

CHAPTER

# 23

## The Muscular System

### Learning Objectives

---

After completing this chapter, you should be able to:

- 23.1 Define and spell the terms for this chapter.
- 23.2 Explain the function of muscles.
- 23.3 Describe the three types of muscle tissue.
- 23.4 Describe how the muscular system changes between childhood and older adulthood.
- 23.5 Explain how energy is used by muscles.
- 23.6 Describe the structure of skeletal muscles.
- 23.7 List major skeletal muscles found throughout the body.
- 23.8 Describe pathology associated with the muscular system.

## Case Study

On returning home from a camping trip, 12-year-old Felix Gutierrez noticed a small black bump near his left ankle. He showed his mother, Rosa, who immediately recognized that the black bump was in fact a tick. She immediately attempted to remove the tick but was not sure if she was completely successful.

## Terms to Learn

agonist	ligament	sprain
antagonist	Lyme disease	strain
aspiration	muscular dystrophy (MD)	striated
atrophy	myasthenia gravis (MG)	synergist
cardiac muscle	origin	tendon
fascia	oxygen debt	tendonitis
fibromyalgia	prime mover	tetanus
ganglion cyst	skeletal muscle	tonicity
insertion	smooth muscle	

**T**he muscular system is composed of all the muscles within the body. Muscle fibers are made of different lengths and shapes and vary in color from white to deep red. The muscle fibers are held together by connective tissue. The connective tissue is held together by a fibrous sheath called **fascia**. Each fiber within a muscle also has its own nervous system connection with a stored supply of energy in the form of glycogen. Muscle must be supplied with proper nutrition and oxygen to perform properly. The muscular system is well permeated by vessels from both the circulatory and the lymphatic systems.

## FUNCTIONS OF MUSCLE

Making up approximately 42 percent of a person's total body weight, muscles serve many functions. The main functions of the muscular system include movement, stability, circulation and respiration, heat production, and aiding in digestion and elimination.

### Movement

Nearly all movement in the body can be attributed to a muscle contraction. Therefore, contractibility is considered the main function of the muscular system. Voluntary movement is easy to understand because it is easy to consider muscles

required to perform specific, conscious movements such as walking, standing up from a seated position, and even smiling. Involuntary muscle movements do not require conscious thought and therefore aren't thought about very often. More about involuntary muscle movements will be discussed later in this section.

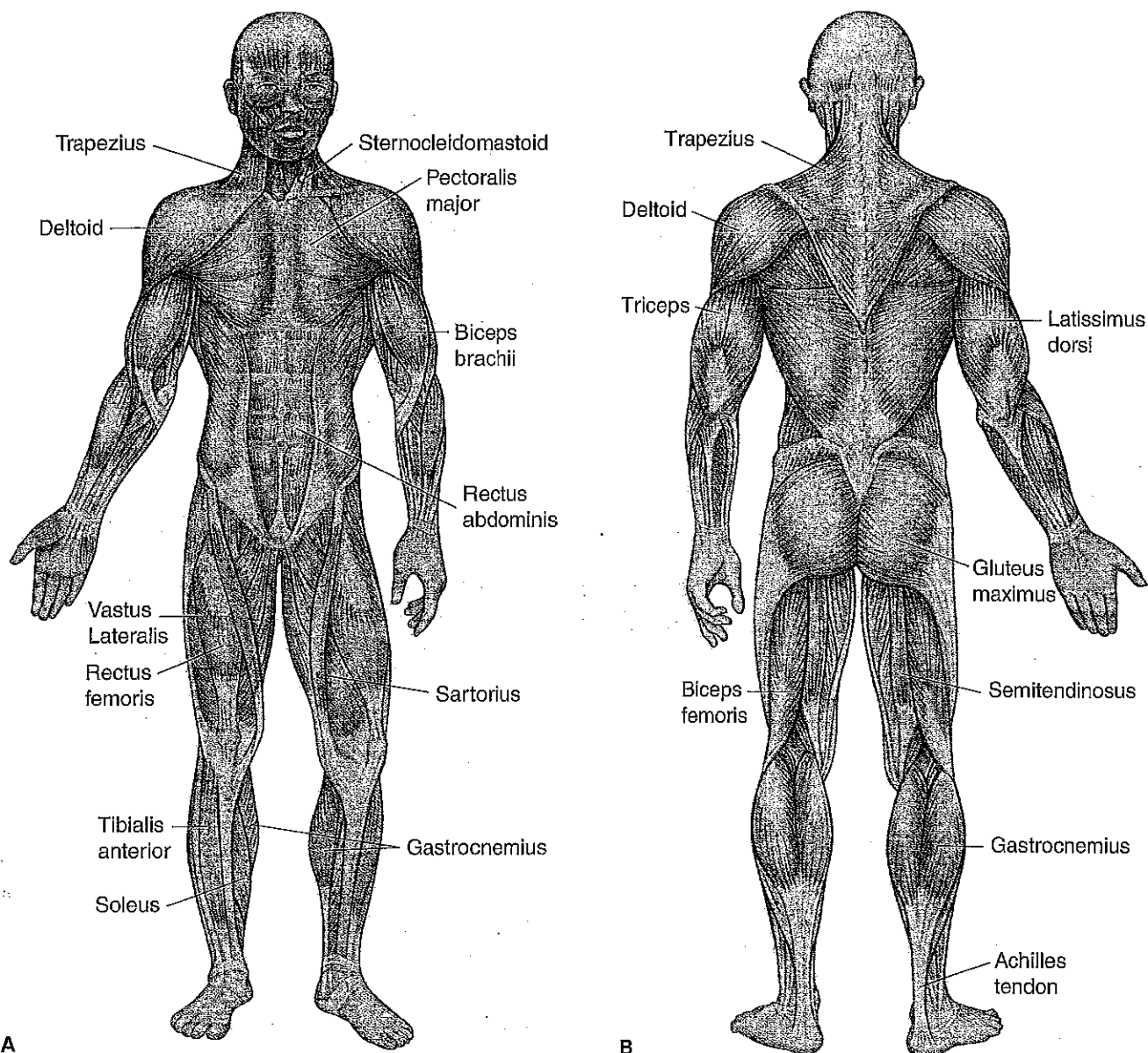
Generally speaking, muscles, where they are attached to bones, internal organs, and blood vessels, are responsible for all types of bodily movement (Figure 23-1).

### Stability

**Tonicity** is the body's ability to maintain posture through a continual partial contraction of skeletal muscles. The muscular system works in conjunction with the skeletal system to provide stability. Without conscious thought, multiple muscles and joints are activated to simply maintain posture, whether standing, sitting, or lying down. Some of the smallest muscles, such as those found in the vertebral column, play an important role in this function.

### Circulation and Respiration

The heart is composed of cardiac muscle tissue, which is discussed in the next section of this chapter. The involuntary movement and contraction of the heart muscle (a pumping mechanism) is responsible for circulating blood throughout the body, providing essential nutrients and oxygen to our



**FIGURE 23-1** (A) Selected skeletal muscles (anterior view); (B) selected skeletal muscles and the Achilles tendon (posterior view).

systems. Respiration is also controlled by muscle movements. The diaphragm, which is located under the rib cage and separates the thoracic and abdominal cavities, is the major muscle responsible for breathing. Accessory muscles found around the rib cage and in the thoracic cavity also assist in respiration.

### Heat Production

Muscles produce heat through the chemical changes involved in muscular contraction. This is what helps the body maintain a normal temperature. As a muscle contracts, it releases heat, making the person feel warmer. As an example, consider a person who is exercising. Exercise requires a lot of muscle contraction, which, in turn, releases a lot of heat. The extra heat causes the person to sweat.

### Digestion and Elimination

Muscles that line the digestive tract are made of smooth muscle tissue. The involuntary action of the smooth muscles of the digestive tract transport food through the stomach and intestines. As food is transported throughout the digestive tract, the body is able to absorb vital nutrients and calories necessary for function. At the end of the digestive process, muscles help in eliminating fecal matter from the body.

### TYPES OF MUSCLE TISSUE

As already noted, muscle tissue has the ability to contract, or shorten, which produces the movement of internal and external body parts. Breathing, speaking, walking, talking, eating, and almost every other bodily function require the

contraction of muscle tissue. The muscles serve as the engines, or powerhouses, of the body and are constructed to provide speed and power. Muscles are composed of about 75 percent water, 20 percent protein, and about 5 percent carbohydrates, lipids, inorganic salts, and nonprotein nitrogenous compounds. The exact composition of various muscles differs.

Three types of muscle cells form three distinct types of muscle tissue. Each type is designed to perform specific functions of the body. The three types of muscle tissue are skeletal, smooth, and cardiac (Figure 23-2).

**Skeletal muscle**, sometimes called voluntary or **striated muscle** (*striated* means striped in appearance), can perform skeletal movement because it is attached to the bones of the body. Skeletal muscle is responsible for voluntary movements, meaning that it is under conscious control. Skeletal muscle is made up of cylindrical fibers. The nucleus tends to be toward the edge of each striated cell. Because all skeletal cells are striated, the skeletal muscle itself tends to have an overall striped look.

**Smooth muscle**, or involuntary muscle, is composed of elongated, spindle-shaped cells. Muscles made from these types of cells are also called visceral muscles because they are found in the body's viscera (organs), including organs found in the respiratory tract, urinary system, and digestive system, as well as in the walls of the blood vessels. In contrast to skeletal muscle cells, smooth muscle cells are not striated and their nucleus is centrally located. Smooth muscle is called involuntary muscle because it is not voluntarily controlled, meaning it is not controlled by conscious thought. For example, you do not have to purposely engage the muscles of your digestive system to perform the act of digestion; your body's muscles perform this action voluntarily, or on their own.

**Cardiac muscle** is found in the heart. The cells of this specific muscle tissue have a single central nucleus and are roughly quadrangular in shape. The cells form a network of branching fibers. Cardiac muscle cells are both striated and involuntary. Cardiac muscle tissues are supplied with nerve fibers that carry messages to and from the central nervous system (brain and spinal cord). Each involuntary contraction and relaxation of cardiac muscle results in a

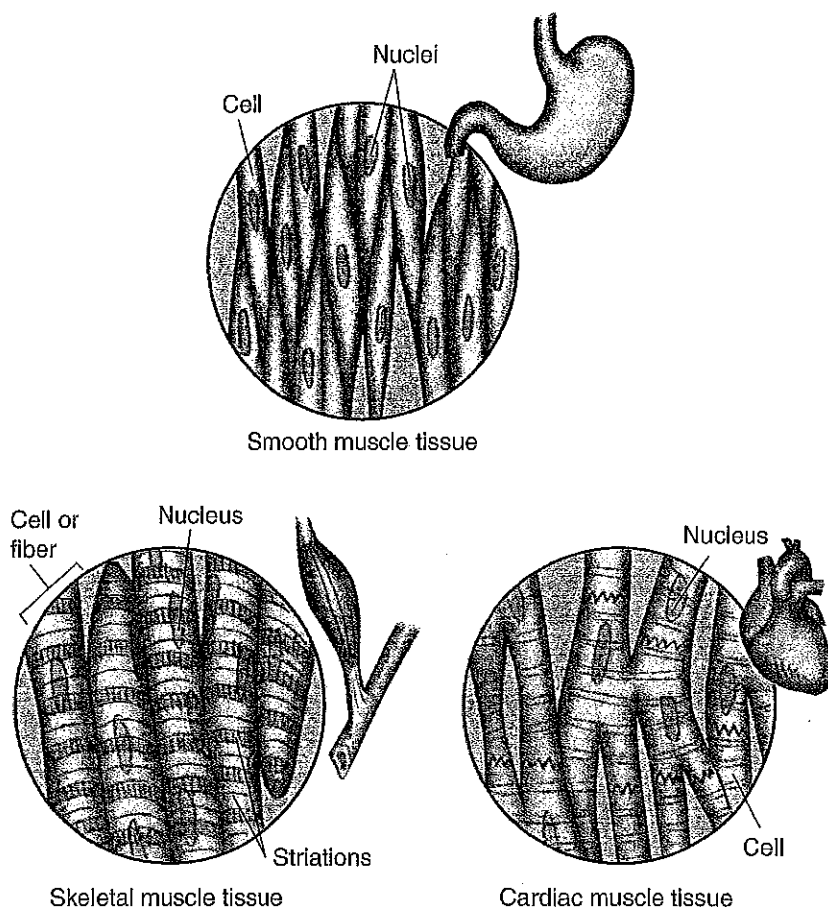


FIGURE 23-2 Types of muscle tissue.

## Professionalism

## The Life Span



### The Child

- Starting with the fetus, and as a child continues to develop, the muscles and bones continue to grow. Although the movements of a newborn are uncoordinated and random, muscular development continues to proceed from head to toe and from the center of the body to the periphery. The head and neck muscles are the first muscles that can be controlled, so a baby will hold his or her head upright before being able to sit up. Babies need freedom of movement to help develop those muscles in the proper order.

### The Older Adult

- The changes related to muscle mobility are the most obvious in the older adult. There can be measurable differences in muscle strength, endurance, range of motion, coordination, elasticity, and flexibility of connective tissue.
- Regular exercise is necessary to prevent a decrease in muscle strength. Exercise helps to strengthen muscles and keeps joints, tendons, and ligaments more flexible, allowing for a more active lifestyle.

heartbeat, which, as discussed earlier, is responsible for pumping blood throughout the body to deliver oxygen and nutrients. The average resting human heart beats 60 to 80 times a minute.

## ENERGY PRODUCTION FOR MUSCLE

Muscles use energy in the form of adenosine triphosphate (ATP), which is a type of chemical energy created within the body's cells. This type of energy is needed for sustained or repeated muscular contractions. ATP can be produced by either aerobic (with oxygen) or anaerobic (without oxygen) means:

- **Aerobic production of ATP**—In the presence of oxygen, the body can use carbohydrates, fats, and proteins to make energy (ATP) that is used by the muscles. When the body uses ATP that is produced aerobically, more energy is available to use. This is the type of energy required for endurance.
- **Anaerobic production of ATP**—The body uses stored glucose, known as glycogen, to make ATP without oxygen. The glycogen, which is the usable form of carbohydrate in the body, breaks down into ATP and lactic acid simultaneously. Generally, this form of energy production is useful for small bursts of energy rather than for endurance.

Another way of acquiring ATP is breaking down creatine phosphate, which is also done without the use of oxygen. This means of ATP production is limited to skeletal muscles and, as with other anaerobic ATP production, provides small bursts of energy.

### Professionalism



All medical practices have patients who call the office because they are upset or unhappy. It could be that they are angry about a bill they do not understand or haven't received information in a timely or efficient manner. It is important to realize that, most of the time, individuals who complain about service are not attacking the person responding to their call but are instead venting their frustration because they do not understand something. As a professional, it is important to realize that listening and learning go hand in hand. If a patient is upset or concerned, take the time to listen instead of getting angry and defensive, and try to focus on how you can best meet that patient's needs.

## Oxygen Debt and Muscle Fatigue

When the body uses an excessive amount of oxygen, it must then take in enough oxygen to make up for the shortage and allow the body to recover, or return to a resting state. The amount of oxygen "owed" to the body to enable recovery is called **oxygen debt**.

Oxygen debt may occur when the skeletal muscles are used vigorously for more than one or two minutes, as with exercise. If your body is working hard, it may not be able to take in and absorb enough oxygen to cope with the level of activity. When oxygen is lacking, the body is unable to produce energy through aerobic means and, as a consequence, the anaerobic method of creating energy is activated.

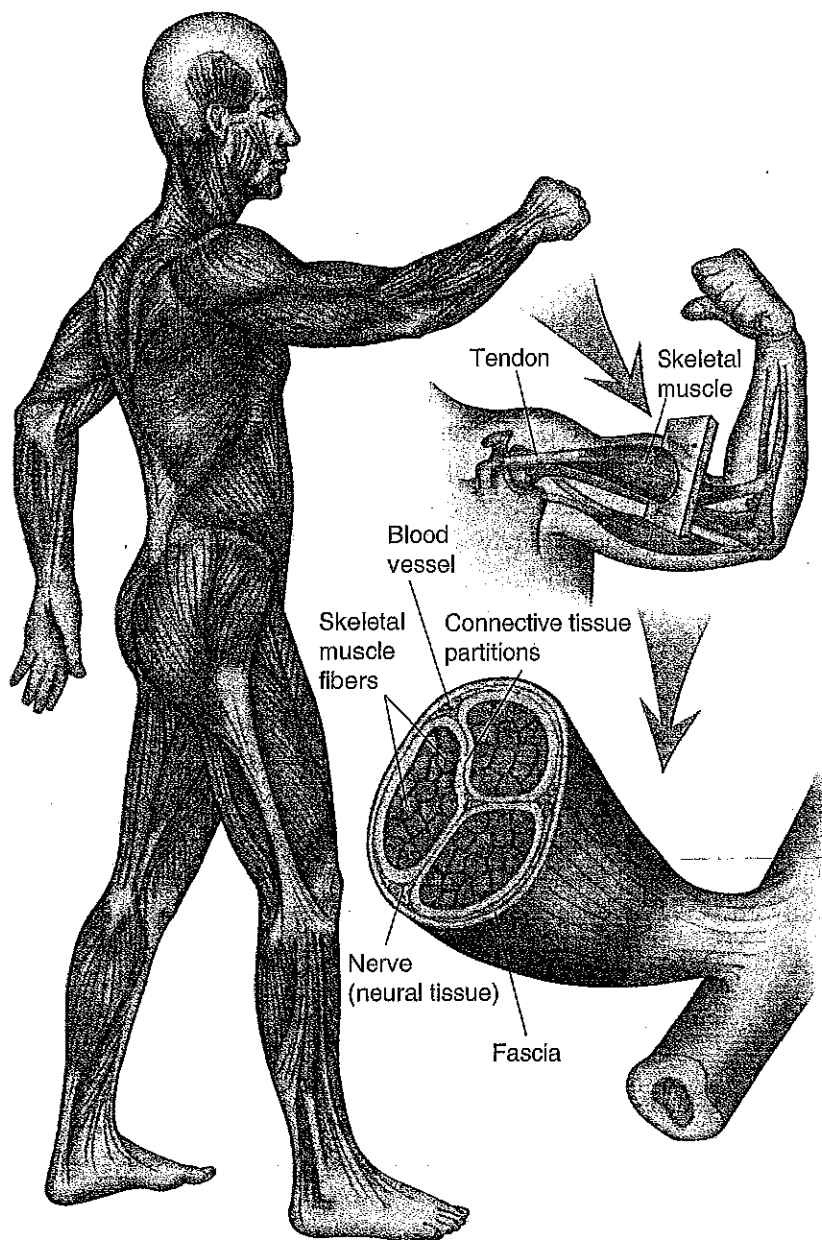
Unfortunately, as already mentioned, anaerobic energy production is only short term, not enough for endurance. The body can only use anaerobic energy for about 60 seconds, depending on the individual. After this, fatigue sets in, making it very difficult to recover. To recover from oxygen debt, the body must increase respiration to bring more oxygen into the bloodstream to reach the muscles. An example is a sprinter running a short distance very fast. At the end of the sprint, the athlete is breathing heavily to compensate for the oxygen debt.

Muscle fatigue usually develops as a result of an accumulation of the lactic acid that is produced along with ATP during anaerobic metabolism. This accumulation of lactic acid decreases the muscle's ability to contract. This causes the muscle to become incredibly fatigued, and muscle cramps may occur. Muscle fatigue may also occur if the blood supply to a muscle is stopped or interrupted or if a motor neuron loses its ability to release a neurotransmitter substance called acetylcholine into the muscle fibers.

## STRUCTURE OF SKELETAL MUSCLES

As already mentioned, skeletal muscle attaches to bone and is voluntarily controlled (Figure 23-3). More than 600 different skeletal muscles are responsible for the movement of the body through contractility, extensibility, and elasticity. Various sizes, shapes, and fiber arrangements create a variety of muscles, each of which can perform a specific function, or multiple functions, in the body.

Connective tissue forms several types of coverings for skeletal muscle for the purpose of function and protection. Mentioned earlier in the chapter, fascia is the connective tissue that covers each skeletal muscle and functions to separate the muscles from one another. Information related to



**FIGURE 23-3** A skeletal muscle consists of a group of fibers held together by connective tissue. It is enclosed in a fibrous sheath (fascia).

additional structures that comprise skeletal muscles is found in Table 23-1.

## Attachments to Skeletal Muscles

Actions of skeletal muscles depend greatly on where the skeletal muscles attach to bone. Origin and insertion are the points at which skeletal muscles attach to given structures. The **origin** is a muscle's attachment point to a bone that is primarily fixed or still; the **insertion** is the attachment point of the other end of that muscle to a bone that moves. For example, the biceps muscle has its origin at the shoulder; its insertion point is in the forearm, close to the elbow. The biceps muscle's insertion point near the elbow enables the forearm to flex during muscle contraction, and the other end of the muscle is anchored at the origin point on the unmoving shoulder (Figure 23-4).

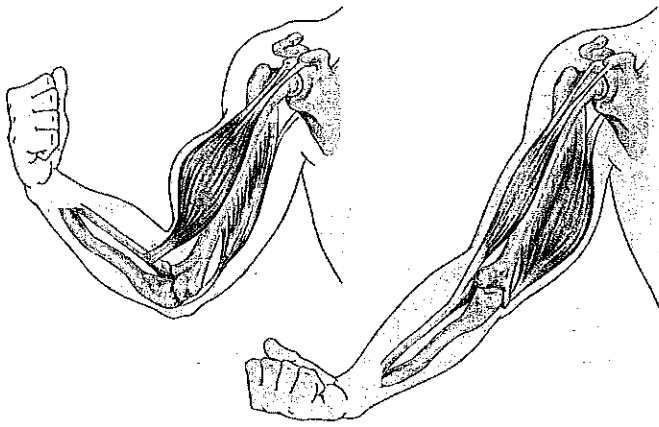
Muscles and nerves function together as a motor unit. For skeletal muscles to contract, they must be stimulated by impulses from motor nerves.

Muscles perform in groups that are classified in the following categories:

- **Prime mover or agonist**—A muscle that is the primary actor in a given movement. This is the muscle that produces the movement in muscle contraction. For example, when the knee extends, the prime mover is the quadriceps.
- **Antagonist**—A muscle that counteracts, or opposes, the action of another muscle. When the biceps contracts, the triceps relaxes; this is an antagonist pair.

**TABLE 23-1 | Skeletal Muscle Structures**

Structure	Description
<b>Epimysium</b>	A thin fascia that surrounds and covers skeletal muscle. It helps keep skeletal muscles separated from one another.
<b>Perimysium</b>	Made of connective tissue, perimysium divides muscle into smaller sections called fascicles.
<b>Endomysium</b>	A protective covering made of connective tissue that surrounds the individual muscle cell.
<b>Tendon</b>	Thick structure made of fibrous connective tissue. Tendons connect skeletal muscle to bones.
<b>Aponeurosis</b>	A thin, sheet-like tendon that connects muscle to muscle.



**FIGURE 23-4** The origin of the bicep is at the shoulder; the insertion is in the forearm.

- **Synergist**—A muscle that acts with another muscle, most often a prime mover, to produce movement. When performing a squat exercise, the prime mover muscles are the quadriceps and the gluteus maximus, and the synergist muscles are those in the hamstrings group.

## MAJOR SKELETAL MUSCLES

When describing the major skeletal muscles, it is important to remember that these muscles are often identified according to their location, size, action, shape, or number of attachments to the muscle. They are usually listed in the following groups:

- Muscles of the head
- Muscles of the arm, wrist, hand, and fingers
- Respiratory muscles
- Abdominal muscles
- Muscles of the pectoral girdle
- Muscles of the leg, ankle, and foot

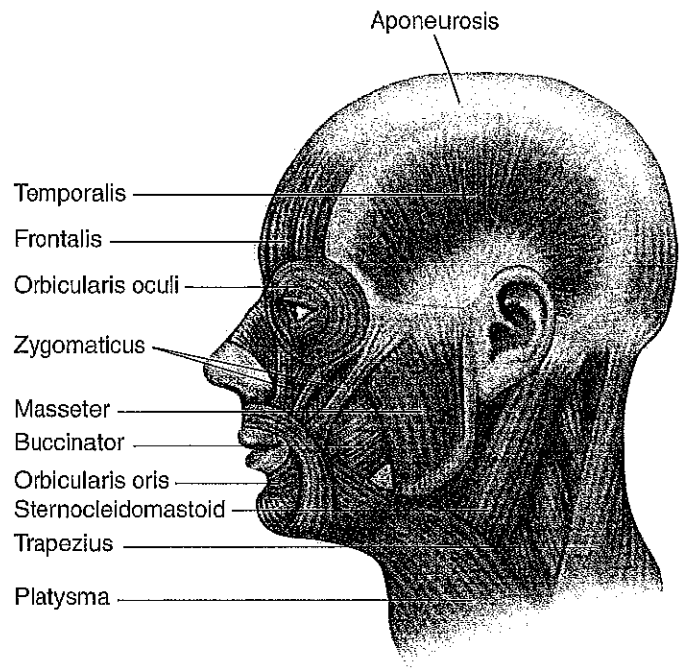
### Muscles of the Head

The muscles of the head include those that move the head, provide facial expressions, and move the jaw (see Figure 23-5). They include the following muscles:

- **Sternocleidomastoid**—Pulls the head from side to side and to the chest
- **Splenius capitis**—Rotates the head and allows it to bend to the side

The muscles that provide for facial expression include the following:

- **Frontalis**—Raises the eyebrows



**FIGURE 23-5** Muscles of the head, neck, and face.

- **Orbicularis oris**—Allows the lips to pucker
- **Orbicularis oculi**—Allows the eyes to close
- **Zygomaticus**—Pulls up the corners of the mouth
- **Platysma**—Pulls down the corners of the mouth

The muscles of the jaw allow for chewing, or mastication. They include the following:

- **Masseter and temporalis**—Close the jaw

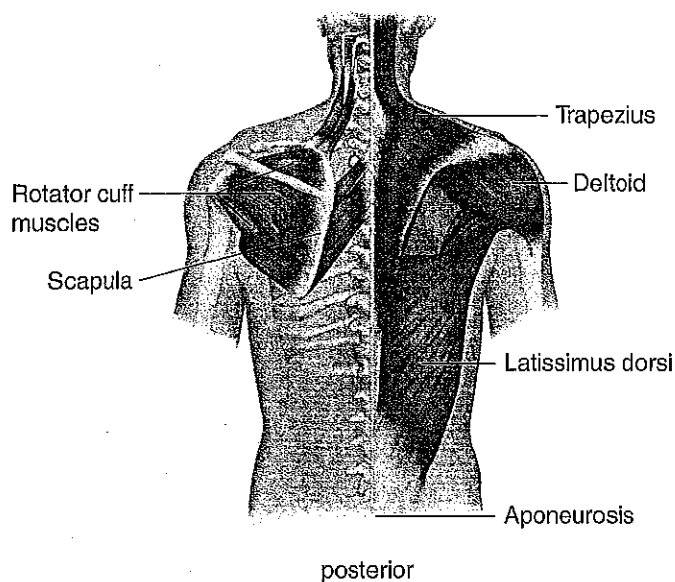
### Muscles of the Arm, Wrist, Hand, and Fingers

Figures 23-6 and 23-7 illustrate many of the muscles of the arm, wrist, hand, and fingers.

Muscles that move the upper extremity include those in the arm and forearm:

- **Pectoralis major**—Pulls the arm across the chest and also rotates and adducts the arms
- **Latissimus dorsi**—Provides for extension, adduction, and inward rotation of the arm
- **Deltoid**—Provides for abduction and extension of the arm at the shoulder
- **Serratus anterior**—Also known as the “boxer’s muscle,” pulls the scapula forward
- **Subscapularis**—Rotates the arm medially
- **Infraspinatus**—Rotates the arm laterally
- **Biceps brachii**—Flexes the arm at the elbow and rotates the hand laterally





**FIGURE 23-6** Muscles of the posterior torso that are responsible for arm movements.

- **Brachialis**—Flexes the arm at the elbow
- **Brachioradialis**—Flexes the forearm at the elbow
- **Triceps brachii**—Extends the arm at the elbow
- **Supinator**—Rotates the forearm laterally
- **Pronator teres**—Rotates the forearm medially

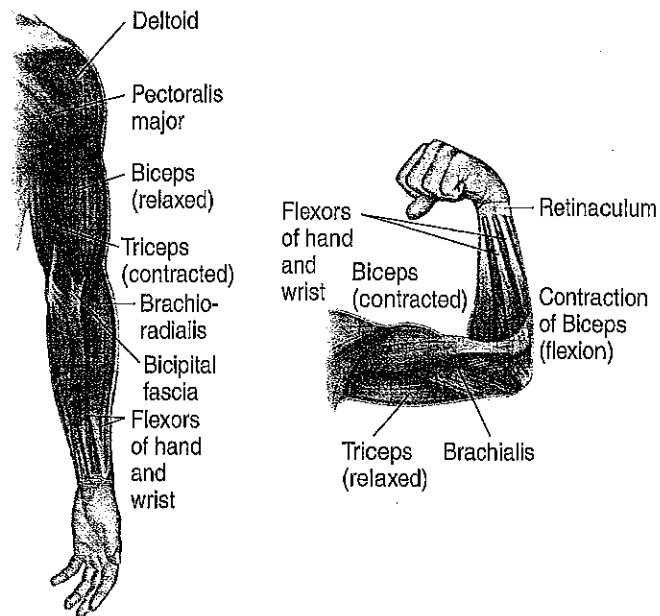
Muscles that move the wrist, hand, and fingers include the following:

- **Flexor carpi radialis and flexor carpi ulnaris**—Flex and abduct the wrist
- **Palmaris longus**—Flexes the wrist
- **Flexor digitorum profundus**—Flexes the distal joints of the fingers but not the thumb
- **Extensor carpi radialis longus and extensor carpi radialis brevis**—Extend the wrist and abduct the hand
- **Extensor carpi ulnaris**—Extends the wrist
- **Extensor digitorum**—Extends the fingers but not the thumb

## Respiratory Muscles

The muscles of respiration include the following:

- **Diaphragm**—Separates the thoracic cavity from the abdominal cavity; its contraction causes the process of inspiration
- **External and internal intercostals**—Contraction expands and lowers the ribs during breathing

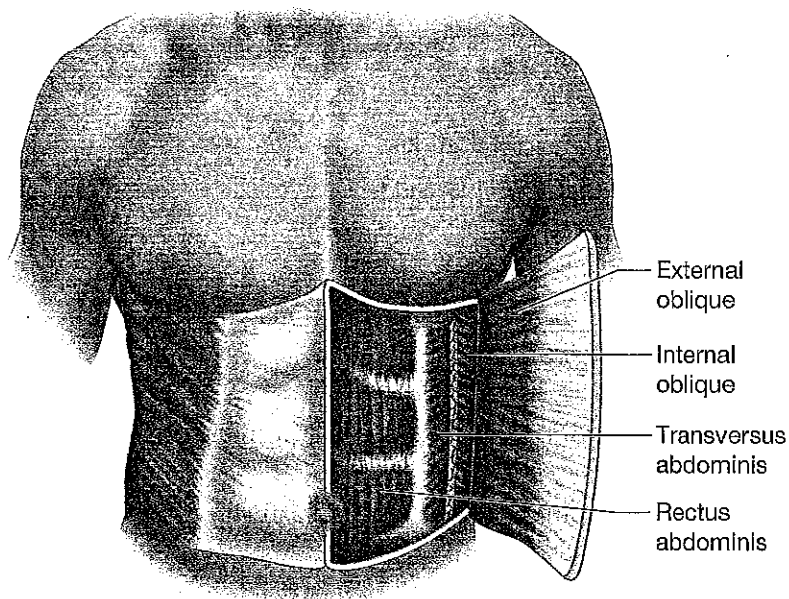


**FIGURE 23-7** Muscles of the arm and hand.

## Abdominal Muscles

The muscles of the abdominal wall include the following (Figure 23-8):

- **External and internal obliques**—Compress the abdominal wall
- **Transversus abdominis**—Also compresses the abdominal wall
- **Rectus abdominis**—Flexes the vertebral column and compresses the abdominal wall



**FIGURE 23-8** Abdominal muscles.



## Muscles of the Pectoral Girdle

The muscles that move the pectoral girdle, or shoulder, include the following:

- **Trapezius**—Raises the arms and pulls the shoulders downward
- **Pectoralis minor**—Pulls the scapula downward and raises the rib cage

## Muscles of the Leg, Ankle, and Foot

The muscles that move the leg include the following (Figure 23-9):

- **Psoas major**—Flexes and externally rotates the hip joint
- **Iliacus**—Flexes the thigh and rotates it medially
- **Gluteus maximus**—Extends the thigh
- **Gluteus medius and minimus**—Abduct the thigh and rotate it laterally

- **Hamstring group**—Flexes the leg at the knee and extends the leg at the thigh; muscles in this group include the biceps femoris, semitendinosus, and semimembranosus
- **Quadriceps group**—Extends the leg at the knee; muscles in this group include vastus lateralis, vastus medialis, vastus intermedius, and the rectus femoris
- **Sartorius**—Performs multiple functions including flexing the knee and thigh, abducting the thigh, and enabling the act of being able to sit cross-legged

The muscles that move the ankle and foot include the following:

- **Gastrocnemius**—Flexes the foot and aids in pushing the body forward
- **Tibialis anterior**—Causes dorsiflexion and inversion of the foot

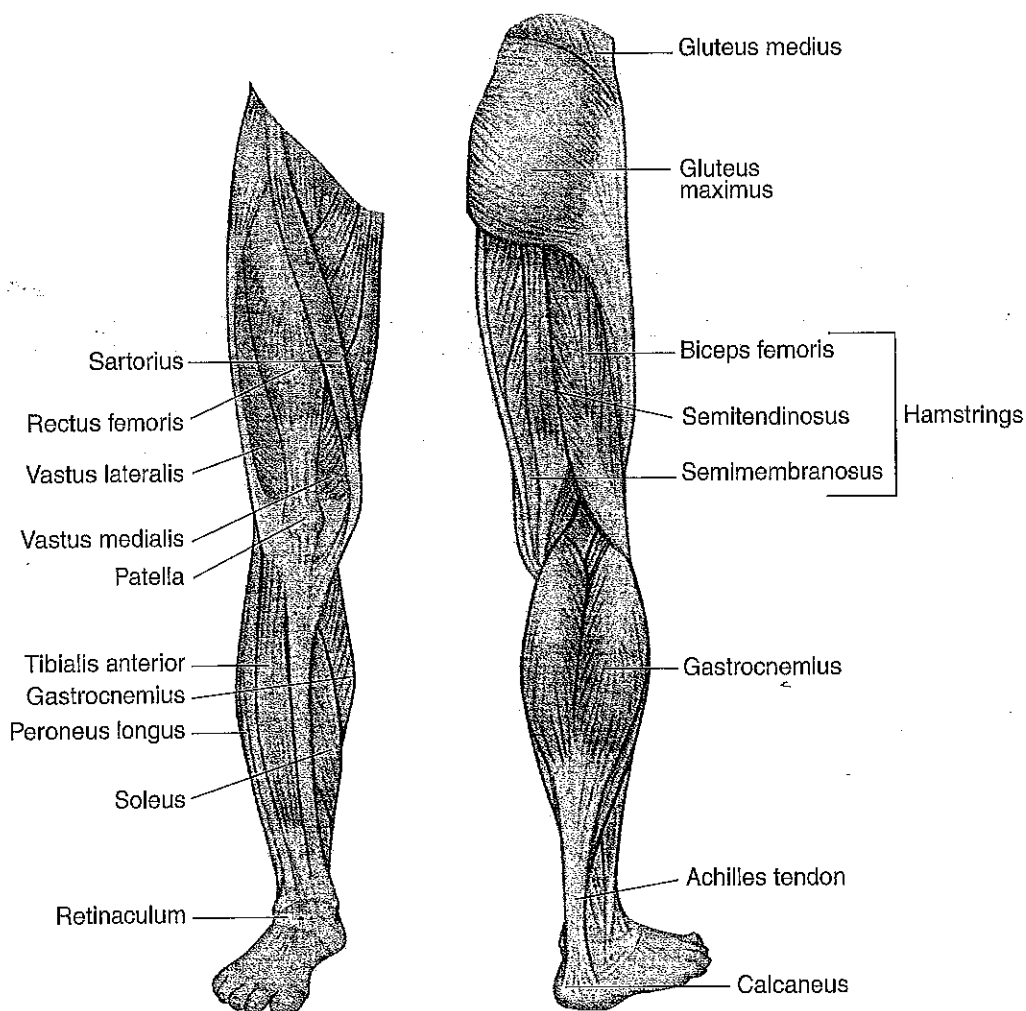


FIGURE 23-9 Muscles of the buttocks, legs, and feet.

- **Peroneus**—Everts the foot and helps bring about plantar flexion
- **Flexor digitorum longus and extensor digitorum longus**—Flex and extend the toes, respectively, and assist in other movements of the feet

## COMMON PATHOLOGY ASSOCIATED WITH THE MUSCULAR SYSTEM

Because of the sheer number of muscles, the diseases and disorders associated with the muscular system are quite numerous. Muscular disorders are characterized by abnormalities of muscle fibers. In addition, many neurological disorders, such as lesions of the central or peripheral nervous system and abnormalities of neuromuscular transmission, can also produce symptoms that are primarily muscular. Other systemic disorders, including those that are frequently seen in conditions of the cardiovascular, respiratory, and endocrine systems, frequently mimic muscular disorders but do not directly affect muscular function. These systemic disorders account for more than half of all muscular complaints. Table 23-2 identifies diagnostic procedures and tests related to the muscular system.

## Atrophy

**Atrophy** is the loss of muscle mass and strength that occurs when muscles aren't used over a long period of time. Often, atrophy results from bed rest and immobility, but it can also be caused by malnutrition and injury. Atrophy can also be secondary to a primary disease or disorder such as a spinal cord injury, polio, or stroke, to name a few. Lipoatrophy (also known as lipodystrophy) is atrophy of fat tissue. It is common for lipoatrophy to occur at a site of insulin or corticosteroid injections.

**Signs and Symptoms.** The most common sign of atrophy is the apparent “wasting away” appearance of a muscle group. Frequently, patients have extreme weakness and fatigue associated with atrophic muscle groups.

**Treatment.** Exercise is the best course of treatment for muscle atrophy. This is done under the care and supervision of a physician and a physical therapist. Isometric exercise of the immobilized muscle can be particularly useful. This form of exercise uses active muscle contractions performed against stable resistance (e.g., tightening the muscles of the thighs or the buttocks). Active exercise of uninjured limbs helps prevent atrophy.

**TABLE 23-2 | Procedures and Diagnostic Tests Related to the Muscular System**

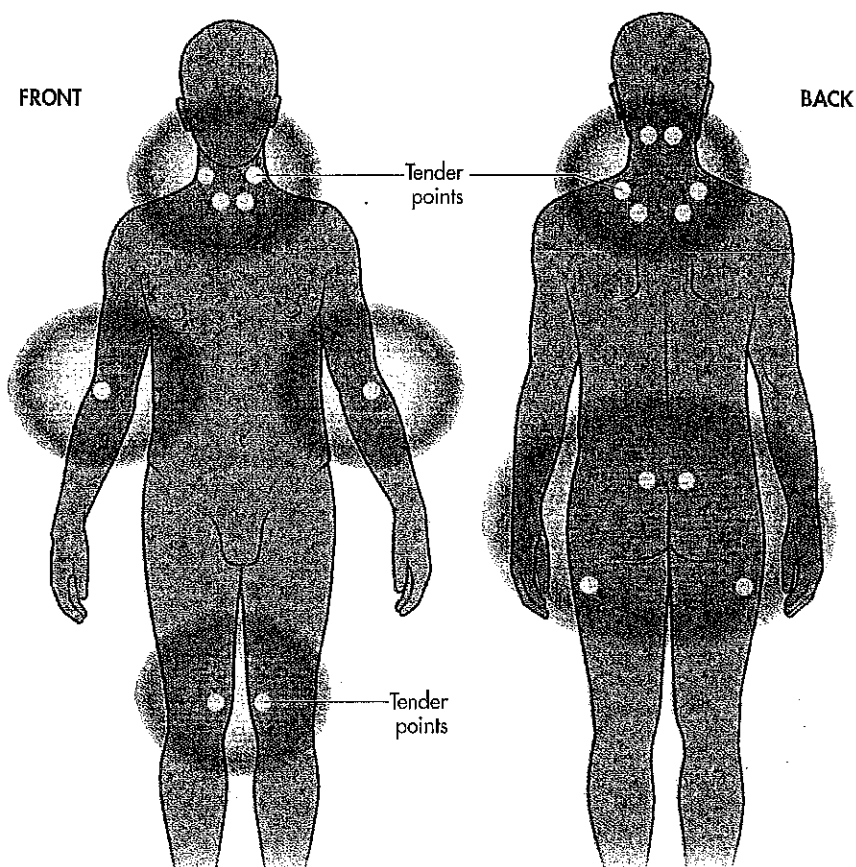
Procedure/Test	Description
<b>Aldolase</b>	Blood serum test to measure ALD enzyme present in skeletal and heart muscle to diagnose Duchenne muscular dystrophy before symptoms appear.
<b>Calcium</b>	Blood serum test to determine levels of calcium. Calcium is essential for muscular contraction, nerve transmission, and blood clotting.
<b>Creatine Phosphatase (CPK)</b>	Blood serum test to measure the CPK level that increases because of necrosis or atrophy of skeletal muscle, traumatic muscle injury, strenuous exercise, progressive muscular dystrophy, and after heart attack.
<b>Electromyography (EMG)</b>	Study and record of the strength of muscle contractions as a result of electrical stimulation. Used in the diagnosis of muscle disorders and to distinguish nerve disorders from muscle disorders.
<b>Fasciectomy</b>	Surgical removal of the fascia (fibrous membrane) covering and supporting muscles.
<b>Lactic Dehydrogenase (LDH)</b>	Blood serum test to measure the level of the enzyme LDH. It is increased in muscular dystrophy, after damage to skeletal muscles, after pulmonary embolism, and during skeletal muscle malignancy.
<b>Magnetic Resonance Imaging (MRI)</b>	Medical imaging that uses a magnetic field and radio waves as its source of energy. It does not require the injection of contrast medium or exposure to ionizing radiation. The technique is useful for visualizing large blood vessels, the heart, brain, and soft tissues.
<b>Muscle Biopsy</b>	Removal of muscle tissue for pathological examination.
<b>Serum Glutamic Oxaloacetic Transaminase (SGOT)</b>	Blood serum test to measure the level of the enzyme SGOT. It is increased in skeletal muscle damage and muscular dystrophy. This test is also called aspartate aminotransferase (AST).
<b>Serum Glutamic Pyruvic Transaminase (SGPT)</b>	Blood serum test to measure the level of the enzyme SGPT. It is increased in skeletal muscle damage. This test is also called alanine aminotransferase (ALT).

## Fibromyalgia

**Fibromyalgia** is a widespread disorder affecting an estimated three million individuals in the United States. It is characterized by musculoskeletal pain and fatigue. Fibromyalgia occurs more often in women than men. There is no obvious known cause of fibromyalgia, but evidence points to a genetic predisposition that creates a neuromuscular or neuroendocrine abnormality that disturbs usual sensory perception, especially pain signals.

**Signs and Symptoms.** Symptoms include mild to severe muscle pain and fatigue, sleep disorders, irritable bowel syndrome, depression, and chronic headaches.

The American College of Rheumatology (ACR) has identified specific criteria for the diagnosis of fibromyalgia. The ACR states that a patient must show pain at 11 of 18 trigger or tender points to be considered for a diagnosis of fibromyalgia (Figure 23-10). The patient must also have a history of widespread pain lasting at least three months.



**FIGURE 23-10** The 18 tender points of fibromyalgia.

**Treatment.** There is no cure for fibromyalgia. Treatment is geared toward improving the quality of life and reducing pain. Sleep is important for many body functions, including tissue repair and antibody production, so the disruption of sleep directly affects the quality of life in a patient with fibromyalgia. Therefore, an emphasis is often placed on improving the patient's sleep as well. Frequently, the medications prescribed for fibromyalgia include muscle relaxants, pain relievers, antiinflammatory drugs, antidepressants, and antianxiety drugs. Other treatments frequently employed include chiropractic, acupuncture, acupressure, relaxation techniques, and massage.

## Ganglion Cyst

A **ganglion cyst** is a benign (noncancerous) saclike swelling or fluid-filled cyst. Typically the cysts develop over a joint or tendon. Ganglion cysts occur more frequently in women than in men. It is thought that these cysts are caused by repetitive motions; however, this might not be true in all cases.

**Signs and Symptoms.** A ganglion cyst is often painless but can be very painful if its location causes it to press on a nerve. Typically, these fluid-filled masses occur on the back

of the hand at the wrist, but also on the palm side of the wrist. They may also develop, less frequently, on the top of the foot, on the outside of the knee or ankle, and where the base of the fingers meet the palm of the hand. Swelling may occur, although it is often erratic, developing and disappearing without apparent cause.

**Treatment.** Treatment is not necessary if the cyst is asymptomatic and painless. Antiinflammatory drugs can be used to reduce swelling and pain. Often **aspiration** (removal by suction of fluid from within the cyst) is performed. This treatment is about 74 percent effective against recurrence of the cyst. If the cyst causes pain or decreased range of motion, surgery may be performed. Even surgical removal of a ganglion cyst is not always 100 percent effective against recurrence.

## Lyme Disease

**Lyme disease** is caused by the *Borrelia burgdorferi* bacterium. It is carried by ticks, frequently found on deer and other wild animals. The bacterium is transmitted through the bite of an infected tick. Prevention of Lyme disease is the best medicine.

**Signs and Symptoms.** A round bull's-eye rash is typically associated with Lyme disease. This rash is also known

as erythema migrans (EM) and generally feels warm to the touch, though it is not generally painful or itchy. Additional symptoms of Lyme disease include headache, fatigue, neck stiffness, and fever. Signs and symptoms of Lyme disease vary from patient to patient, with many of the signs and symptoms also typical of other diseases. Not everyone who contracts Lyme disease develops the hallmark bull's-eye rash. With symptoms mimicking other diseases and lack of the bull's-eye rash, this condition can be difficult to diagnose. Unfortunately, the condition often worsens when left untreated. Prevention measures include wearing long sleeves and long pants while in heavily wooded areas, the proper use of insect repellent, and the prompt removal of any tick that may be lodged in the skin.

**Treatment.** If Lyme disease is detected early, full recovery is possible. This is accomplished by taking the prescribed round of antibiotic medications. Antibiotics often prescribed include erythromycin, penicillins, or doxycycline. If not detected early, Lyme disease can result in skin, joint, heart, and nervous system disorders. Because Lyme disease is difficult to diagnose with certainty but can have severe consequences, the course of treatment is usually prescribed if Lyme disease is strongly suspected.

## Muscular Dystrophy

**Muscular dystrophy (MD)** is a disease that progressively weakens and causes degeneration of the body's skeletal (voluntary) muscles, thereby reducing the patient's control of movement. It is a genetic disease with more than 30 different forms. Although mostly affecting skeletal muscles, some involuntary muscles including the muscles of the heart may also be affected. Some forms of the MD also impact organ functions. The major forms of MD include the following:

- Duchenne MD
- Becker MD
- limb-girdle MD
- facioscapulohumeral (FSH) MD
- congenital MD
- oculopharyngeal MD
- distal MD
- Emery-Dreifuss MD
- myotonic MD

**Signs and Symptoms.** Each form of MD has its own set of specific signs and symptoms. However, there are general signs and symptoms that are common in all forms and are specific to muscle groups affected. These include muscle weakness, loss of coordination, and immobility. Signs and

symptoms that are more varied based on the specific form of MD could include difficulty walking and frequent falls, delayed development of motor skills, and mental retardation. Skeletal deformities such as a curved spine, clubfoot, and the formation of a claw hand may occur. Unfortunately, the progression of this disease results in fatality.

**Treatment.** There is no cure for MD in any form. Treatment is geared toward prolonging and improving the quality of life. Physical therapy is implemented to sustain and build muscle strength and overall flexibility. Some patients may use orthotic devices to provide support, and others undergo corrective orthopedic surgeries. Respiratory therapy is especially important for those whose respiratory muscles and overall respiratory system are affected by the disease. Patients with MD may be prescribed a variety of medications, including corticosteroids that help slow the progression of muscle degeneration and antibiotics to prevent respiratory infections. Anticonvulsants are also commonly used.

## Myasthenia Gravis

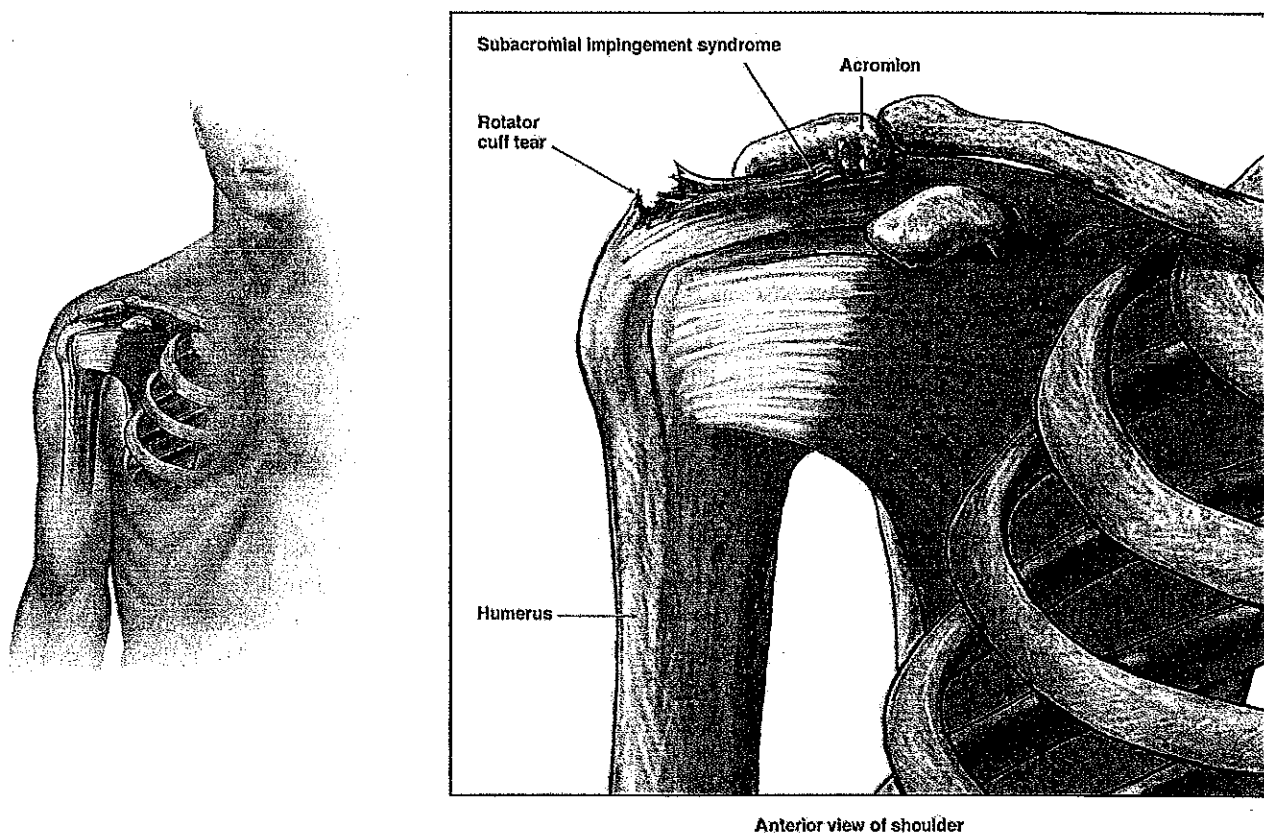
**Myasthenia gravis (MG)** is a chronic autoimmune neuromuscular disease. Its name, translated from its Latin origin, means "grave muscle weakness." The hallmark characteristic of this disease is muscle weakness that affects voluntary muscles. MG most commonly occurs in young adult women and older men but can occur at any age. Although MG may affect any voluntary muscle, certain muscles, including those that control eye movements, eyelids, chewing, swallowing, coughing, and facial expressions, are more often affected.

**Signs and Symptoms.** The primary symptom of MG is muscle weakness. The muscle weakness increases during periods of activity and improves after periods of rest. The muscles involved in MG vary from one individual to the next.

**Treatment.** Although there is no cure for MG, people living with this disease are not only able to control it but also can lead full and productive lives. Because it is an autoimmune disorder, medications may be given to decrease the production of antibodies that the body perceives as abnormal and a threat. Medications to improve muscle strength as well as neuromuscular transmission are also prescribed. Physicians determine individualized treatment based on the patient's age, symptoms, overall health, and general prognosis of the disease.

## Rotator Cuff Tears

The rotator cuff is the area that enables people to reach above their heads and lift with the arms. Rotator cuff tears are



**FIGURE 23-11** A rotator cuff tear.

increasingly common in the muscles that form the shoulder and their tendons (supraspinatus, infraspinatus, teres minor, and subscapularis) (Figure 23-11). Most rotator cuff tears occur as the result of many years of overuse of the muscles and tendons; however, one single traumatic injury can also cause a rotator cuff tear.

**Signs and Symptoms.** These tears can cause considerable pain and limit the function and range of motion of the patient. In addition, signs include atrophy of the shoulder muscle and a crackling sensation when moving the shoulder in certain positions.

**Treatment.** Treatment for a torn rotator cuff includes rest, narcotic and nonsteroidal antiinflammatory drugs (NSAIDs), splinting, physical therapy, and performing range-of-motion exercises. More severe rotator cuff tears may require steroid injections and possibly surgery.

## Shin Splints

Shin splints are caused by inflammation of the periosteum of the extensor muscles of the lower leg (particularly the tibia) and surrounding tissues. The condition is usually caused by overuse or improper conditioning of the leg muscles. Shin splints commonly occur with running sports, military

training, and high-impact dancing and in people with flat feet or rigid arches.

**Signs and Symptoms.** General symptoms and signs of a shin splint include increased pain, tenderness, and possible swelling in the shin area. These effects can cause pain when walking or moving the lower legs.

**Treatment.** Shin splint treatment includes rest and applying ice or cold compresses to the shin area. Medication such as aspirin and NSAIDs may be used for pain management and to reduce swelling. Treatment also includes the use of proper footwear, which can prevent future episodes.

## Sprains and Strains

A **sprain**—a stretching or tearing—is an injury to a **ligament** (connective tissue that connects bones or cartilage, or holds a joint together), whereas a **strain** is an injury to either a muscle or a tendon (which connects muscle to bone). A strain may be the result of a simple overstretching muscle injury, or it could be as severe as a tear to the tendon or muscle.

### Sprains

Sprains are very common injuries, especially among athletes. Often a sprain will occur after a ligament has been

overstretched or torn, especially in ligaments of major joints such as elbows, knees, wrists, ankles, and feet. Ankle sprains are the most common injury in the United States.

**Signs and Symptoms.** Typically, the signs and symptoms associated with a sprain include pain, swelling, bruising, and loss of joint mobility and function. Depending on the severity of the sprain, these signs and symptoms vary in intensity. Often the signs and symptoms have a sudden onset as they immediately follow an injury.

**Treatment.** Sprains are generally treated using the RICE method:

- **Rest**—If the injured joint is a weight-bearing joint, such as the ankle, it is important to use canes, crutches, or other walking devices.
- **Ice**—Ice the sprain with an ice pack or cold compress.
- **Compression**—Compression bandages should be worn around the sprain to encourage proper healing.
- **Elevation**—Elevate the affected sprain as soon as possible after an injury. It is most beneficial to have the strained muscle either above or at the same level as the heart.

Additional treatments may include range-of-motion exercises, physical therapy, and NSAIDs. Surgery, which is a rarity, may be performed when a sprain has been classified as chronic and other forms of treatment are not effective.

### Strains

The twisting or pulling of a muscle often results in a strain. Prolonged, repetitive movements generally result in a chronic strain, whereas an acute strain may be caused by improperly lifting a heavy object. In addition, sports including soccer, football, hockey, tennis, gymnastics, and many others tend to place individuals at higher risk for muscle strains.

**Signs and Symptoms.** Common symptoms associated with a strain include pain, muscle weakness, muscle spasm, and loss of muscle function. Inflammation and cramping, accompanied by swelling, may also be associated with a strain.

**Treatment.** The treatment for a strain is very similar to that of a sprain. Rest, cold compressions, antiinflammatory medication, and gentle stretching are often helpful. Heat application, as with a heating pad, is also beneficial and should be alternated with applications of cold compresses. At times, a physician may recommend the application of a brace to limit mobility of the injured muscle.

### Tendonitis

Mentioned earlier in this chapter, a **tendon** is the band of connective tissue found at each end of a muscle that attaches

## Professionalism The Workplace



It is important to know the main muscles in the body, but it is especially important to be familiar with those into which injections are frequently given. Children do not have well-developed arm or buttocks muscles, so their injections are usually given in the vastus lateralis muscle of the leg. In adults, the deltoid muscle in the arm is used for small amounts of injected fluid. However, if the fluid is thick (viscous) or a large amount must be injected, the ventrogluteal muscle near the hip may be preferred.

the muscle to a bone. Excessive and repetitive movements are often the cause of **tendonitis** (also spelled *tendinitis*), an inflammation of the tendon, which occurs when the tiny fibers of the tendon begin to tear. The following are the areas commonly associated with tendonitis:

- Elbow and wrist
- Biceps and shoulder
- Hip, leg, and knee
- Achilles tendon

**Signs and Symptoms.** Pain and stiffness commonly surround the affected area. Also, this condition has been known to cause a burning sensation that surrounds the joint and inflamed tendon. Generally, pain is worse during and immediately after activity, whereas the following day the tendon tends to become stiffer, though it still causes a significant amount of pain.

**Treatment.** With proper care, tendonitis should lessen with rest over time. However, complete healing may take up to six weeks following the initial injury. The initial approach to treating tendonitis is to support and protect the tendons by bracing any areas of the tendon that are being pulled during use. It is important to loosen up the tendon, reduce the pain, and minimize any inflammation. Physical therapy, including exercises to increase range of motion, has proven to be a very beneficial treatment for tendonitis.

### Tetanus

**Tetanus** can be fatal. It is an infectious disease caused by the bacterium *Clostridium tetani*, which usually enters the body through a puncture, cut, or open wound. *Clostridium tetani* releases a toxin that affects the motor nerves (which stimulate the muscles). This bacterium is commonly found in dust, soil, and manure.

**Signs and Symptoms.** Tetanus is characterized by profoundly painful muscle spasms all over the body. Most recognized is a locking effect that results in the mouth being unable to open (lockjaw). Difficulty swallowing is experienced because of neck stiffness, along with stiffness of the chest, abdominal, and back muscles. Fevers are also common with tetanus.

**Treatment.** Preventing tetanus is the best course of treatment. All children should be immunized against tetanus by receiving a full series of five diphtheria, pertussis, and tetanus (DPT, or Tdap) vaccinations, which generally are started at 2 months of age and are completed around 5 years of age. The tetanus and diphtheria (Td) vaccination is now recommended at 11 to 12 years of age if at least five years have elapsed since the last dose of a tetanus and diphtheria toxoid containing vaccine. Follow-up booster vaccination is recommended every 10 years thereafter (i.e., 21 years old, 31 years old, etc.). In adult patients, it is recommended that the patient receive one dose of Tdap as a booster for tetanus, diphtheria, and pertussis during adulthood. It is recommended that the Tdap booster be given at least two years after a Td booster has been administered. Should an unvaccinated person contract tetanus, the likely course of treatment would include the administration of antitoxin, such as tetanus immune globulin, administration of antibiotics, and vaccination.

## 23 CHAPTER REVIEW

### COMPETENCY REVIEW

1. Define and spell the terms for this chapter.
2. Name the three types of muscle tissue.
3. What are the two points of attachment for muscles?
4. What are the other names for skeletal muscle?
5. What are other names for smooth muscle?
6. List the six groups of major skeletal muscles.
7. Give examples of internal organs with smooth muscle.
8. What is the name and special property of heart muscle?
9. Why is the rotator cuff especially important to the patient's range of motion?
10. What are the five main functions of muscle?

### PREPARING FOR THE CERTIFICATION EXAM

1. Which of the following muscles is located in the arm?
  - a. rectus abdominis
  - b. gastrocnemius
  - c. rectus femoris
  - d. triceps
  - e. pectoralis major
2. A muscle that is considered a prime mover, may also be termed a/an
  - a. synergist.
  - b. agonist.
  - c. antagonist.
  - d. primary muscle.
  - e. synergist mover.

## SUMMARY

The muscular system is composed of specialized cells called muscle fibers. These fibers, when brought together, form muscle, which makes up about 42 percent of a person's total body weight. The purpose of muscles is to create movement, maintain stability, assist in circulation and respiration, assist in heat production, and aid in digestion and elimination. To achieve this, muscles must be supplied with proper nutrition and oxygen.

The three types of muscle are smooth, skeletal, and cardiac. Voluntary muscles, which are striated, move in coordination with decisions from the nervous system, either from the brain or spinal column. Involuntary muscles, which are smooth, are not regulated by the conscious thought of the individual. Cardiac tissue is both smooth and striated. Thus, a person does not voluntarily control whether the heart contracts but can influence its rate or rhythm.

Muscles are named by their purpose, structure, or location. Prime movers (agonists) are the primary actor in a given movement. Antagonists counteract the action of another muscle. Synergists act with another muscle to produce movement.

Muscles receive a lot of wear and tear, and thus many disorders can develop. Among the disorders associated with the muscular system are atrophy, fibromyalgia, ganglion cysts, Lyme disease, muscular dystrophy, myasthenia gravis, rotator cuff tears, shin splints, sprains and strains, tendonitis, and tetanus.



3. Which muscle pulls the head from side to side and pulls the head to the chest?
  - a. gastrocnemius
  - b. biceps femoris
  - c. gluteus maximus
  - d. deltoid
  - e. sternocleidomastoid
4. Which muscle(s) extends the thigh?
  - a. tibialis anterior
  - b. gastrocnemius
  - c. gluteus maximus
  - d. extensor carpi ulnaris
  - e. external obliques
5. Which of the following diseases is caused by *Borrelia burgdorferi*?
  - a. Lyme disease
  - b. muscular dystrophy
  - c. myasthenia gravis
  - d. tetanus
  - e. plantar fasciitis
6. Which of the following diseases has a preventative vaccine?
  - a. muscular dystrophy
  - b. ganglion cyst
  - c. fibromyalgia
  - d. tetanus
  - e. myasthenia gravis
7. Which of the following is a genetic disorder?
  - a. muscular dystrophy
  - b. Lyme disease
  - c. myasthenia gravis
  - d. tetanus
  - e. ganglion cyst
8. Which of the following separates the thoracic cavity from the abdominal cavity?
  - a. peroneus
  - b. diaphragm
  - c. supinator
  - d. pronator teres
  - e. trapezius
9. Which of the following is in the pectoral girdle?
  - a. gluteus maximus
  - b. deltoid
  - c. trapezius
  - d. internal oblique
  - e. frontalis
10. Which of the following is caused by twisting or pulling a muscle or tendon?
  - a. sprain
  - b. tendonitis
  - c. strain
  - d. myasthenia gravis
  - e. cramping

## CRITICAL THINKING

Refer to the case study at the beginning of the chapter and use the information you have learned to answer the following questions.

1. Should Rosa seek medical care for Felix? Explain why or why not.
2. What are some signs and symptoms Rosa should be looking for if she is concerned that her son may have been bitten by a tick infected with the *Borrelia burgdorferi* bacterium?
3. What measures can be taken to prevent being bitten by infected ticks?

## INTERNET ACTIVITY

Do an Internet search to learn about resources for families who have members with muscular dystrophy.