingredient in a product in descending order of prominence - ***544***

Initial Interview Packet - The first health and liability intake forms that a client will complete before beginning to work with a fitness professional - ***205***

Innervation - The distribution or supply of nerves - ***162***

In-person Training - Live, face-to-face fitness training done individually or in small or large groups - ***662***, ***663***

Insertion - The distal muscular attachment point to a bone - ***156***, ***157***, ***158***, ***159***, ***160***

Inspiration - Breathing air into the lungs - ***109***

Insulin - A hormone produced in the pancreas to regulate blood sugar - ***113***, ***116***, ***117***, ***118***, ***510***, ***608***, ***610***

Insulin-Like Growth Factors (IGF) - A protein similar to insulin that stimulates growth of cells ***116***

Insulin Resistance - An impaired response of the body to insulin, increasing levels of blood glucose - ***610***

Insulin Shock - A medical condition caused by too much insulin in the body that results in stark drops in blood glucose - ***713***

Integumentary System - Organ system protecting the body; composed of skin, hair, and nails - 127

Intensity - The measurable amount of force or effort given to an activity or exercise often expressed as a percentage of effort compared to a person's maximum effort - ***284***, ***286***, ***287***, ***289***, ***297***, ***301***

Internal Respiration - The process of diffusing oxygen from the blood into the interstitial fluid and into the cells - ***110***

Internal Stimuli - Sensory input from within the body - ***67***

International Units (IU) - The quantity of a substance that has a biological effect. Amount varies depending on the substance ***582***

Interneurons - Nerve cells that connect neurons to other neurons - ***61***

Interstitial Fluid - The fluid found between cells - ***106***

Interval Training - Training that varies between high- and low-intensity work to challenge the cardiorespiratory system - ***280***

Intra-Alveolar Pressure - The pressure within the alveoli that changes throughout respiration - ***109***

Intracellular Fluid (ICF) - Water found within the cells of the body - ***529***

Intraset Muscle Fatigue - Muscle fatigue that occurs within a single set of an exercise - ***288***

Intrinsic Factor (IF) - A substance secreted by the stomach that enables the body to absorb vitamin B12 - ***582***

Intrinsic Motivation - The drive to execute behaviors that are driven by internal or personal rewards - ***30***

Intuitive Limbering - Stretching after waking or when standing up from a prolonged seated position - ***316***

Ipsilateral Loading - Loading the body on the same side as the work being executed - ***478***

Isolation Exercises - Single-joint exercises that primarily activate an individual muscle or muscle group - Single-joint exercises that primarily activate an individual muscle or muscle group - ***421***, ***422***, ***495***

Isometric Muscle Action - When the length of a muscle remains constant as tension is produced - ***79***

J

Joint - An articulation between two bones in the body - ***16***, ***80***, ***89***, ***90***, ***92***, ***141***, ***147***, ***153***, ***165***, ***166***, ***167***, ***176***, ***177***

Joint Capsule - A thin, strong layer of connective tissue containing synovial fluid in freely moving joints - ***92***

Joint Mobility - The degree of movement around a joint before movement is restricted by surrounding tissues - ***141***

Joint Stability - The ability of the muscles around a joint to control movement or hold the joint in a fixed (stable) position - ***141***

K

Karvonen Formula - The formula to estimate a target heart rate with consideration of heart rate reserve and resting heart rate - ***392***

Ketoacidosis - An increase in blood acidity caused by excess ketones in the bloodstream - ***552***, ***614***

Keto Diet - A popular diet that reduces carbohydrate intake to deliberately increase fat metabolism and ketones in the blood - ***552***

Ketone Bodies - Molecules released by the liver in starvation states for an alternate energy source - ***118***

Ketones - By-products of the breakdown of fatty acids - ***614***

Ketosis - A metabolic process that occurs when the body does not have enough carbohydrates for energy; the liver metabolizes fatty acids to produce ketones as a replacement energy source - ***118***, ***552***

Kinesiology - The study of the mechanics of human movement - ***130***

Kinesthetic Learners - People who learn by physical touch - ***455***, ***457***

Kinetic Chain - A system of links—or joints—in the body that generate and transfer force from one to the other - ***233***

Kinetic Chain Checkpoints - The six anatomical locations of predictable movement patterns where movement dysfunctions can be detected - ***233***

Kinetics - The study of forces acting on a mechanism - ***149***

Knee Valgus - The position of the knee near the midline of the body (i.e., knock knees) - ***241***, ***242***, ***244***, ***245***

Knee Varus - The position of the knee away from the midline of the body (i.e., bowlegged) - ***241***, ***242***

Krebs Cycle - A series of chemical reactions inside the mitochondria that use acetyl-CoA to generate ATP and other substrates that contribute to the electron transport chain - ***190***, ***191***

Kyphosis - The exaggerated rounding of the thoracic spine - ***238***, ***239***, ***240***

L

Lactate Threshold - The maximum effort or intensity an individual can maintain for an extended time with minimal effect on blood lactate levels. This is the point where muscle tissue begins to make large amounts of lactate - ***190***, ***387***

Lactic Acid - The chemical by-product of anaerobic glycolysis ***189, 190***

Lactic Acidosis - The accumulation of excess H+ causing muscle fatigue and soreness - ***190***

Laws Of Motion - The laws of physics describing movement - ***142***

Leads - Potential clients not yet using a professional's services - ***679***, ***682***, ***692***

Lean Body Mass - The fat-free mass of the body calculated by total weight minus the weight of bodyfat - ***210***, ***211***

Length-Tension Relationship - The amount of tension a muscle can produce as a function of sarcomere length - ***265***

Lever Arm - The rigid bar portion of a lever that rotates around the fulcrum - ***153***

Levers - A rigid or semirigid bar rotating around a fixed point when force is applied to one end - ***6***, ***152***, ***154***, ***155***

Liability Waiver - A short form that, when signed by a client, releases a fitness professional and/or their training facility from any liability should the client be injured while working with them - ***205***, ***206***

Ligaments - Short bands of tough but flexible fibrous connective tissue connecting two bones or cartilages or holding together a joint - ***17***, ***92***

Limited Liability Company (LLC) - A corporate structure in the US limiting the liability of the owner; it combines aspects of corporations and sole proprietorships - ***669***

Linear Displacement - The distance an object moves in a straight line - ***147***

Linear Motion - Movement along a line, straight or curved - ***147***, ***149***

Linear Periodization - Progresses from low-intensity to high-intensity across the entire macrocycle - ***300***

Linear Strength - Two or more strength variables that are directly correlated to one another - ***417***, ***419***

Linear Strength Endurance Activity - Activity that requires a sustained, all-out maximum effort for an extended period - ***419***

Line Of Gravity - A vertical line straight through the center of gravity - ***139***, ***140***

Load - A term used to describe the amount of resistance used in a strength training exercise - ***286***, ***297***

Locomotion - Movement from one place to another - ***486***

Loose-Packed Joint Position - The less stable joint position represented by any other joint position other than close-packed - ***90***

Lordosis - The excessive inward curve of the lumbar spine - ***238***, ***239***, ***240***

Low-Density Lipoprotein - The form of lipoprotein in which cholesterol is transported in the blood. It is sometimes considered the "bad cholesterol." ***416***

Lumbopelvic Hip Complex (LPHC) - The musculature of the hip that attaches to the pelvis and lumbar spine and works to stabilize the trunk and lower extremities - ***234***, ***266***

Lupus - A chronic autoimmune disease that creates inflammation and pain in various parts of the body - ***617***

Lymph - The colorless fluid of the lymphatic system - ***97***, ***106***, ***107***

Lysosomes - An organelle filled with digestive enzymes that breaks down materials the cell has absorbed - ***184***

M

Macronutrients - A type of food necessary in large quantities in the diet to support function and energy production (i.e., carbohydrate, protein, and fat.) - ***182***, ***186***, ***194***, ***508***, ***530***

Market Analysis - A qualitative and quantitative assessment of a business market that examines product and service volume, buying patterns, regulations, and business competition - ***671***

Mass - The amount of matter in an object - ***139***, ***142***

Maximum Heart Rate - The estimated maximum number of times the heart should beat per minute during exercise. Calculated by subtracting a person's age from 220 - ***279***, ***376***, ***388***, ***391***

Maximum Strength - The ability for a muscle (or muscle group) to recruit and engage as many muscle fibers as possible - ***414***, ***430***, ***436***, ***437***

Mechanical Advantage - The ratio of force that creates meaningful movement compared to the force applied to generate the movement - ***151***

Mechanical Work - The amount of energy transferred by a force, the product of force and distance - ***152***

Mechanoreceptors - Nervous system receptors responding to mechanical stimuli such as sound or touch - ***67***, ***68***

Medulla Oblongata - The base of the brain stem, responsible for involuntary functions like swallowing, sneezing, and heart function - ***63***

Meniscus - A form of fibrocartilage present in the knee, wrist, acromioclavicular, sternoclavicular, and temporomandibular joints - ***93***

Metabolic Equivalent (MET) - The measure of the ratio of a person's expended energy to their mass while performing physical activity - ***209***, ***375***

Metabolic Syndrome - A cluster of at least three biochemical and physiological abnormalities associated with the development of cardiovascular disease and type 2 diabetes - ***553***, ***643***

Metabolic Training - A style of training that typically uses high-intensity intervals to train both the aerobic and anaerobic energy systems - ***301***, ***304***, ***306***, ***308***

Metabolism - All of the chemical processes that occur in the body to support life including converting food into energy - ***6***, ***16***, ***100***, ***181***, ***182***, ***191***, ***193***, ***194***, ***198***

Metronome - A device marking time at a selected rate - ***226***

Micronutrients - Substances required in small quantities in the diet for optimal body functioning; vitamins and minerals - ***508***, ***530***

Midbrain - The brain region responsible for motor movement and processing auditory and visual information - ***62***

Millimeters Of Mercury - The measure of a unit of pressure - ***603***

Minerals - Elements in food that the body needs to develop and function - ***511***, ***529***, ***530***, ***531***, ***533***, ***534***, ***535***, ***536***, ***568***, ***575***, ***580***

Minute Ventilation - The total amount of air entering the lungs over the course of one minute - ***383***

Mission Statement - A short statement of why a business exists and their overall goal for operating - ***670***

Mitochondria - An organelle with a double membrane and many folds inside responsible for generating the chemical energy needed for biochemical reactions - ***76***, ***184***

Mitosis - Cell division that results in two cells identical to the original cell - ***183***

Mobility - The ability of a joint to move freely through a given range of motion - ***302***, ***450***

Moment Arm - The perpendicular distance between the fulcrum and the line of the force being applied - ***153***

Momentum - The quantity of motion of a moving body, measured as a product of its mass and velocity - ***144***

Monitoring - The process of observing and taking notice of routine behaviors that impact goal progress and achievement - ***46***, ***49***

Monosaccharides - Any of the class of sugars that cannot be hydrolyzed to give a simple sugar - ***509***

Motivation - The reason(s) one has for behaving in a certain way - ***30***, ***31***, ***41***

Motivational Interviewing (MI) - A collaborative, client-focused method of guiding a client toward a self-identified motivation for change - ***24***

Motor Cortex - The region of the frontal lobe that plans and coordinates movement - ***63***

Motor Neurons - Nerve cells that initiate muscle contraction or activate glands - ***61***, ***66***, ***68***, ***74***

Motor Skills - The ability to learn and manage the process of moving the body in a coordinated way - ***633***

Motor Unit - A single motor neuron and the muscle fibers it controls - ***68***

Motor Unit Pool - A group of motor units that work together - ***68***

Movement Assessments - Observation and critique of movement patterns or exercise form - ***204***, ***236***

Movement Categories - The six fundamental movements that are the basis for most exercise selections in exercise programming - ***457***

Multipennate Muscle - Muscle fibers extending from both sides of multiple central tendons - ***78***

Multiset - Multiple sets per exercise or muscle group - ***443***

Multivitamins/Minerals (MVMs) - Supplements or pills containing a combination of vitamins and minerals - ***570***

Muscle Actions - Force production by a muscle that can result in a change of length (i.e., shortening or lengthening) or no length change at all - ***79***

Muscle Activation Exercises - Low-level resistance movements to activate blood flow and activate the nervous control of a muscle - ***316***

Muscle Protein Synthesis (MPS) - A process that produces protein to repair muscle damage and oppose muscle breakdown - ***24***, ***586***

Muscle Spindle - The proprioceptive sensory organ that senses muscle stretch in a muscle and promotes muscle action - ***91***

Muscle Synergies - The activation of a group of muscles to generate movement around a particular joint - ***162***, ***233***

Muscular Contraction - The shortening or resistance to lengthening of a muscle fiber - ***142***, ***147***

Muscular Endurance - The ability of a muscle or group of muscles to continuously exert force against resistance over time - ***262***, ***263***, ***285***, ***287***, ***288***, ***290***, ***292***, ***306***

Muscular Endurance Tests - Assessments testing the ability of a muscle group to overcome resistance in as many repetitions as possible - ***228***

Muscular Force - Involves the contraction of a muscle while exerting a force and performing work. It can be concentric (shortening), eccentric (lengthening), or isometric (tension without joint movement) - ***138***

Muscular Force Couple - Two or more muscles generate force in different linear directions at the same time to produce one movement - ***234***

Muscular Imbalance - When the muscle or muscles on one side of the body are stronger, weaker, or more or less active than the corresponding muscle on the other side of the body - ***233***

Muscular Strength - The measure of force produced by a muscle or group of muscles - ***262***, ***263***, ***268***, ***278***

Myelin Sheath - The insulation of neuron axons, made of proteins and fats, which propagates neural impulses - ***68***

Myofascial Release (MFR) - Stretches and loosens the fascia using gentle, gradual, sustained pressure or stretch on areas of tension - ***360***

Myofibrils - Parallel filaments that form muscle - ***71***, ***72***

Myofilaments - The filaments of myofibrils composed of actin and myosin - ***71***

Myoglobin - A protein in muscles cells that carries and stores oxygen - ***394***

Myosin - The thick filaments of myofilaments with a fibrous head, neck, and tail that bind to actin - ***71***

Myositis Ossificans - A condition when bone tissue forms within a muscle or other soft tissue as a result of trauma or injury - ***87***

MyPlate - The current visual nutrition guide published by the USDA Center for Nutrition Policy and Promotion - ***538***, ***540***, ***541***, ***542***, ***543***

N

Negative Energy Balance - More energy is expended than consumed - ***195***

Nephropathy - Disease or damage of the kidney - ***613***

Nerve Impulses - The electrical signals used for nerve communication - ***68***

Nervous Tissue - Tissue found in the brain, spinal cord, and nerves that coordinates body activities - ***59***

Neuroglia - Cells in the brain and spinal cord that form a supporting structure for the neurons and provide them with insulation - ***60***

Neuromuscular Junction - The space between a motor neuron and muscle fiber - ***73***

Neurons - The most fundamental component of the brain and nervous system capable of transmitting information to and from other neurons, muscles, or glands. ***59***, ***60***, ***61***, ***66***

Neuropathy - Disease or dysfunction of one or more peripheral nerves, typically causing numbness or weakness - ***613***

Neurosecretory Tissues - Neurons that translate neural signals into chemical stimuli - ***60***

Neurotransmitter - A chemical messenger that transmits messages between neurons or from neurons to muscles - ***73***

Nociceptors - Pain-sensitive nerve endings -***93***

Non-Exercise Activity Thermogenesis (NEAT) - Energy expended as a result of any movements of the body that require energy. This includes all activities of daily living outside of planned and structured workouts - ***197***

Nonlinear Strength - Two or more strength variables that are not directly correlated to one another - ***417***, ***419***

Nonlinear Strength Endurance Activity - An activity with intermittent activity and rest periods - ***419***

Non-synovial Joints - Joints that lack a fluid junction - ***88***

Nonverbal - Not involving words or speech - ***452***

Nutrient Density - The amount of nutrients in a food relative to the number of calories it provides, usually measured per 100 kilocalories - ***539***

Nutritional Limiting Factors - The nutritional choices a client makes that keep them from making progress or seeing results - ***561***

Nutrition Facts - A label required by the FDA on most food and beverages that details the food's nutrient content - ***543***

O

OARS Model - A communication model for motivational interviewing that includes open-ended questions, affirmations, reflective listening, and summarizing - ***38***

Obesity - An abnormal or excessive accumulation of bodyfat that may cause additional health risks - ***12***, ***510***, ***604***, ***617***, ***622***, ***627***, ***632***, ***648***

Objective Assessments - Fitness assessments that collect repeatable, measurable data such as body composition or circumference measurement - ***204***

Objective Goal - A goal based on objective, quantifiable data that can be measured and evaluated - ***48***

Occipital Lobe - The posterior lobe of the brain responsible for vision - ***64***

Omega-3 Fatty Acids - An unsaturated fatty acid occurring chiefly in fish oils - ***518***

Omega-6 Fatty Acids - A family of pro-inflammatory and anti-inflammatory polyunsaturated fatty acids that have in common a final carbon-carbon double bond - ***518***

Onboarding Emails - A series of email communications that gather the required documentation and assessments to begin a training program - ***678***

One-Repetition Max (1RM) - A single maximum-strength repetition with maximum load - ***228***, ***286***, ***430***

Open-Ended Questions - Questions that require more than a yes or no answer and encourage the client to communicate the “how” and “why.” - ***38***, ***42***

Open Kinetic Chain Movement - A movement in which the distal aspect of the body segment in action is free (i.e., not fixed) - ***236***

Organelles - Tiny structures within cells, each with a unique function - ***182***

Organ Systems - A group of organs working together to perform biological functions - ***58***

Origin - The proximal muscular attachment point to a bone - ***156***, ***157***, ***158***, ***159***, ***160***

Osteoarthritis - Degeneration of joint cartilage and the underlying bone - ***615***, ***617***

Osteogenesis - The process of bone formation or remodeling - ***86***

Osteoporosis - A skeletal condition that results in weak or brittle bones - ***116***, ***222***, ***643***, ***648***

Outcome Goal - A goal where the end result is a specific desired outcome - ***46***

Overactive Muscles - Muscles that are shortened beyond the ideal length-tension relationship with high neural activation that feel tight - ***233***

Overhead Squat Assessment - The uncoached movement assessment of the overhead squat with the goal of identifying movement dysfunctions along the kinetic chain - ***245***

Overreaching - An accumulation of training or non-training stress resulting in a short-term decrease in performance capacity - ***302***

Overtraining - An accumulation of training or non-training stress resulting in a long-term decrease in performance capacity - ***302***, ***303***

Overtraining Syndrome (OTS) - A maladapted response to excessive exercise without adequate rest, resulting in perturbations of multiple body systems (neural, endocrine, and immune) coupled with mood changes - ***302***

Oxidation - The chemical reaction of combining with oxygen or removing hydrogen - ***190***

Oxidative Energy Pathway - An aerobic energy pathway using primarily fat and carbohydrates to produce energy - ***190***

Oxidative Phosphorylation - The energy-producing process that occurs in mitochondria in the presence of oxygen - ***184***

P

Paralanguage - Components of speech like tone, pitch, facial expressions, cadence, and hesitation noises - ***452***, ***454***

Parallel Muscle - Muscle fibers running parallel to the axis of the muscle - ***78***

Parallel Play - A form of play in which children play adjacent to each other, but do not try to influence one another's behavior - ***636***

Parasympathetic Nervous System - The autonomic system responsible for "rest and digest." ***66***

Parietal Lobe - The brain lobe involved in processing sensory information - ***63***

Parkinson's Disease - A progressive disease of the nervous system marked by tremor, muscular rigidity, and slow, imprecise movement - ***643***

Partial Repetitions - Repetitions of an exercise intentionally done with a reduced range of motion - ***289***, ***435***

Participation Restrictions - A problem experienced by an individual in involvement in life situations - ***655***

Partnership - A business structure with two or more people running the business who share liability and responsibility for the business's performance - ***669***

Passive Range Of Motion - The range of motion achievable when aided by an external force - ***315***

Passive Stretching - An external force such as a stretching strap or the hand to move a joint to the end of a range of motion - ***314***

Pennate Muscles - Muscles with fascicles that attach obliquely (diagonally) - ***78***

Penniform - Muscle fibers that run diagonally in respect to the tendon similar to a feather - ***78***

Performance Supplements - Supplements intended to help enhance athletic performance - ***568***, ***584***

Perichondrium - The connective tissue enveloping cartilage everywhere except at a joint - ***93***

Perimysium - The connective tissue that covers a bundle of muscle fibers - ***73***

Periodization - An organized approach to training involving progressive cycling of various aspects of a training program during a specific time - ***284***, ***299***, ***300***, ***301***

Periosteum - A dense layer of vascular connective tissue enveloping the bones except at the surfaces of the joints - ***73***

Peripheral Nervous System (PNS) - The nerves and ganglia (relay areas for nerve signals) outside of the brain and spinal cord - ***62***

Peripheral Resistance - The vascular resistance of the arteries to blood flow - ***105***

Peripheral Vasoconstriction - Constriction of smaller arterioles near the skin to keep blood closer to the core of the body and preserve heat - ***410***

Peristalsis - The muscular contractions of the smooth muscle of the digestive tract, which moves food through the digestive tract - ***120***

Personal Development - Activities that improve awareness and identity, develop talents and potential, build human capital and facilitate employability, enhance the quality of life, and contribute to the realization of dreams and aspirations - ***637***

Phase Potentiation - The strategic sequencing of programming categories to increase the potential of later training and increase long-term adaptive potential - ***301***

Phospholipid Bilayer - The dual layer of lipids that make up the cell membrane of most human cells - ***182***

Physical Activity Readiness Questionnaire (PAR-Q) - An intake form to assess a client's readiness to begin a physical activity program and assess injury potential - ***206***

Physician's Letter Of Clearance - A signed letter from a client's health care provider stating they are cleared for physical activity and exercise that should also include any restrictions or limitations they should adhere to - ***205***, ***207***

Placenta Previa - A condition in which the placenta partially or wholly blocks the neck of the uterus, thus interfering with normal delivery of a baby - ***654***

Plant-Based Diet - Eating mostly or entirely foods that are plants or derived from plants - ***550***

Plasma Membrane - The cellular membrane made of lipids and proteins that forms the external boundary of the cytoplasm and regulates the passage of molecules in and out of the cytoplasm - ***182***

Pliability - The quality of being easily bent or flexible - ***338***

Plyometric Training - Reactive training seeking maximum force in the shortest amount of time - ***273***

Polycystic Ovary Syndrome - A hormonal disorder common among women of reproductive age - ***612***

Polyunsaturated Fats - Fat molecules containing more than one unsaturated carbon bond, are liquid at room temperature, and solid when chilled - ***591***

Pons - The brain region responsible for posture, facial movement, and sleep - ***63***

Positive Energy Balance - More energy is consumed than expended - ***195***

Positive Reinforcement - Including a favorable outcome, event, or reward after a child completes a desired behavior or action - ***637***

Postexercise Hypotension (PEH) - A drop in blood pressure in the first minutes after an exercise session - ***603***

Postpartum - The period of time following childbirth - ***651***, ***653***

Post-Traumatic Stress Disorder (PTSD) - A persistent mental and emotional stress that occurs as a result of injury or psychological shock - ***617***

Power - The combination of strength and speed—the ability for a muscle to generate maximal tension as quickly as possible - ***152***, ***285***, ***287***, ***288***, ***290***, ***292***, ***308***, ***414***, ***430***, ***434***, ***436***, ***437***, ***446***

Prediabetes - A condition where blood glucose is higher than it should be, but not in the diabetes range - ***609***

Preeclampsia - A condition in pregnancy characterized by high blood pressure, sometimes with fluid retention and proteinuria - ***654***

Prefrontal Cortex - The part of the frontal lobe responsible for high-level thinking and language - ***63***

Prenatal - Occurring or existing before birth - ***651***

Presidential Youth Fitness Program - A comprehensive school-based program that promotes health and regular physical activity for America's youth - ***640***

Principle Of Individual Differences - The concept that there is no one specific way to train every client due to the uniqueness of each person - ***296***

Principle Of Progressive Overload - The body must be forced to adapt to or overcome a stress greater than what is normally encountered - ***297***

Principle Of Reversibility - Clients lose the effects of training after they stop working out - ***297***

Principle Of Specificity - The concept that training must be specific to an individual's goals, as the adaptations they will see will be based on the training completed - ***293***

Principle Of Variability - Training programs must include variations in intensity, duration, volume, and other aspects of practice - ***295***

Principles Of Program Design - Fundamental propositions to serve as the foundation for effective fitness programming - ***284***

Processed Foods - Foods that have been frozen, packaged, enhanced with vitamins or minerals (fortified), previously cooked, or canned to preserve them for consumption - ***509***, ***515***, ***541***

Processes Of Change - The strategies and techniques that can influence an individual's transition from one stage of change to the next - ***24***, ***26***

Process Goal - A goal where the focus is on the process or action that will lead to the desired end result - ***46***

Profit And Loss Statement - A financial statement summarizing revenues, costs, and expenses in a given time period - ***688***

Progesterone - Female hormone that regulates the menstrual cycle and is crucial for pregnancy - ***651***

Progressions - Modifications to acute training variables that increase the challenge of a movement pattern - ***451***

Proliferative Retinopathy - An overgrowth of blood vessels around the retina - ***613***

Promotional Emails - An email communication series that presents an offer or promotion for a limited time - ***678***

Proprioception - Perception or awareness of body movement or position - ***67***

Proprioceptive Neuromuscular Facilitation (PNF) Stretching - A flexibility technique used to increase range of motion and neuromuscular efficiencies - ***315***

Prospect - A person who has shown interest in a product or service and is a potential customer - ***676***

Protein Digestibility-Corrected Amino Acid Score (PDCAAS) - Measures the nutritional quality of protein - ***586***

Protein Synthesis - The process of arranging amino acids into protein structures - ***116***

Proxemics - The study of what is communicated by the way a person uses personal space - ***453***

Puberty - The period of hormonal change in an adolescent where they reach sexual maturity - ***634***

Pulmonary Arteries - Blood vessels moving blood from the heart to the lungs - ***99***

Pulmonary Circulation - The blood flow between the heart and the lungs - ***99***

Pulmonary Veins - Blood vessels returning oxygenated blood to the heart from the lungs - ***99***

Pulmonary Ventilation - The process of exchange of air between the lungs and the ambient air - ***108***

Pulse - A rhythmical throbbing of the arteries as blood is propelled through them - ***104***

Purines - A number of biologically important compounds, such as adenosine, caffeine, and uric acid - ***618***

Pyruvate - A metabolic intermediate molecule in several energy pathways - ***191***

Q

Q Angle - The quadriceps angle formed between the quadriceps muscle and the patellar tendon - ***241***, ***242***

Quickness - The ability to react and change body position with a maximum rate of force production - ***272***

R

Range of Motion (ROM) - The measurement of movement around a specific joint or body part - ***134 ,*** ***284***, ***288***, ***312***, ***315***

Rapport - A close, harmonious relationship in which all parties involved understand one another's feelings and communicate well - ***38***

Rates of Perceived Exertion (RPE) A subjective sliding scale of a client's perception of their exercise intensity - ***278***, ***375***

Reactive Training - Quick, powerful movements with an eccentric action followed by an immediate concentric action - ***265***, ***272***, ***273***

Recommended Daily Allowance (RDA) - The average daily level of intake that is sufficient to meet the needs of nearly all (97%-98%) healthy people ***519***, ***570***

Recovery Time - The rest time allowed between training sessions - ***291***

Reengagement Emails - An email communication method to reach out to former clients and prospects and encourage a reply - ***679***

Refeed - Reintroducing carbohydrates into the diet after an extended reduction of a week or more - ***560***

Refractory Period - A window where muscle protein synthesis (MPS) becomes resistant and amino acids are used for other processes - ***589***

Regressions - Modifications to acute training variables that decrease the challenge of a movement pattern - ***451***

Relatedness - The need to feel connected to and supported by others as well as a sense of belonging within a group - ***32***, ***36***, ***37***

Relationship Emails - Emails used to engage with clients and prospects and build a relationship - ***677***

Relative Strength - The individual's body weight in relation to the amount of resistance they can overcome and found with the following calculation: 1RM / body weight = force per unit of body weight - ***414***

Relaxin - A sex hormone that facilitates birth by causing relaxation of the pelvic ligaments - ***651***

Remission - A significant reduction in symptoms and signs of rheumatoid arthritis - ***615***

Repetitions (REPS) - The number of times an exercise is completed within a set - ***284***, ***287***, ***288***,

Resistance Arm - The portion of the lever arm between the load and the axis - ***153***

Resistance Training - The category of training that includes physical activities designed to increase muscle mass, improve strength, muscular endurance, or muscular power - ***265***, ***278***

Resisted Range Of Motion - Range of motion available while a load is also being moved through that range of motion - ***315***

Respiration - The intake of oxygen and subsequent release of carbon dioxide in an organism - ***108***, ***110***, ***111***

Respiratory Quotient (RQ) - A method of determining the fuel mix being used; a way to measure the relative amounts of fats, carbohydrates, and proteins being burned for energy - ***185***

Rest - The amount of time spent in recovery between sets or repetitions - ***285***, ***289***, ***291***, ***292***, ***297***, ***306***, ***308***

Resting Heart Rate (RHR) - The measure of heart rate when completely at rest - ***12***, ***223***, ***384***

Resting Metabolic Rate (RMR) - The energy expenditure of metabolic and physical processes when the body is at rest - ***195***

Retinopathy - Disease of the retina that results in impairment or loss of vision - ***613***

Rheumatoid Arthritis (RA) - A chronic progressive disease causing inflammation in the joints - ***615***

Ribosomes - Small cellular organelles involved in polypeptide and protein synthesis - ***183***

Risk Factors - Variables associated with increased risk of disease or infection - ***12***, ***602***

Rotary Motion - The movement around a fixed axis moving in a curved path - ***155***

Rough Endoplasmic Reticulum - Endoplasmic reticulum with ribosomes attached - ***183***

S

Sagittal Plane - An imaginary line that divides the body into left and right halves - ***134***

SAID Principle - Specific adaptations to imposed demands—stress on the human system, whether biomechanical or neurological, will require the body to adapt specifically to those demands - ***293***

Salivary Amylase - An enzyme found in saliva that converts starches and glycogen to more simple sugars - ***126***

Sarcomere - The contractile unit of muscle tissue - ***72***

Sarcopenia - The degenerative loss of skeletal muscle mass - ***642***

Sarcoplasm - The cytoplasm of a muscle fiber - ***71***

Satiety - The feeling of fullness and satisfaction - ***583***

Scaffolding - A process in which teachers model or demonstrate how to solve a problem, and then step back, offering support as needed -***636***

Scoliosis - The sideways curvature of the spine - ***239***, ***240***

Scope Of Practice - The practices, procedures, and actions a personal trainer is permitted to undertake in keeping with their professional certification - ***687***

Screen Time - The time spent using a device such as a computer, television, smartphone, or games console - ***632***

Seizure - A burst of uncontrolled neural activity that causes temporary abnormalities in muscle movements or muscle tone, behaviors, or sensations - ***715***

Self-Determination Theory (SDT) - A general theory of human motivation that suggests a person is motivated to change by three basic psychological needs of autonomy, competence, and relatedness - ***30***

Self-Efficacy - The certainty of one's ability to accomplish a particular task - ***24***

Self-myofascial release - ***24***, ***36***, ***281***, ***314***

Self-Myofascial Release (SMR) - Applying manual pressure to an adhesion or overactive tissue to elicit an autogenic inhibitory response, which is characterized by a decrease in the excitability of a contracting or stretched muscle arising from the Golgi - ***281***, ***314***

Senescence - The process or state of growing old - ***641***

Sensitive Period - A time or stage in a person's development when they are more responsive to external stimuli and quicker to learn particular skills - ***636***

Sensory Integration - The way the brain works to affect responses to neural input - ***68***

Sensory Neurons - Nerve cells involved in communicating tactile, auditory, or visual information ***61***, ***66***

Set - The number of times an exercise or group of exercises is completed - ***287***

Shear Force - The force of two surfaces moving across one another - ***146***

Sherrington's Law Of Reciprocal Inhibition - A law that states that for every muscle activation, there is a corresponding inhibition of the opposing muscle - ***160***

Shivering - Involuntary contraction or twitching of muscle tissue as a physiological means of heat production - ***410***

Shock - An acute medical condition brought on by a sudden drop in blood flow through the body - ***710***, ***713***

Shoulder Girdle - The clavicle, scapula, and coracoid bones of the appendicular skeleton - ***236***

Single Set - The use of one set per exercise or muscle group - ***443***

Sinoatrial (SA) Node - The pacemaker of the heart that generates the first electrical signal of a heartbeat and stimulates the atria to contract - ***102***

Size Principle Of Fiber Recruitment - Principle stating that motor units are recruited in order according to their recruitment thresholds and firing rates - ***77***

Skeletal Muscles - The voluntary muscles attached to bones via tendons (thick fibrous connective tissue) that produce human movement - ***70***

Sleep Apnea - A disorder of breathing during sleep - ***643***

Sleep Deprivation - Achieving a less than ideal sleep duration - ***370***

Sliding-Filament Theory - The interaction of actin and myosin that describes the process of muscle contraction - ***75***

Small Business Administration (SBA) - A US government agency established in 1953 to promote economic growth by helping new and existing small businesses and providing advice, financial assistance, counseling, and tips for sustainable business growth - ***669***

Small Group Personal Training - Exercise instruction delivered to two to four clients at the same time - ***662***, ***665***

SMART Principle - Acronym to enable goals to be more objective; S—specific, M—measurable, A—achievable, R—relevant, T—time-bound - ***47***, ***48***

Smooth Endoplasmic Reticulum (SER) - Endoplasmic reticulum that lacks ribosomes - ***183***

Smooth Muscle - Muscle tissue that occurs in the gut and internal organs that is involuntarily controlled - ***70***

Social Proof - A success story of a program or something similar to prove that the style of training works - ***675***

Social Stigmatization - The disapproval of, or discrimination against, a person based on perceivable social characteristics - ***633***

Sole Proprietorship - The most common business structure, in which the single owner has complete control over and liability for a business - ***669***

Somatic Nervous System - The part of the nervous system in charge of controlling voluntary movement - ***66***

Somatosensory Cortex - The region of the parietal lobe responsible for processing sensations like pain, temperature, and touch - ***63***

Somatotype - Categories of physical body type - ***200***

Spatial Relations - How objects are located relative to one another in space - ***452***

Specific Exercises - Exercises that directly improve performance and functional capacity - ***423***

Specific Warm-Ups - Activities that prepare the body for specific exercise to follow by incorporating movements that mimic the planned activity - ***265, 228***

Speed - The ability to move the body in one direction as fast as possible - ***145***, ***147***, ***272***

Speed, Agility, And Quickness (SAQ) Training - The training category including reactive, ballistic, plyometric, and agility training - ***301***

Speed Strength - The ability of a muscle or muscle group to absorb and transmit forces quickly - ***414***

Spinal Cord - The neural tissue extending from the medulla oblongata to the lumbar region (lower back) of the vertebral column - ***64***, ***69***, ***74***

Spinal Nerves - Bundles of nerves connected to the spinal cord carrying information toward the periphery - ***65***, ***74***

Spirometer - An apparatus for measuring the volume of air inspired and expired by the lungs - ***381***

Split-Routine - The division of training sessions by body part or body region - ***428***

Squat Assessment - The uncoached movement assessment of body mechanics during a squat with the goal of identifying movement dysfunctions along the kinetic chain - ***242***

Stability - The ability to control and maintain control of joint movement or body position - ***6***, ***138***, ***139***, ***141***, ***149***

Stabilizer Muscles - The muscles playing the role of stabilizing or minimizing joint movement - ***161***

Stages Of Change - The series of temporal stages of readiness that a person progresses through during the behavior change process - ***24***

Starting Strength - The ability to recruit as many motor units as possible instantaneously at the start of a movement - ***414***

Static Balance - The ability to remain upright and balanced when the body is at rest - ***138***, ***139***

Static Posture - Posture when standing upright and still - ***236***, ***237***

Static Stretching - Lengthening a muscle and holding the lengthened position - ***265***, ***313***, ***314***, ***316***, ***343***

Steady-State Sxercise - Exercise that maintains a steady level of exertion from start to finish - ***194***, ***279***

Steroid Myopathy - Weakness primarily to proximal muscles of the upper and lower extremities and neck caused by treatment with corticosteroids - ***629***

Steroids - A class of chemicals characterized by their carbon structure, working to reduce inflammation and the activity of the immune system - ***111***

Stimulants - A class of drugs that temporarily improve physical or mental function - ***594***

Stimulus-Fatigue-Recovery-Adaptation Principle - The concept that training response is based on the stimulus intensity, and the greater the stimulus intensity is, the longer the recovery needed to produce the adaptations will be - ***299***

Straight Sets - The use of the same weight for every set - ***443***

Strategic Emails - Email communications that explain why a trainer does what they do, training philosophies, and more about themselves - ***677***

Strength - The amount of force that can be created by a muscle or group of muscles - ***285***, ***292***, ***296***, ***301***, ***304***, ***305***, ***306***, ***308***

Strength Training - The category of training that includes resistance training for increased muscle mass and improved strength and muscular endurance - ***292***, ***301***, ***304***, ***305***, ***308***

Stretch-Shortening Cycle (SSC) - The cycling between the eccentric (stretch) action of a muscle and the concentric (shortening) action of the same muscle - ***79***, ***274***

Stroke - When the blood flow to the brain is interrupted long enough to cause damage - ***602***, ***710***, ***714***

Stroke Volume - The amount of blood pumped by the left ventricle of the heart in one contraction - ***102***

Subcutaneous Fat - Generally harmless fat cells located just beneath the skin - ***127***

Subjective Assessments - Fitness assessments that require observation or a subjective, opinion-based measure - ***204***, ***236***

Subjective Goal - A goal based on a subjective outcome that will be dependent on the interpretation of the individual client - ***48***

Supercompensation - The post-training period during which the trained function/parameter has a higher performance capacity than it did before the training period - ***298***

Superior Vena Cava - The blood vessel moving blood from the upper body and head to the heart - ***97***, ***99***, ***100***, ***101***

Supersets - Two exercises, typically opposing muscle groups, performed back-to-back followed by a short rest - ***443***, ***444***

Swayback - A posterior tilt with excessive extension of the lumbar spine that protrudes the buttocks - ***239***

Sympathetic Nervous system - The autonomic system responsible for “fight-or-flight.” - ***66***

Syncope - Temporary loss of consciousness related to insufficient blood flow to the brain - ***434***, ***607***

Synergistic Dominance - When a synergist (helper) muscle takes over a movement pattern when the prime mover fails or is too weak to control the movement - ***451***

Synergists - Muscle(s) supporting the mechanical movement of a prime mover - ***160***

Synovial Fluid - A viscous fluid found in the cavities of synovial joints - ***88***, ***89***

Synovial Joints - Fluid-filled joints found between bones that move against one another -***88***, ***89***

Systemic Circulation - The blood flow between the heart and the rest of the body - ***99***

Systole - The heartbeat phase where muscle contraction moves blood from the heart chambers to the arteries - ***102***

Systolic - The pressure in blood vessels when the heart beats (ventricular contraction) - ***104***, ***105***, ***602***, ***604***

T

Talk Test - The ability to speak during exercise as a gauge of the relative intensity - ***375***, ***607***

Tapering - A decrease in training volume or frequency to allow the body adequate rest and recovery - ***425***, ***426***

Taper Period - A training period where the volume or frequency of training decreases to allow the body adequate rest and recovery - ***373***

Target Heart Rate (THR) - The estimated beats per minute that needs to be reached to achieve a specific exercise intensity - ***278***, ***375***

Target Market - The particular group(s) of consumers that a product or service targets - ***671***

Tempo - The speed at which an exercise or movement pattern is completed - ***64, 285***, ***290***, ***291***, ***292***, ***306***, ***308***

Temporal Lobe - The lateral lobe of the brain responsible for hearing, memory, and emotion - ***64***

Tendon - A strong, fibrous cord made of collagen that attaches muscle to bone - ***16, 73***, ***89***, ***91***

Tensile force - The force when two surfaces pull apart from one another - ***146***

Testosterone - A steroid hormone found in both males and females - ***114***, ***116***

Three-day dietary record - A common fitness and nutrition intake form that allows clients to log their food consumption for three consecutive days to observe their habits - ***205, 207***

Thalamus - The brain region responsible for relaying sensory and motor signals and regulating consciousness - ***63***

Thermic Effect of Food (TEF) - The energy expenditure associated with food digestion and absorption - ***195***

Thoracic Cavity - The chest cavity enclosed by the ribs, sternum, and spinal column - ***109***

Tidal Volume - The lung volume representing the normal volume of air displaced between normal inhalation and exhalation when extra effort is not applied - ***381***

Time - The duration of an activity or training session - ***285***, ***289***, ***290***, ***291***, ***306***

Time Under Tension (TUT) - The amount of time a muscle is engaged as a set, completed from start to finish - ***285***, ***290***, ***306***

Torque - Force applied that results in rotation about an axis - ***16***, ***155***

Total Daily Energy Expenditure (TDEE) - The accumulated calorie burn made up of resting metabolic rate, the thermic effect of food, physical activity, and physical growth - ***195***

Training Density - A combination of volume and time equaling the total volume of work in a specific amount of time - ***297***

Training Effect - The body's adaptation to the learned and expected stress imposed by physical activity - ***12***

Training Macrocycle - The overall training period, usually one year or more - ***299***

Training Mesocycle - A training phase in the annual training plan made up of three to nine microcycles - ***299***

Training Microcycle - A one-week-long cycle of training sessions, or a single session - ***299***

Training Volume - The total amount of work performed, typically measured as Sets x Reps x Load (or intensity) - ***297***, ***300***

Transtheoretical Model (TTM) - A behavior change model focused on the stages of change, the process of changing behavior, self-efficacy, and the decision balance - ***23***

Transverse Plane - An imaginary line that divides the body into inferior and superior halves - ***134***

Triggers - Any chemical, irritant, or allergen that causes an inflammatory response of the airways - ***625***, ***626***

Triglyceride - A chemical compund formed when three fatty acids combine with glycerol. The most abundant fat in the body - ***185***, ***191***, ***416, 517***

Type - The techniques, equipment, or methods used to complete an activity - ***284***, ***285***, ***289***, ***294***, ***305***

Type 1 Diabetes - A chronic condition in which the pancreas produces little or no insulin - ***609***, ***612***

Type 2 Diabetes - A long-term metabolic disorder that is characterized by high blood sugar, insulin resistance, and relative lack of insulin - ***22***, ***264***, ***609***, ***610***

Type I Fibers - Slow-twitch, fatigue-resistant muscle fibers with high mitochondrial density - ***76***, ***77***

Type IIa Fibers - Fast-twitch, moderately fatigable muscle fibers with moderate mitochondrial density - ***76***

Type IIx Fibers - Fast-twitch, fast-fatigable muscle fibers with low mitochondrial density - ***76***

U

Underactive Muscles - Muscles that are lengthened beyond the ideal length-tension relationship and are, therefore, inhibited and less capable of producing force - ***233***

Undulating Periodization - Short durations of hypertrophy training alternated with short durations of strength and power training - ***300***

Unipennate Muscle - Muscle fibers extending from one side of a central tendon - ***78***

Unprocessed Foods - Fresh or raw foods that are the natural, edible parts of an animal or plant - ***511***

Upper Limit (UL) - The highest level of nutrient intake that is likely to pose no risk of adverse effects for almost all individuals in the general population -***580***

Upsell - A sales technique where a client is encouraged to purchase additional services, products, or add-ons to generate more revenue - ***684***

US Department of Agriculture (USDA) - A US federal department that manages programs for food, nutrition, agriculture, natural resources, and rural development - ***511***, ***532***, ***538***

US Department of Health and Human Services - A US federal department that oversees public health, welfare, and civil rights issues - ***538***

V

Valgus - An abnormal joint movement toward the midline of the body (i.e., knock-kneed) - ***92***

Valsalva Maneuver - The act of forcibly exhaling with a closed windpipe, where there is no air that is exiting via the nose or mouth - ***434***, ***607***, ***620***

Varus - An abnormal joint movement away from the midline of the body (i.e., bowlegged) - ***92***

Veins - Blood vessels carrying blood toward the heart to remove waste and pick up more oxygen - ***96***

Velocity - The speed of an object and the direction it takes while moving - ***143***, ***144***

Ventilatory Threshold (VT) - The threshold where ventilation increases faster than the volume of oxygen - ***224, 387***

Ventricle - One of the two lower cavities of the heart passing blood to the body or to the lungs - ***99***, ***100***, ***101***

Venules - The small branches of the veins gathering blood from the capillaries - ***98***

Virtual Training - Remote training sessions conducted via website, phone applications, or social media platforms - ***662***, ***663***, ***664***

Visceral Fat - Fat accumulated within the abdomen and around internal organs. It has potentially negative effects on arteries, the liver, and the breakdown of sugars and fats - ***415***

Visual Cortex - The specific region of the occipital lobe responsible for sight and visual perception - ***64***

Visual Learners - People who learn by seeing information - ***455***, ***456***

Vital Capacity - The greatest volume of air that can be expelled from the lungs after taking the deepest possible breath - ***381***, ***382***

Vitamins - Organic compounds essential for normal growth and nutrition - ***511***, ***531***, ***532***, ***533***, ***534***, ***535***, ***536***, ***568***, ***571***, ***572***, ***573***, ***574***, ***576***, ***577***, ***578***, ***579***, ***580***, ***582***

VO_2 Max - The maximum amount of oxygen an individual can use during exercise - ***6***, ***224***, ***225***, ***226***, ***227***, 228, ***373***, ***376***, ***380***, ***383***, ***384***, ***385***, ***387***, ***388***

W

Waist-To-Height Ratio - An objective assessment to measure cardiometabolic risk - ***212***, ***213***

Waist-To-Hip Ratio (WHR) - A predictive health measure comparing the circumference of the waist to the circumference of the hips - ***218***

Weight - The gravitational force of attraction on an object - ***7***, ***139***

Weight-Bearing Exercise - Activities that move one's own body weight against gravity - ***638***

Weight Machines - Pieces of equipment with fixed or a variable range of motion that uses gravity and a load to generate resistance - ***440***, ***442***

Weight Management - The physiological processes and techniques one uses to achieve or maintain a specific body weight - ***198***

Wheezing - Breathing with a whistling or rattling sound in the chest - ***626***

Wolff's Law - The explanation for bone adaptations as a result of the loads placed on them - ***87***

Work - Force times distance measured in foot-pounds - ***151***, ***152***

Z

Z line - The lateral boundary of the sarcomere where the myofilament actin attaches - ***72***

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CHAPTER 15: SUPPLEMENTATION

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CHAPTER 16: CHRONIC CONDITIONS

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