CHAPTER 11

The Muscular System

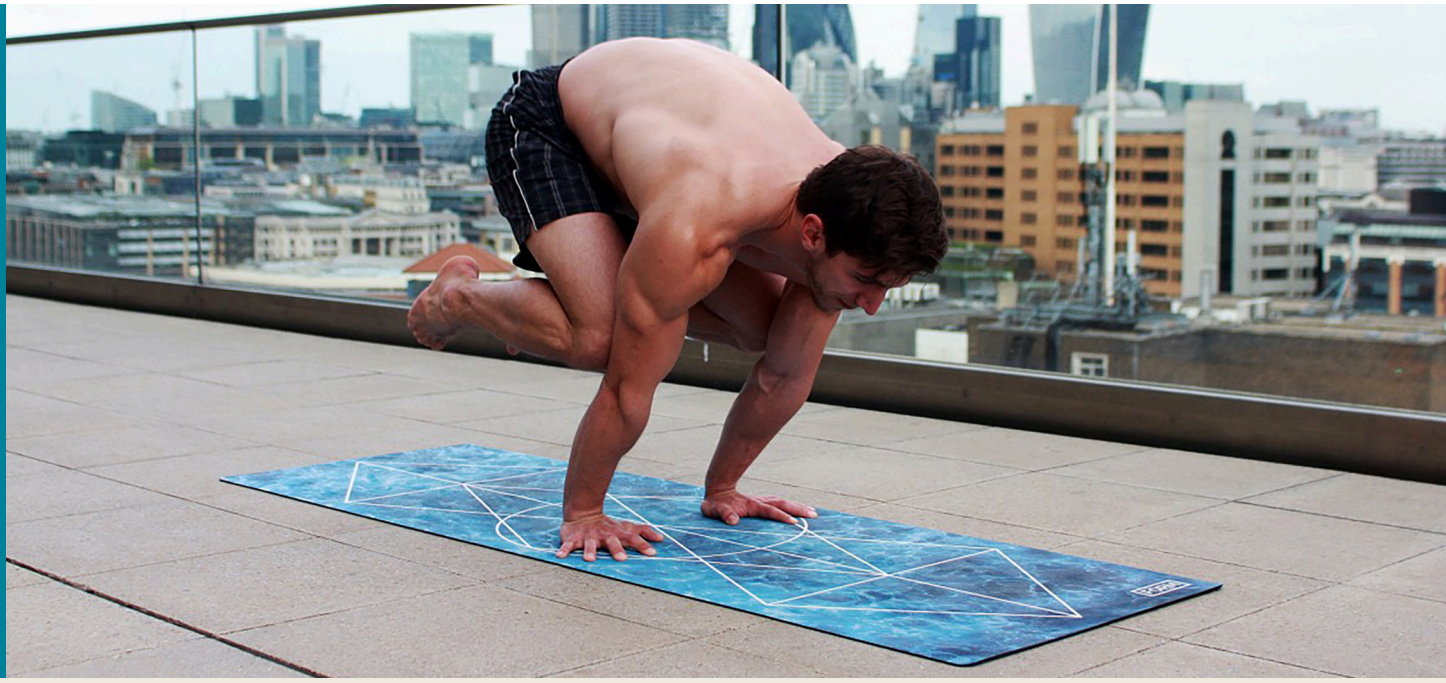


FIGURE 11.1 A Body in Motion The muscular system allows us to move, flex and contort our bodies. Practicing yoga, as pictured here, is a good example of the voluntary use of the muscular system. (credit: Dmitry Yanchylenko)

Chapter Objectives

After studying this chapter, you will be able to:

- Describe the actions and roles of agonists and antagonists
- Explain the structure and organization of muscle fascicles and their role in generating force
- Explain the criteria used to name skeletal muscles
- Identify the skeletal muscles and their actions on the skeleton and soft tissues of the body
- Identify the origins and insertions of skeletal muscles and the prime movements

INTRODUCTION Think about the things that you do each day—talking, walking, sitting, standing, and running—all of these activities require movement of particular skeletal muscles. Skeletal muscles are even used during sleep. The diaphragm is a sheet of skeletal muscle that has to contract and relax for you to breathe day and night. If you recall from your study of the skeletal system and joints, body movement occurs around the joints in the body. The focus of this chapter is on skeletal muscle organization. The system to name skeletal muscles will be explained; in some cases, the muscle is named by its shape, and in other cases it is named by its location or attachments to the skeleton. If you understand the meaning of the name of the muscle, often it will help you remember its location and/or what it does. This chapter also will describe how skeletal muscles are arranged to accomplish movement, and how other muscles may assist, or be arranged on the skeleton to resist or carry out the opposite movement. The actions of the skeletal muscles will be covered in a regional manner, working from the head down to the toes.

11.1 Interactions of Skeletal Muscles, Their Fascicle Arrangement, and Their Lever Systems

LEARNING OBJECTIVES

By the end of this section, you will be able to:

- Compare and contrast agonist and antagonist muscles
- Describe how fascicles are arranged within a skeletal muscle
- Explain the major events of a skeletal muscle contraction within a muscle in generating force

To move the skeleton, the tension created by the contraction of the fibers in most skeletal muscles is transferred to the tendons. The tendons are strong bands of dense, regular connective tissue that connect muscles to bones. The bone connection is why this muscle tissue is called skeletal muscle.

Interactions of Skeletal Muscles in the Body

To pull on a bone, that is, to change the angle at its synovial joint, which essentially moves the skeleton, a skeletal muscle must also be attached to a fixed part of the skeleton. The moveable end of the muscle that attaches to the bone being pulled is called the muscle's **insertion**, and the end of the muscle attached to a fixed (stabilized) bone is called the **origin**. During forearm **flexion**—bending the elbow—the brachioradialis assists the brachialis.

Although a number of muscles may be involved in an action, the principal muscle involved is called the **prime mover**, or **agonist**. To lift a cup, a muscle called the biceps brachii is actually the prime mover; however, because it can be assisted by the brachialis, the brachialis is called a **synergist** in this action (Figure 11.2). A synergist can also be a **fixator** that stabilizes the bone that is the attachment for the prime mover's origin.

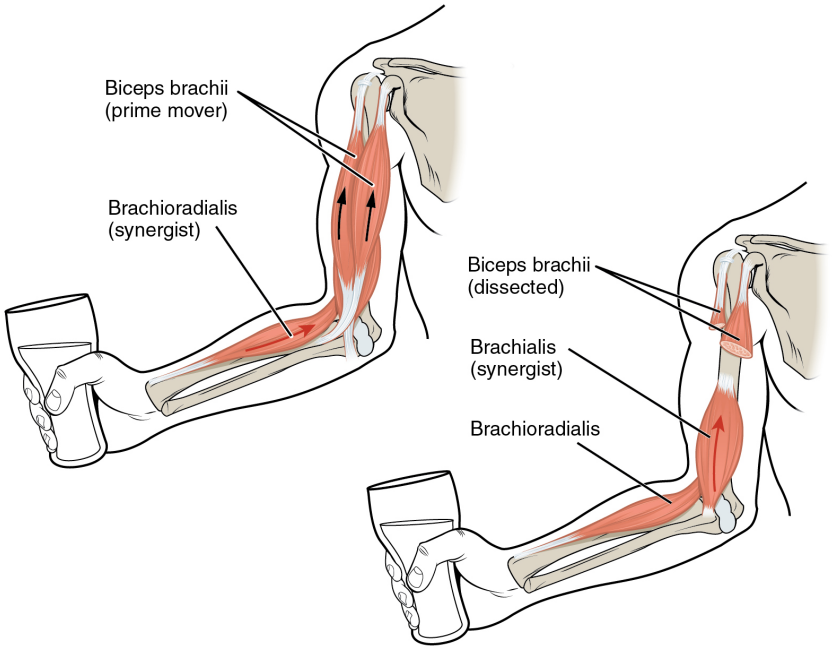


FIGURE 11.2 Prime Movers and Synergists The biceps brachii flex the lower arm. The brachoradialis, in the forearm, and brachialis, located deep to the biceps in the upper arm, are both synergists that aid in this motion.

A muscle with the opposite action of the prime mover is called an **antagonist**. Antagonists play two important roles in muscle function: (1) they maintain body or limb position, such as holding the arm out or standing erect; and (2) they control rapid movement, as in shadow boxing without landing a punch or the ability to check the motion of a limb.

For example, to extend the knee, a group of four muscles called the quadriceps femoris in the anterior compartment of the thigh are activated (and would be called the agonists of knee extension). However, to flex the knee joint, an opposite or antagonistic set of muscles called the hamstrings is activated.

As you can see, these terms would also be reversed for the opposing action. If you consider the first action as the knee bending, the hamstrings would be called the agonists and the quadriceps femoris would then be called the antagonists. See Table 11.1 for a list of some agonists and antagonists.

Agonist and Antagonist Skeletal Muscle Pairs

Agonist	Antagonist	Movement
Biceps brachii: in the anterior compartment of the arm	Triceps brachii: in the posterior compartment of the arm	The biceps brachii flexes the forearm, whereas the triceps brachii extends it.
Hamstrings: group of three muscles in the posterior compartment of the thigh	Quadriceps femoris: group of four muscles in the anterior compartment of the thigh	The hamstrings flex the leg, whereas the quadriceps femoris extend it.
Flexor digitorum superficialis and flexor digitorum profundus: in the anterior compartment of the forearm	Extensor digitorum: in the posterior compartment of the forearm	The flexor digitorum superficialis and flexor digitorum profundus flex the fingers and the hand at the wrist, whereas the extensor digitorum extends the fingers and the hand at the wrist.

TABLE 11.1

There are also skeletal muscles that do not pull against the skeleton for movements. For example, there are the muscles that produce facial expressions. The insertions and origins of facial muscles are in the skin, so that certain individual muscles contract to form a smile or frown, form sounds or words, and raise the eyebrows. There also are skeletal muscles in the tongue, and the external urinary and anal sphincters that allow for voluntary regulation of urination and defecation, respectively. In addition, the diaphragm contracts and relaxes to change the volume of the pleural cavities but it does not move the skeleton to do this.

EVERYDAY CONNECTION

Exercise and Stretching

When exercising, it is important to first warm up the muscles. Stretching pulls on the muscle fibers and it also results in an increased blood flow to the muscles being worked. Without a proper warm-up, it is possible that you may either damage some of the muscle fibers or pull a tendon. A pulled tendon, regardless of location, results in pain, swelling, and diminished function; if it is moderate to severe, the injury could immobilize you for an extended period.

Recall the discussion about muscles crossing joints to create movement. Most of the joints you use during exercise are synovial joints, which have synovial fluid in the joint space between two bones. Exercise and stretching may also have a beneficial effect on synovial joints. Synovial fluid is a thin, but viscous film with the consistency of egg whites. When you first get up and start moving, your joints feel stiff for a number of reasons. After proper stretching and warm-up, the synovial fluid may become less viscous, allowing for better joint function.

Patterns of Fascicle Organization

Skeletal muscle is enclosed in connective tissue scaffolding at three levels. Each muscle fiber (cell) is covered by endomysium and the entire muscle is covered by epimysium. When a group of muscle fibers is “bundled” as a unit within the whole muscle by an additional covering of a connective tissue called perimysium, that bundled group of muscle fibers is called a **fascicle**. Fascicle arrangement by perimysia is correlated to the force generated by a muscle; it also affects the range of motion of the muscle. Based on the patterns of fascicle arrangement, skeletal muscles can be classified in several ways. What follows are the most common fascicle arrangements.

Parallel muscles have fascicles that are arranged in the same direction as the long axis of the muscle (Figure 11.3). The majority of skeletal muscles in the body have this type of organization. Some parallel muscles are flat sheets that expand at the ends to make broad attachments. Other parallel muscles are rotund with tendons at one or both ends. Muscles that seem to be plump have a large mass of tissue located in the middle of the muscle, between the insertion and the origin, which is known as the central body. A more common name for this muscle is **belly**. When a muscle contracts, the contractile fibers shorten it to an even larger bulge. For example, extend and then flex your biceps brachii muscle; the large, middle section is the belly (Figure 11.4). When a parallel muscle has a central, large belly that is spindle-shaped, meaning it tapers as it extends to its origin and insertion, it sometimes is called **fusiform**.

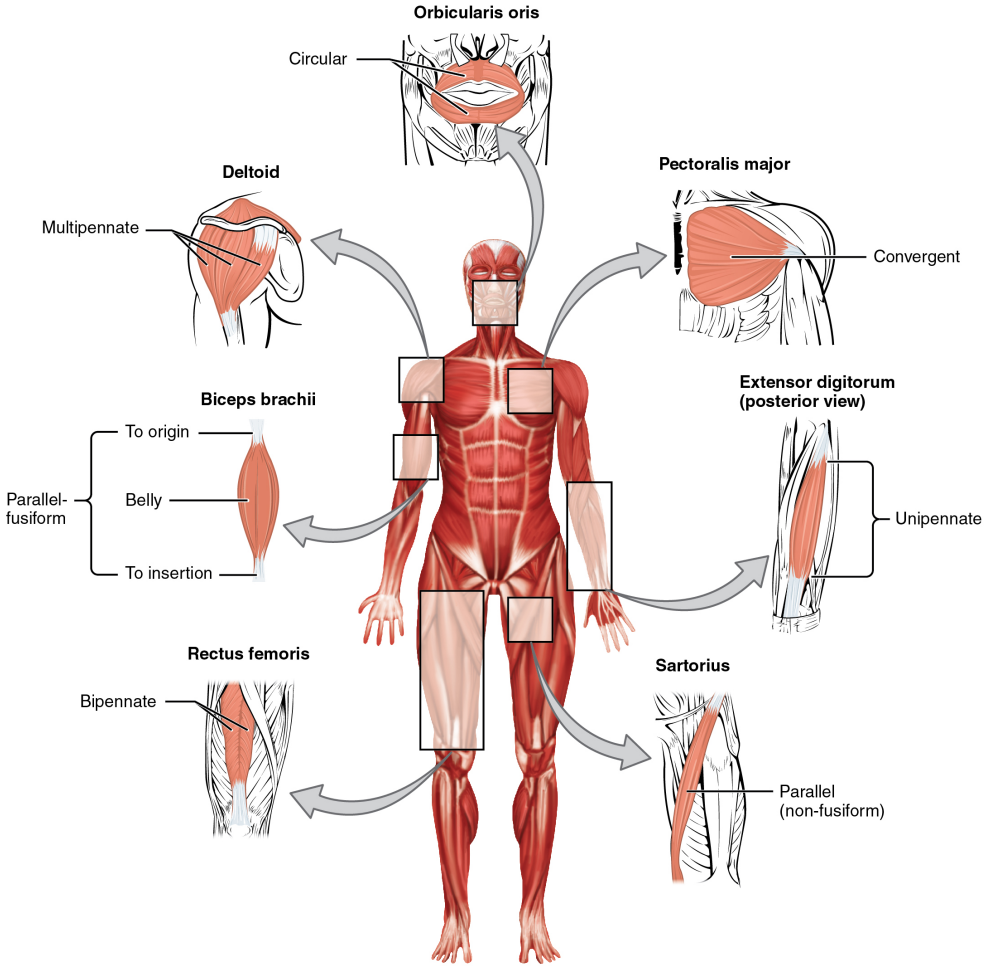


FIGURE 11.3 **Muscle Shapes and Fiber Alignment** The skeletal muscles of the body typically come in seven different general shapes.



FIGURE 11.4 Biceps Brachii Muscle Contraction The large mass at the center of a muscle is called the belly. Tendons emerge from both ends of the belly and connect the muscle to the bones, allowing the skeleton to move. The tendons of the bicep connect to the upper arm and the forearm. (credit: Victoria Garcia)

Circular muscles are also called sphincters (see Figure 11.3). When they relax, the sphincters' concentrically arranged bundles of muscle fibers increase the size of the opening, and when they contract, the size of the opening shrinks to the point of closure. The orbicularis oris muscle is a circular muscle that goes around the mouth. When it contracts, the oral opening becomes smaller, as when puckering the lips for whistling. Another example is the orbicularis oculi, one of which surrounds each eye. Consider, for example, the names of the two orbicularis muscles (orbicularis oris and oribicularis oculi), where part of the first name of both muscles is the same. The first part of orbicularis, orb (orb = "circular"), is a reference to a round or circular structure; it may also make one think of orbit, such as the moon's path around the earth. The word oris (oris = "oral") refers to the oral cavity, or the mouth. The word oculi (ocular = "eye") refers to the eye.

There are other muscles throughout the body named by their shape or location. The deltoid is a large, triangular-shaped muscle that covers the shoulder. It is so-named because the Greek letter delta looks like a triangle. The rectus abdominis (rector = "straight") is the straight muscle in the anterior wall of the abdomen, while the rectus femoris is the straight muscle in the anterior compartment of the thigh.

When a muscle has a widespread expansion over a sizable area, but then the fascicles come to a single, common attachment point, the muscle is called **convergent**. The attachment point for a convergent muscle could be a tendon, an aponeurosis (a flat, broad tendon), or a raphe (a very slender tendon). The large muscle on the chest, the pectoralis major, is an example of a convergent muscle because it converges on the greater tubercle of the humerus via a tendon. The temporalis muscle of the cranium is another.

Pennate muscles (penna = "feathers") blend into a tendon that runs through the central region of the muscle for its whole length, somewhat like the quill of a feather with the muscle arranged similar to the feathers. Due to this design, the muscle fibers in a pennate muscle can only pull at an angle, and as a result, contracting pennate muscles do not move their tendons very far. However, because a pennate muscle generally can hold more muscle fibers within it, it can produce relatively more tension for its size. There are three subtypes of pennate muscles.

In a **unipennate** muscle, the fascicles are located on one side of the tendon. The extensor digitorum of the forearm is an example of a unipennate muscle. A **bipennate** muscle has fascicles on both sides of the tendon. In some pennate muscles, the muscle fibers wrap around the tendon, sometimes forming individual fascicles in the process. This arrangement is referred to as **multipennate**. A common example is the deltoid muscle of the shoulder, which covers the shoulder but has a single tendon that inserts on the deltoid tuberosity of the humerus.

Because of fascicles, a portion of a multipennate muscle like the deltoid can be stimulated by the nervous system to change the direction of the pull. For example, when the deltoid muscle contracts, the arm abducts (moves away from midline in the sagittal plane), but when only the anterior fascicle is stimulated, the arm will **abduct** and flex (move anteriorly at the shoulder joint).

The Lever System of Muscle and Bone Interactions

Skeletal muscles do not work by themselves. Muscles are arranged in pairs based on their functions. For muscles attached to the bones of the skeleton, the connection determines the force, speed, and range of movement. These characteristics depend on each other and can explain the general organization of the muscular and skeletal systems.

The skeleton and muscles act together to move the body. Have you ever used the back of a hammer to remove a nail from wood? The handle acts as a lever and the head of the hammer acts as a fulcrum, the fixed point that the force is applied to when you pull back or push down on the handle. The effort applied to this system is the pulling or pushing on the handle to remove the nail, which is the load, or "resistance" to the movement of the handle in the system. Our musculoskeletal system works in a similar manner, with bones being stiff levers and the articular endings of the bones—encased in synovial joints—acting as fulcrums. The load would be an object being lifted or any resistance to a movement (your head is a load when you are lifting it), and the effort, or applied force, comes from contracting skeletal muscle.

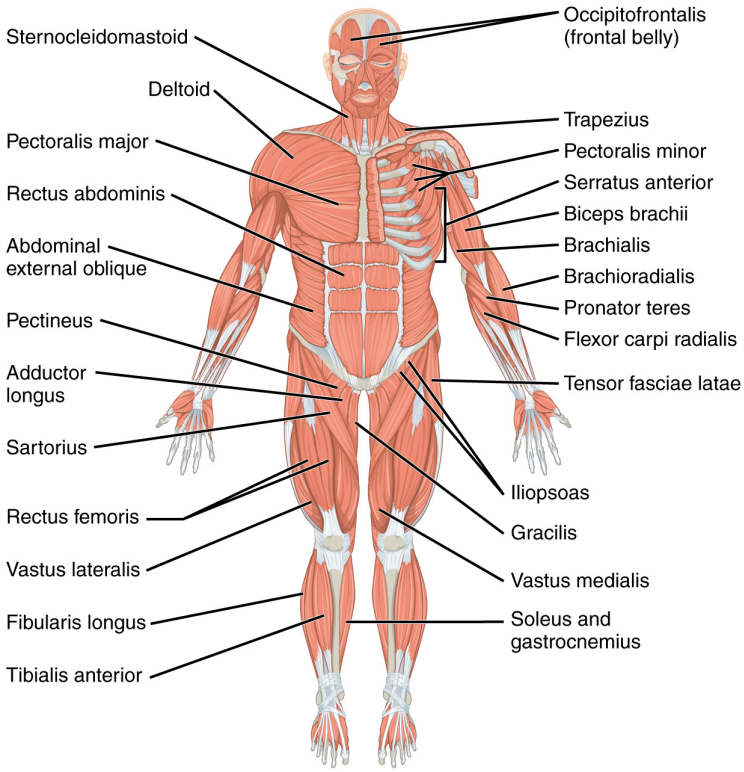
11.2 Naming Skeletal Muscles

LEARNING OBJECTIVES

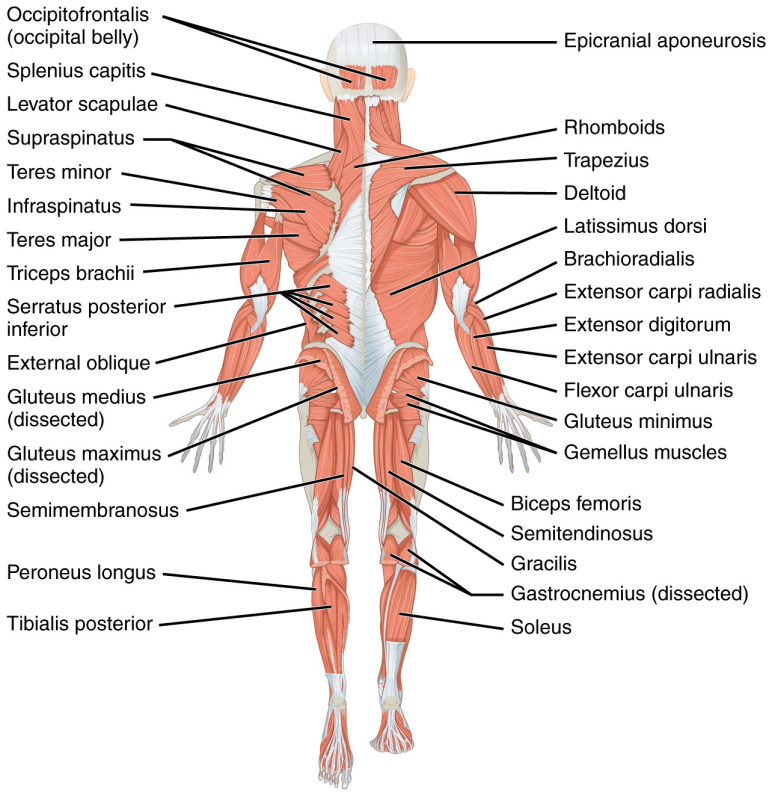
By the end of this section, you will be able to:

- Describe the criteria used to name skeletal muscles
- Explain how understanding the muscle names helps describe shapes, location, and actions of various muscles

The Greeks and Romans conducted the first studies done on the human body in Western culture. The educated class of subsequent societies studied Latin and Greek, and therefore the early pioneers of anatomy continued to apply Latin and Greek terminology or roots when they named the skeletal muscles. The large number of muscles in the body and unfamiliar words can make learning the names of the muscles in the body seem daunting, but understanding the etymology can help. Etymology is the study of how the root of a particular word entered a language and how the use of the word evolved over time. Taking the time to learn the root of the words is crucial to understanding the vocabulary of anatomy and physiology. When you understand the names of muscles it will help you remember where the muscles are located and what they do (Figure 11.5, Figure 11.6, and Table 11.2). Pronunciation of words and terms will take a bit of time to master, but after you have some basic information; the correct names and pronunciations will become easier.



Major muscles of the body.
Right side: superficial; left side: deep (anterior view)



Major muscles of the body.
Right side: superficial; left side: deep (posterior view)

FIGURE 11.5 Overview of the Muscular System On the anterior and posterior views of the muscular system above, superficial muscles (those at the surface) are shown on the right side of the body while deep muscles (those underneath the superficial muscles) are shown on the left half of the body. For the legs, superficial muscles are shown in the anterior view while the posterior view shows both superficial and

deep muscles.

Example	Word	Latin Root 1	Latin Root 2	Meaning	Translation
abductor digiti minimi	abductor	ab = away from	duct = to move	a muscle that moves away from	A muscle that moves the little finger or toe away
	digiti	digitus = digit		refers to a finger or toe	
	minimi	minimus = mini, tiny		little	
adductor digiti minimi	adductor	ad = to, toward	duct = to move	a muscle that moves towards	A muscle that moves the little finger or toe toward
	digiti	digitus = digit		refers to a finger or toe	
	minimi	minimus = mini, tiny		little	

FIGURE 11.6 Understanding a Muscle Name from the Latin

Mnemonic Device for Latin Roots

Example	Latin or Greek Translation	Mnemonic Device
ad	to; toward	ADvance toward your goal
ab	away from	n/a
sub	under	SUBmarines move under water.
ductor	something that moves	A conDUCTOR makes a train move.
anti	against	If you are antisocial, you are against engaging in social activities.
epi	on top of	n/a
apo	to the side of	n/a
longissimus	longest	“Longissimus” is longer than the word “long.”
longus	long	long
brevis	short	brief
maximus	large	max
medius	medium	“Medius” and “medium” both begin with “med.”
minimus	tiny; little	mini
rectus	straight	To RECTify a situation is to straighten it out.
multi	many	If something is MULTIcolored, it has many colors.
uni	one	A UNIcorn has one horn.

TABLE 11.2

Example	Latin or Greek Translation	Mnemonic Device
bi/di	two	If a ring is DIcast, it is made of two metals.
tri	three	TRIple the amount of money is three times as much.
quad	four	QUADruplets are four children born at one birth.
externus	outside	EXternal
internus	inside	INternal

TABLE 11.2

Anatomists name the skeletal muscles according to a number of criteria, each of which describes the muscle in some way. These include naming the muscle after its shape, its size compared to other muscles in the area, its location in the body or the location of its attachments to the skeleton, how many origins it has, or its action.

The skeletal muscle's anatomical location or its relationship to a particular bone often determines its name. For example, the frontalis muscle is located on top of the frontal bone of the skull. Similarly, the shapes of some muscles are very distinctive and the names, such as orbicularis, reflect the shape. For the buttocks, the size of the muscles influences the names: gluteus **maximus** (largest), gluteus **medius** (medium), and the gluteus **minimus** (smallest). Names were given to indicate length—**brevis** (short), **longus** (long)—and to identify position relative to the midline: **lateralis** (to the outside away from the midline), and **medialis** (toward the midline). The direction of the muscle fibers and fascicles are used to describe muscles relative to the midline, such as the **rectus** (straight) abdominis, or the **oblique** (at an angle) muscles of the abdomen.

Some muscle names indicate the number of muscles in a group. One example of this is the quadriceps, a group of four muscles located on the anterior (front) thigh. Other muscle names can provide information as to how many origins a particular muscle has, such as the biceps brachii. The prefix **bi** indicates that the muscle has two origins and **tri** indicates three origins.

The location of a muscle's attachment can also appear in its name. When the name of a muscle is based on the attachments, the origin is always named first. For instance, the sternocleidomastoid muscle of the neck has a dual origin on the sternum (sterno) and clavicle (cleido), and it inserts on the mastoid process of the temporal bone. The last feature by which to name a muscle is its action. When muscles are named for the movement they produce, one can find action words in their name. Some examples are **flexor** (decreases the angle at the joint), **extensor** (increases the angle at the joint), **abductor** (moves the bone away from the midline), or **adductor** (moves the bone toward the midline).

11.3 Axial Muscles of the Head, Neck, and Back

LEARNING OBJECTIVES

By the end of this section, you will be able to:

- Identify the axial muscles of the face, head, and neck
- Identify the movement and function of the face, head, and neck muscles

The skeletal muscles are divided into **axial** (muscles of the trunk and head) and **appendicular** (muscles of the arms and legs) categories. This system reflects the bones of the skeleton system, which are also arranged in this manner. The axial muscles are grouped based on location, function, or both. Some of the axial muscles may seem to blur the boundaries because they cross over to the appendicular skeleton. The first grouping of the axial muscles you will review includes the muscles of the head and neck, then you will review the muscles of the vertebral column, and finally you will review the oblique and rectus muscles.

Muscles That Create Facial Expression

The origins of the muscles of facial expression are on the surface of the skull (remember, the origin of a muscle does

not move). The insertions of these muscles have fibers intertwined with connective tissue and the dermis of the skin. Because the muscles insert in the skin rather than on bone, when they contract, the skin moves to create facial expression (Figure 11.7).

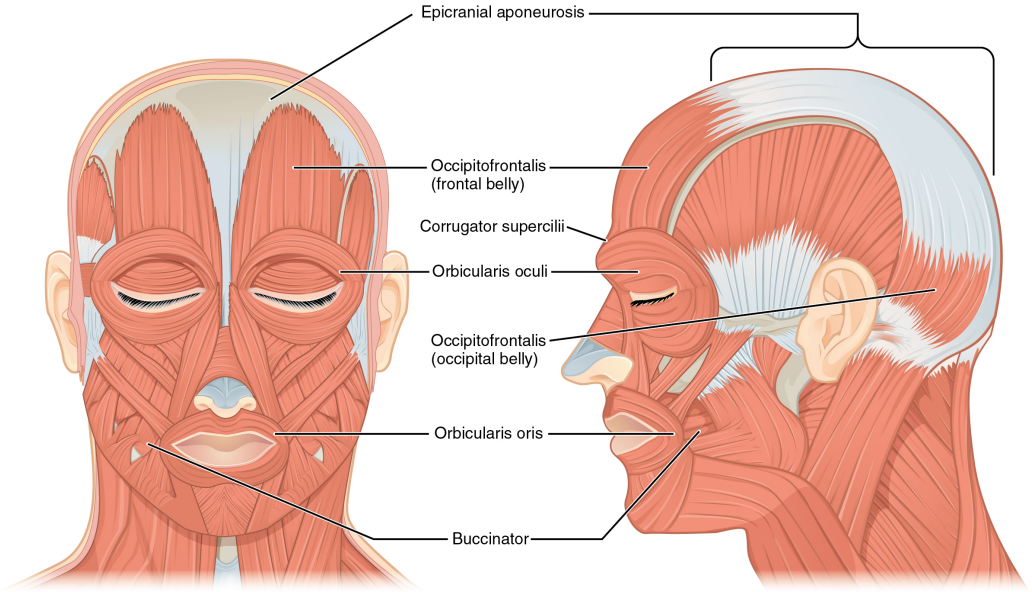


FIGURE 11.7 Muscles of Facial Expression Many of the muscles of facial expression insert into the skin surrounding the eyelids, nose and mouth, producing facial expressions by moving the skin rather than bones.

The **orbicularis oris** is a circular muscle that moves the lips, and the **orbicularis oculi** is a circular muscle that closes the eye. The **occipitofrontalis** muscle moves up the scalp and eyebrows. The muscle has a frontal belly and an occipital (near the occipital bone on the posterior part of the skull) belly. In other words, there is a muscle on the forehead (**frontalis**) and one on the back of the head (**occipitalis**), but there is no muscle across the top of the head. Instead, the two bellies are connected by a broad tendon called the **epicranial aponeurosis**, or galea aponeurosis (galea = "helmet"). The physicians originally studying human anatomy thought the skull looked like a helmet.

A large portion of the face is composed of the **buccinator** muscle, which compresses the cheek. This muscle allows you to whistle, blow, and suck; and it contributes to the action of chewing. There are several small facial muscles, one of which is the **corrugator supercilii**, which is the prime mover of the eyebrows. Place your finger on your eyebrows at the point of the bridge of the nose. Raise your eyebrows as if you were surprised and lower your eyebrows as if you were frowning. With these movements, you can feel the action of the corrugator supercilii. Additional muscles of facial expression are presented in Figure 11.8.

Movement	Target	Target motion direction	Prime mover	Origin	Insertion
Brow					
Raising eyebrows (e.g., showing surprise)	Skin of scalp	Anterior	Occipito-frontalis, frontal belly	Epicraneal aponeurosis	Underneath skin of forehead
Tensing and retracting scalp	Skin of scalp	Posterior	Occipito-frontalis, occipital belly	Occipital bone; mastoid process (temporal bone)	Epicraneal aponeurosis
Lowering eyebrows (e.g., scowling, frowning)	Skin underneath eyebrows	Inferior	Corrugator supercilii	Frontal bone	Skin underneath eyebrow
Nose					
Flaring nostrils	Nasal cartilage (pushes nostrils open when cartilage is compressed)	Inferior compression; posterior compression	Nasalis	Maxilla	Nasal bone
Mouth					
Raising upper lip	Upper lip	Elevation	Levator labii superioris	Maxilla	Underneath skin at corners of the mouth; orbicularis oris
Lowering lower lip	Lower lip	Depression	Depressor labii inferioris	Mandible	Underneath skin of lower lip
Opening mouth and sliding lower jaw left and right	Lower jaw	Depression, lateral	Depressor angulus oris	Mandible	Underneath skin at corners of mouth
Smiling	Corners of mouth	Lateral elevation	Zygomaticus major	Zygomatic bone	Underneath skin at corners of mouth (dimple area); orbicularis oris
Shaping of lips (as during speech)	Lips	Multiple	Orbicularis oris	Tissue surrounding lips	Underneath skin at corners of the mouth
Lateral movement of cheeks (e.g., sucking on a straw; also used to compress air in mouth while blowing)	Cheeks	Lateral	Buccinator	Maxilla, mandible; sphenoid bone (via pterygomandibular raphae)	Orbicularis oris
Pursing of lips by straightening them laterally	Corners of mouth	Lateral	Risorius	Fascia of parotid salivary gland	Underneath skin at corners of the mouth
Protrusion of lower lip (e.g., pouting expression)	Lower lip and skin of chin	Protraction	Mentalis	Mandible	Underneath skin of chin

FIGURE 11.8 Muscles in Facial Expression

Muscles That Move the Eyes

The movement of the eyeball is under the control of the **extrinsic eye muscles**, which originate outside the eye and insert onto the outer surface of the white of the eye. These muscles are located inside the eye socket and cannot be seen on any part of the visible eyeball (Figure 11.9 and Table 11.3). If you have ever been to a doctor who held up a finger and asked you to follow it up, down, and to both sides, the doctor is checking to make sure your eye muscles are acting in a coordinated pattern.

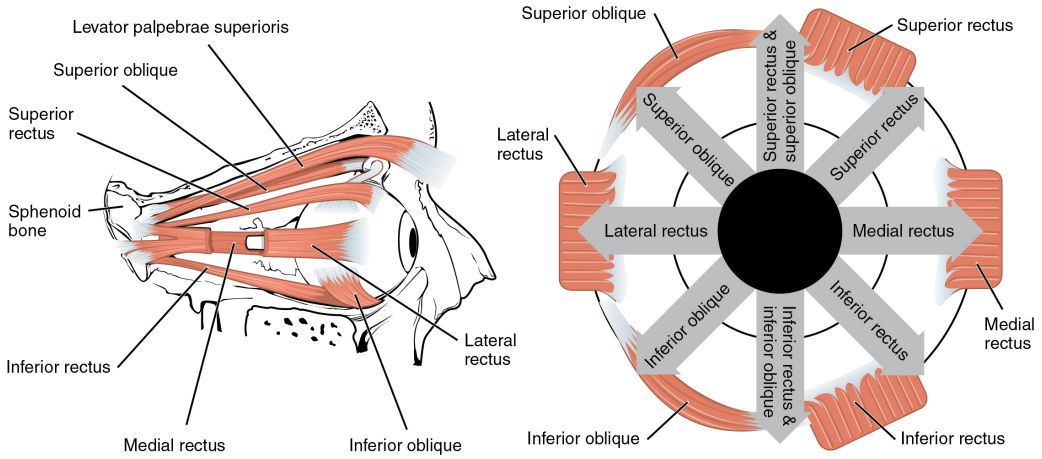


FIGURE 11.9 Muscles of the Eyes (a) The extrinsic eye muscles originate outside of the eye on the skull. (b) Each muscle inserts onto the eyeball.

Muscles of the Eyes

Movement	Target	Target motion direction	Prime mover	Origin	Insertion
Moves eyes up and toward nose; rotates eyes from 1 o'clock to 3 o'clock	Eyeballs	Superior (elevates); medial (adducts)	Superior rectus	Common tendinous ring (ring attaches to optic foramen)	Superior surface of eyeball
Moves eyes down and toward nose; rotates eyes from 6 o'clock to 3 o'clock	Eyeballs	Inferior (depresses); medial (adducts)	Inferior rectus	Common tendinous ring (ring attaches to optic foramen)	Inferior surface of eyeball
Moves eyes away from nose	Eyeballs	Lateral (abducts)	Lateral rectus	Common tendinous ring (ring attaches to optic foramen)	Lateral surface of eyeball
Moves eyes toward nose	Eyeballs	Medial (adducts)	Medial rectus	Common tendinous ring (ring attaches to optic foramen)	Medial surface of eyeball
Moves eyes up and away from nose; rotates eyeball from 12 o'clock to 9 o'clock	Eyeballs	Superior (elevates); lateral (abducts)	Inferior oblique	Floor of orbit (maxilla)	Surface of eyeball between inferior rectus and lateral rectus
Moves eyes down and away from nose; rotates eyeball from 6 o'clock to 9 o'clock	Eyeballs	Inferior (depress); lateral (abducts)	Superior oblique	Sphenoid bone	Surface of eyeball between superior rectus and lateral rectus

TABLE 11.3

Movement	Target	Target motion direction	Prime mover	Origin	Insertion
Opens eyes	Upper eyelid	Superior (elevates)	Levator palpabrae superioris	Roof of orbit (sphenoid bone)	Skin of upper eyelids
Closes eyelids	Eyelid skin	Compression along superior–inferior axis	Orbicularis oculi	Medial bones composing the orbit	Circumference of orbit

TABLE 11.3

Muscles That Move the Lower Jaw

In anatomical terminology, chewing is called **mastication**. Muscles involved in chewing must be able to exert enough pressure to bite through and then chew food before it is swallowed (Figure 11.10 and Table 11.4). The **masseter** muscle is the main muscle used for chewing because it elevates the mandible (lower jaw) to close the mouth, and it is assisted by the **temporalis** muscle, which retracts the mandible. You can feel the temporalis move by putting your fingers to your temple as you chew.

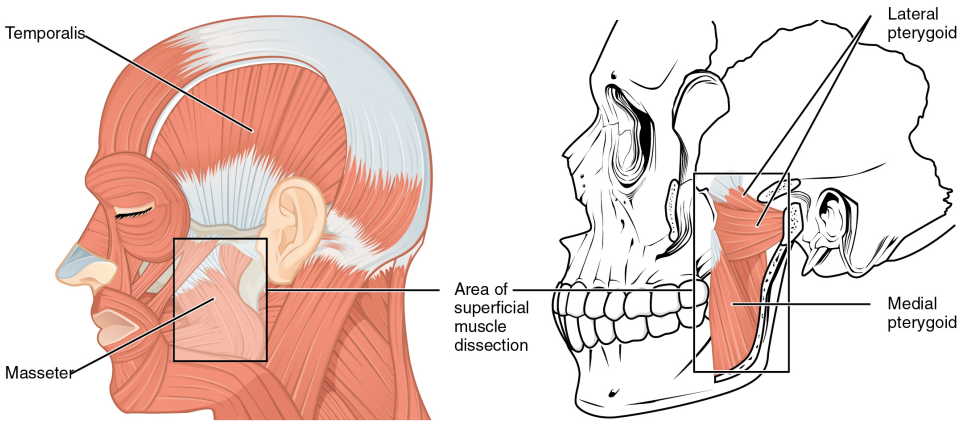


FIGURE 11.10 **Muscles That Move the Lower Jaw** The muscles that move the lower jaw are typically located within the cheek and originate from processes in the skull. This provides the jaw muscles with the large amount of leverage needed for chewing.

Muscles of the Lower Jaw

Movement	Target	Target motion direction	Prime mover	Origin	Insertion
Closes mouth; aids chewing	Mandible	Superior (elevates)	Masseter	Maxilla arch; zygomatic arch (for masseter)	Mandible
Closes mouth; pulls lower jaw in under upper jaw	Mandible	Superior (elevates); posterior (retracts)	Temporalis	Temporal bone	Mandible

TABLE 11.4

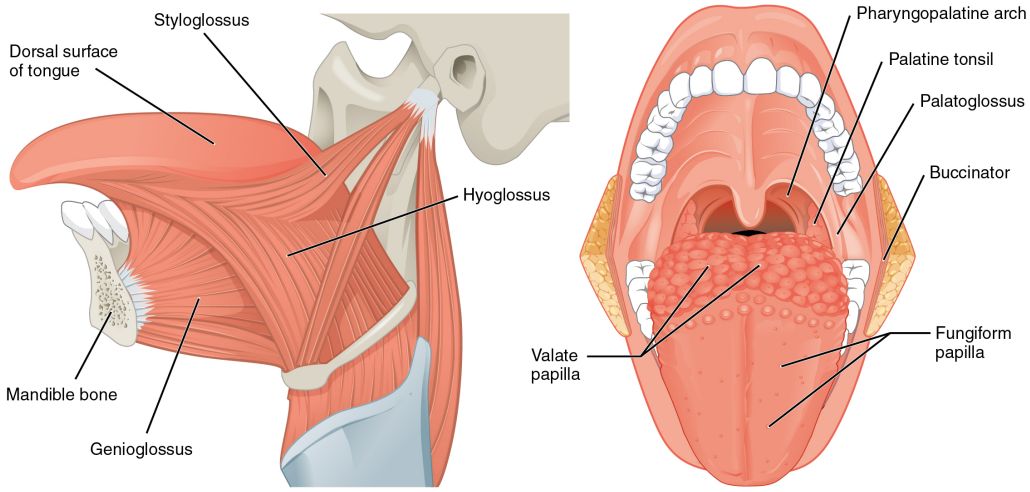
Movement	Target	Target motion direction	Prime mover	Origin	Insertion
Opens mouth; pushes lower jaw out under upper jaw; moves lower jaw side-to-side	Mandible	Inferior (depresses); posterior (protracts); lateral (abducts); medial (adducts)	Lateral pterygoid	Pterygoid process of sphenoid bone	Mandible
Closes mouth; pushes lower jaw out under upper jaw; moves lower jaw side-to-side	Mandible	Superior (elevates); posterior (protracts); lateral (abducts); medial (adducts)	Medial pterygoid	Sphenoid bone; maxilla	Mandible; temporo-mandibular joint

TABLE 11.4

Although the masseter and temporalis are responsible for elevating and closing the jaw to break food into digestible pieces, the **medial pterygoid** and **lateral pterygoid** muscles provide assistance in chewing and moving food within the mouth.

Muscles That Move the Tongue

Although the tongue is obviously important for tasting food, it is also necessary for mastication, **deglutition** (swallowing), and speech (Figure 11.11 and Figure 11.12). Because it is so moveable, the tongue facilitates complex speech patterns and sounds.



(a) Extrinsic tongue muscles (b) Palatoglossus and surface of tongue

FIGURE 11.11 **Muscles that Move the Tongue**

Movement	Target	Target motion direction	Prime mover	Origin	Insertion
Tongue					
Moves tongue down; sticks tongue out of mouth	Tongue	Inferior (depresses); anterior (protracts)	Genioglossus	Mandible	Tongue undersurface; hyoid bone
Moves tongue up; retracts tongue back into mouth	Tongue	Superior (elevates); posterior (retracts)	Styloglossus	Temporal bone (styloid process)	Tongue undersurface and sides
Flattens tongue	Tongue	Inferior (depresses)	Hyoglossus	Hyoid bone	Sides of tongue
Bulges tongue	Tongue	Superior (elevation)	Palatoglossus	Soft palate	Side of tongue
Swallowing and speaking					
Raises the hyoid bone in a way that also raises the larynx, allowing the epiglottis to cover the glottis during deglutition; also assists in opening the mouth by depressing the mandible	Hyoid bone; larynx	Superior (elevates)	Digastric	Mandible; temporal bone	Hyoid bone
Raises and retracts the hyoid bone in a way that elongates the oral cavity during deglutition	Hyoid bone	Superior (elevates); posterior (retracts)	Stylohyoid	Temporal bone (styloid process)	Hyoid bone
Raises hyoid bone in a way that presses tongue against the roof of the mouth, pushing food back into the pharynx during deglutition	Hyoid bone	Superior (elevates)	Mylohyoid	Mandible	Hyoid bone; median raphe
Raises and moves hyoid bone forward, widening pharynx during deglutition	Hyoid bone	Superior (elevates); anterior (protracts)	Geniohyoid	Mandible	Hyoid bone
Retracts hyoid bone and moves it down during later phases of deglutition	Hyoid bone	Inferior (depresses); posterior (retracts)	Omohyoid	Scapula	Hyoid bone
Depresses the hyoid bone during swallowing and speaking	Hyoid bone	Inferior (depresses)	Sternohyoid	Clavicle	Hyoid bone
Shrinks distance between thyroid cartilage and hyoid bone, allowing production of high-pitch vocalizations	Hyoid bone; thyroid cartilage	Hyoid bone: inferior (depresses); thyroid cartilage: superior (elevates)	Thyrohyoid	Thyroid cartilage	Hyoid bone
Depresses larynx, thyroid cartilage, and hyoid bone to create different vocal tones	Larynx; thyroid cartilage; hyoid bone	Inferior (depresses)	Sternothyroid	Sternum	Thyroid cartilage
Rotates and tilts head to he side; tilts head forward	Skull; cervical vertebrae	Individually: medial rotation; lateral flexion; bilaterally: anterior (flexes)	Sternocleid-omastoid; semispinalis capitis	Sternum; clavicle	Temporal bone (mastoid process); occipital bone
Rotates and tilts head to the side; tilts head backwards	Skull; cervical vertebrae	Individually: lateral rotation; lateral flexion; bilaterally: anterior (flexes)	Splenius capitis; longissimus capitis		

FIGURE 11.12 Muscles for Tongue Movement, Swallowing, and Speech

Tongue muscles can be extrinsic or intrinsic. Extrinsic tongue muscles insert into the tongue from outside origins, and the intrinsic tongue muscles insert into the tongue from origins within it. The extrinsic muscles move the whole tongue in different directions, whereas the intrinsic muscles allow the tongue to change its shape (such as, curling the tongue in a loop or flattening it).

The extrinsic muscles all include the word root glossus (glossus = “tongue”), and the muscle names are derived from where the muscle originates. The **genioglossus** (genio = “chin”) originates on the mandible and allows the tongue to move downward and forward. The **styloglossus** originates on the styloid bone, and allows upward and backward motion. The **palatoglossus** originates on the soft palate to elevate the back of the tongue, and the **hyoglossus** originates on the hyoid bone to move the tongue downward and flatten it.

EVERYDAY CONNECTION

Anesthesia and the Tongue Muscles

Before surgery, a patient must be made ready for general anesthesia. The normal homeostatic controls of the body are put "on hold" so that the patient can be prepped for surgery. Control of respiration must be switched from the patient's homeostatic control to the control of the anesthesiologist. The drugs used for anesthesia relax a majority of the body's muscles.

Among the muscles affected during general anesthesia are those that are necessary for breathing and moving the tongue. Under anesthesia, the tongue can relax and partially or fully block the airway, and the muscles of respiration may not move the diaphragm or chest wall. To avoid possible complications, the safest procedure to use on a patient is called endotracheal intubation. Placing a tube into the trachea allows the doctors to maintain a patient's (open) airway to the lungs and seal the airway off from the oropharynx. Post-surgery, the anesthesiologist gradually changes the mixture of the gases that keep the patient unconscious, and when the muscles of respiration begin to function, the tube is removed. It still takes about 30 minutes for a patient to wake up, and for breathing muscles to regain control of respiration. After surgery, most people have a sore or scratchy throat for a few days.

Muscles of the Anterior Neck

The muscles of the anterior neck assist in deglutition (swallowing) and speech by controlling the positions of the larynx (voice box), and the hyoid bone, a horseshoe-shaped bone that functions as a solid foundation on which the tongue can move. The muscles of the neck are categorized according to their position relative to the hyoid bone (Figure 11.13). **Suprahyoid muscles** are superior to it, and the **infrahyoid muscles** are located inferiorly.

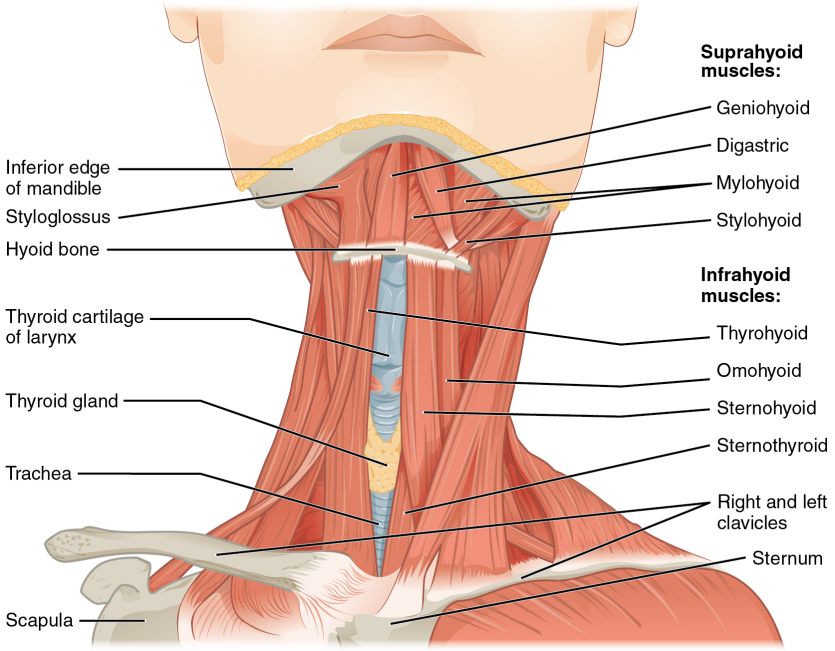


FIGURE 11.13 Muscles of the Anterior Neck The anterior muscles of the neck facilitate swallowing and speech. The suprahyoid muscles originate from above the hyoid bone in the chin region. The infrahyoid muscles originate below the hyoid bone in the lower neck.

The suprahyoid muscles raise the hyoid bone, the floor of the mouth, and the larynx during deglutition. These include the **digastric** muscle, which has anterior and posterior bellies that work to elevate the hyoid bone and larynx when one swallows; it also depresses the mandible. The **stylohyoid** muscle moves the hyoid bone posteriorly, elevating the larynx, and the **mylohyoid** muscle lifts it and helps press the tongue to the top of the mouth. The **geniohyoid** depresses the mandible in addition to raising and pulling the hyoid bone anteriorly.

The strap-like infrahyoid muscles generally depress the hyoid bone and control the position of the larynx. The **omohyoid** muscle, which has superior and inferior bellies, depresses the hyoid bone in conjunction with the **sternohyoid** and **thyrohyoid** muscles. The thyrohyoid muscle also elevates the larynx's thyroid cartilage, whereas the **sternothyroid** depresses it to create different tones of voice.

Muscles That Move the Head

The head, attached to the top of the vertebral column, is balanced, moved, and rotated by the neck muscles (Table 11.5). When these muscles act unilaterally, the head rotates. When they contract bilaterally, the head flexes or extends. The major muscle that laterally flexes and rotates the head is the **sternocleidomastoid**. In addition, both muscles working together are the flexors of the head. Place your fingers on both sides of the neck and turn your head to the left and to the right. You will feel the movement originate there. This muscle divides the neck into anterior and posterior triangles when viewed from the side (Figure 11.14).

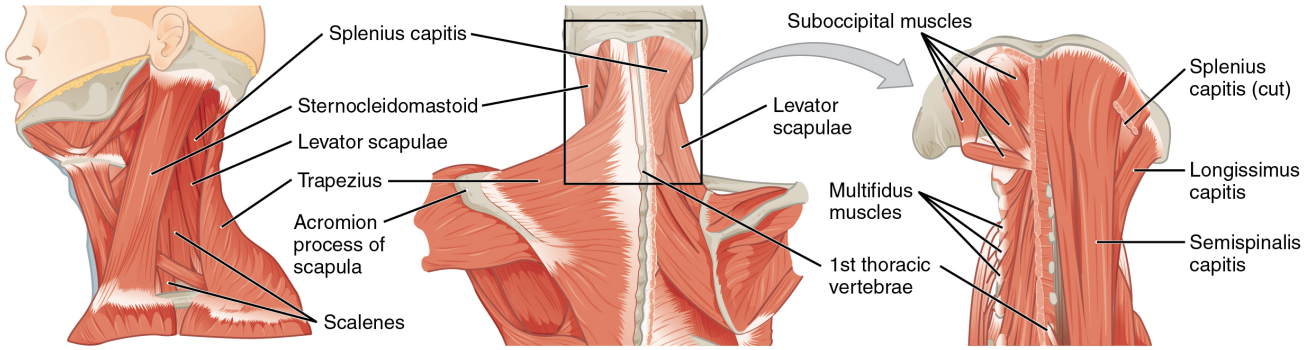


FIGURE 11.14 Posterior and Lateral Views of the Neck The superficial and deep muscles of the neck are responsible for moving the head, cervical vertebrae, and scapulas.

Muscles That Move the Head

Movement	Target	Target motion direction	Prime mover	Origin	Insertion
Rotates and tilts head to the side; tilts head forward	Skull; vertebrae	Individually: rotates head to opposite side; bilaterally: flexion	Sternocleidomastoid	Sternum; clavicle	Temporal bone (mastoid process); occipital bone
Rotates and tilts head backward	Skull; vertebrae	Individually: laterally flexes and rotates head to same side; bilaterally: extension	Semispinalis capitis	Transverse and articular processes of cervical and thoracic vertebra	Occipital bone

TABLE 11.5

Movement	Target	Target motion direction	Prime mover	Origin	Insertion
Rotates and tilts head to the side; tilts head backward	Skull; vertebrae	Individually: laterally flexes and rotates head to same side; bilaterally: extension	Splenius capitis	Spinous processes of cervical and thoracic vertebra	Temporal bone (mastoid process); occipital bone
Rotates and tilts head to the side; tilts head backward	Skull; vertebrae	Individually: laterally flexes and rotates head to same side; bilaterally: extension	Longissimus capitis	Transverse and articular processes of cervical and thoracic vertebra	Temporal bone (mastoid process)

TABLE 11.5

Muscles of the Posterior Neck and the Back

The posterior muscles of the neck are primarily concerned with head movements, like extension. The back muscles stabilize and move the vertebral column, and are grouped according to the lengths and direction of the fascicles.

The **splenius** muscles originate at the midline and run laterally and superiorly to their insertions. From the sides and the back of the neck, the **splenius capitis** inserts onto the head region, and the **splenius cervicis** extends onto the cervical region. These muscles can extend the head, laterally flex it, and rotate it (Figure 11.15).

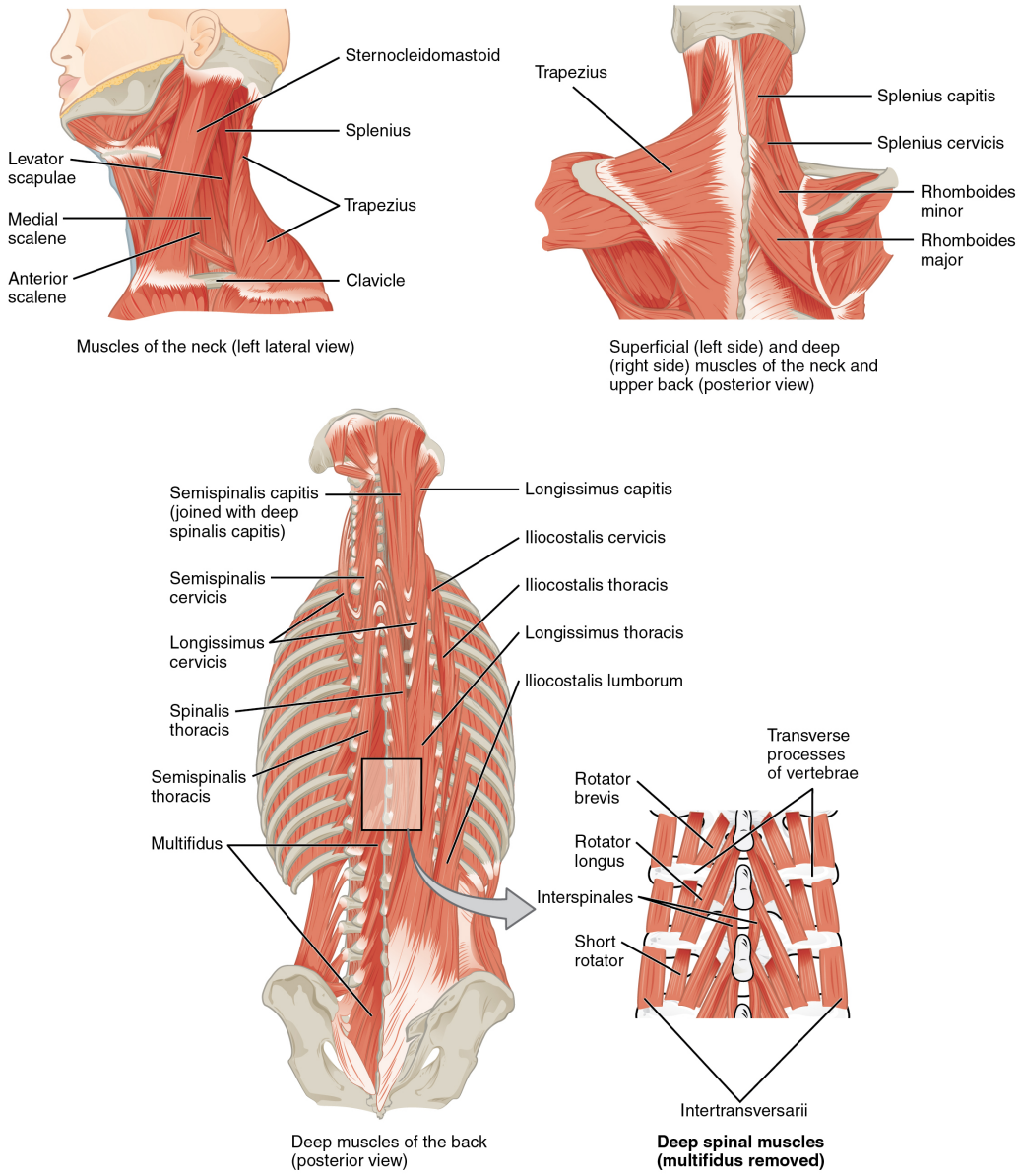


FIGURE 11.15 Muscles of the Neck and Back The large, complex muscles of the neck and back move the head, shoulders, and vertebral column.

The **erector spinae group** forms the majority of the muscle mass of the back and it is the primary extensor of the vertebral column. It controls flexion, lateral flexion, and rotation of the vertebral column, and maintains the lumbar curve. The erector spinae comprises the iliocostalis (laterally placed) group, the longissimus (intermediately placed) group, and the spinalis (medially placed) group.

The **iliocostalis group** includes the **iliocostalis cervicis**, associated with the cervical region; the **iliocostalis thoracis**, associated with the thoracic region; and the **iliocostalis lumborum**, associated with the lumbar region. The three muscles of the **longissimus group** are the **longissimus capitis**, associated with the head region; the **longissimus cervicis**, associated with the cervical region; and the **longissimus thoracis**, associated with the thoracic region. The third group, the **spinalis group**, comprises the **spinalis capitis** (head region), the **spinalis cervicis** (cervical region), and the **spinalis thoracis** (thoracic region).

The **transversospinales** muscles run from the transverse processes to the spinous processes of the vertebrae. Similar to the erector spinae muscles, the semispinalis muscles in this group are named for the areas of the body with which they are associated. The semispinalis muscles include the **semispinalis capitis**, the **semispinalis cervicis**, and the **semispinalis thoracis**. The **multifidus** muscle of the lumbar region helps extend and laterally flex

the vertebral column.

Important in the stabilization of the vertebral column is the **segmental muscle group**, which includes the interspinales and intertransversarii muscles. These muscles bring together the spinous and transverse processes of each consecutive vertebra. Finally, the **scalene muscles** work together to flex, laterally flex, and rotate the head. They also contribute to deep inhalation. The scalene muscles include the **anterior scalene** muscle (anterior to the middle scalene), the **middle scalene** muscle (the longest, intermediate between the anterior and posterior scalenes), and the **posterior scalene** muscle (the smallest, posterior to the middle scalene).

11.4 Axial Muscles of the Abdominal Wall, and Thorax

LEARNING OBJECTIVES

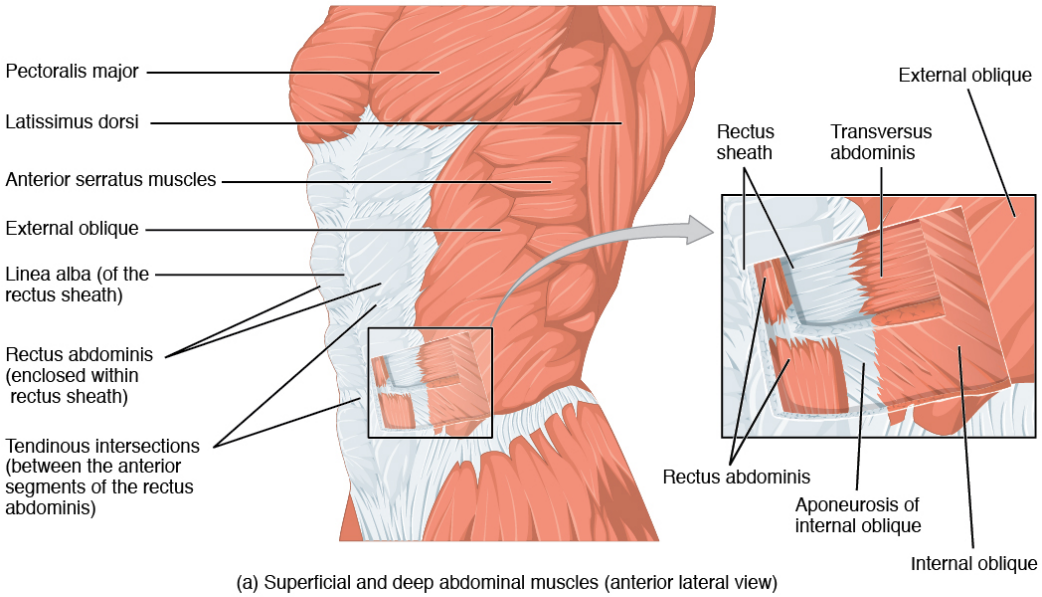
By the end of this section, you will be able to:

- Identify the intrinsic skeletal muscles of the back and neck, and the skeletal muscles of the abdominal wall and thorax
- Identify the movement and function of the intrinsic skeletal muscles of the back and neck, and the skeletal muscles of the abdominal wall and thorax

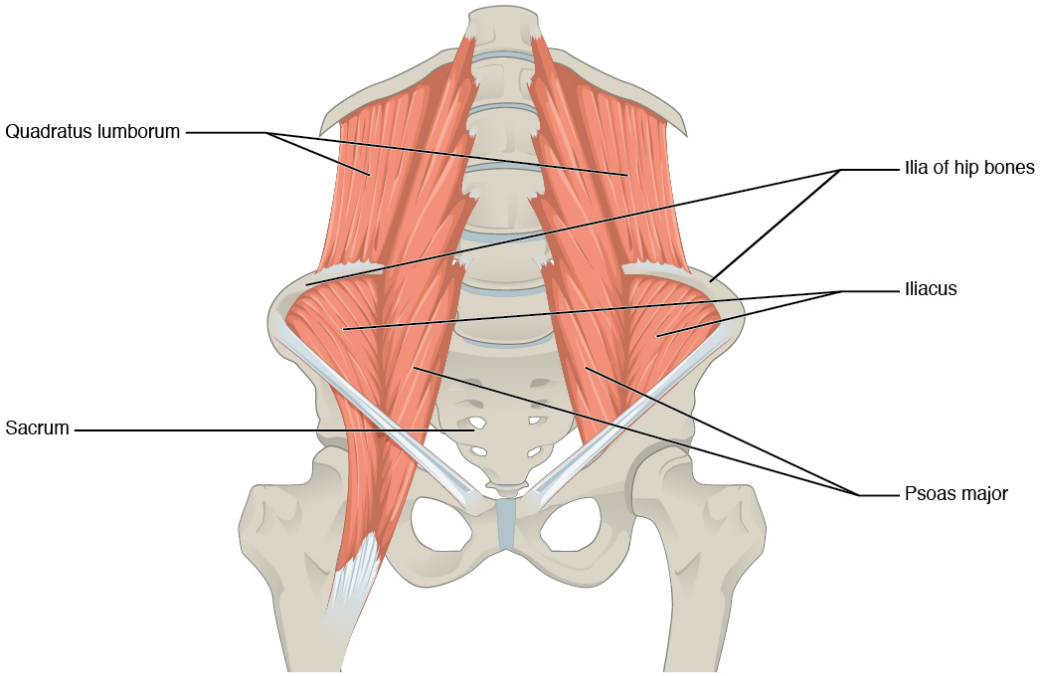
It is a complex job to balance the body on two feet and walk upright. The muscles of the vertebral column, thorax, and abdominal wall extend, flex, and stabilize different parts of the body's trunk. The deep muscles of the core of the body help maintain posture as well as carry out other functions. The brain sends out electrical impulses to these various muscle groups to control posture by alternate contraction and relaxation. This is necessary so that no single muscle group becomes fatigued too quickly. If any one group fails to function, body posture will be compromised.

Muscles of the Abdomen

There are four pairs of abdominal muscles that cover the anterior and lateral abdominal region and meet at the anterior midline. These muscles of the anterolateral abdominal wall can be divided into four groups: the external obliques, the internal obliques, the transversus abdominis, and the rectus abdominis (Figure 11.16 and Table 11.6).



(a) Superficial and deep abdominal muscles (anterior lateral view)



(b) Posterior abdominal muscles (anterior view)

FIGURE 11.16 Muscles of the Abdomen (a) The anterior abdominal muscles include the medially located rectus abdominis, which is covered by a sheet of connective tissue called the rectus sheath. On the flanks of the body, medial to the rectus abdominis, the abdominal wall is composed of three layers. The external oblique muscles form the superficial layer, while the internal oblique muscles form the middle layer, and the transversus abdominis forms the deepest layer. (b) The muscles of the lower back move the lumbar spine but also assist in femur movements.

Muscles of the Abdomen

Movement	Target	Target motion direction	Prime mover	Origin	Insertion
Twisting at waist; also bending to the side	Vertebral column	Supination; lateral flexion	External obliques; internal obliques	Ribs 5–12; ilium	Ribs 7–10; linea alba; ilium
Squeezing abdomen during forceful exhalations, defecation, urination, and childbirth	Abdominal cavity	Compression	Transversus abdominis	Ilium; ribs 5–10	Sternum; linea alba; pubis
Sitting up	Vertebral column	Flexion	Rectus abdominis	Pubis	Sternum; ribs 5 and 7
Bending to the side	Vertebral column	Lateral flexion	Quadratus lumborum	Ilium; ribs 5–10	Rib 12; vertebrae L1–L4

TABLE 11.6

There are three flat skeletal muscles in the antero-lateral wall of the abdomen. The **external oblique**, closest to the surface, extend inferiorly and medially, in the direction of sliding one's four fingers into pants pockets. Perpendicular to it is the intermediate **internal oblique**, extending superiorly and medially, the direction the thumbs usually go when the other fingers are in the pants pocket. The deep muscle, the **transversus abdominis**, is arranged transversely around the abdomen, similar to the front of a belt on a pair of pants. This arrangement of three bands of muscles in different orientations allows various movements and rotations of the trunk. The three layers of muscle also help to protect the internal abdominal organs in an area where there is no bone.

The **linea alba** is a white, fibrous band that is made of the bilateral **rectus sheaths** that join at the anterior midline of the body. These enclose the **rectus abdominis** muscles (a pair of long, linear muscles, commonly called the "sit-up" muscles) that originate at the pubic crest and symphysis, and extend the length of the body's trunk. Each muscle is segmented by three transverse bands of collagen fibers called the **tendinous intersections**. This results in the look of "six-pack abs," as each segment hypertrophies on individuals at the gym who do many sit-ups.

The posterior abdominal wall is formed by the lumbar vertebrae, parts of the ilia of the hip bones, psoas major and iliacus muscles, and **quadratus lumborum** muscle. This part of the core plays a key role in stabilizing the rest of the body and maintaining posture.

CAREER CONNECTION

Physical Therapists

Those who have a muscle or joint injury will most likely be sent to a physical therapist (PT) after seeing their regular doctor. PTs have a master's degree or doctorate, and are highly trained experts in the mechanics of body movements. Many PTs also specialize in sports injuries.

If you injured your shoulder while you were kayaking, the first thing a physical therapist would do during your first visit is to assess the functionality of the joint. The range of motion of a particular joint refers to the normal movements the joint performs. The PT will ask you to abduct and adduct, circumduct, and flex and extend the arm.

The PT will note the shoulder's degree of function, and based on the assessment of the injury, will create an appropriate physical therapy plan.

The first step in physical therapy will probably be applying a heat pack to the injured site, which acts much like a warm-up to draw blood to the area, to enhance healing. You will be instructed to do a series of exercises to continue the therapy at home, followed by icing, to decrease inflammation and swelling, which will continue for several weeks. When physical therapy is complete, the PT will do an exit exam and send a detailed report on the improved range of motion and return of normal limb function to your doctor. Gradually, as the injury heals, the shoulder will begin to function correctly. A PT works closely with patients to help them get back to their normal level of physical activity.

Muscles of the Thorax

The muscles of the chest serve to facilitate breathing by changing the size of the thoracic cavity (Table 11.7). When you inhale, your chest rises because the cavity expands. Alternately, when you exhale, your chest falls because the thoracic cavity decreases in size.

Muscles of the Thorax

Movement	Target	Target motion direction	Prime mover	Origin	Insertion
Inhalation; exhalation	Thoracic cavity	Compression; expansion	Diaphragm	Sternum; ribs 6–12; lumbar vertebrae	Central tendon
Inhalation;exhalation	Ribs	Elevation (expands thoracic cavity)	External intercostals	Rib superior to each intercostal muscle	Rib inferior to each intercostal muscle
Forced exhalation	Ribs	Movement along superior/inferior axis to bring ribs closer together	Internal intercostals	Rib inferior to each intercostal muscle	Rib superior to each intercostal muscle

TABLE 11.7

The Diaphragm

The change in volume of the thoracic cavity during breathing is due to the alternate contraction and relaxation of the **diaphragm** (Figure 11.17). It separates the thoracic and abdominal cavities, and is dome-shaped at rest. The superior surface of the diaphragm is convex, creating the elevated floor of the thoracic cavity. The inferior surface is concave, creating the curved roof of the abdominal cavity.

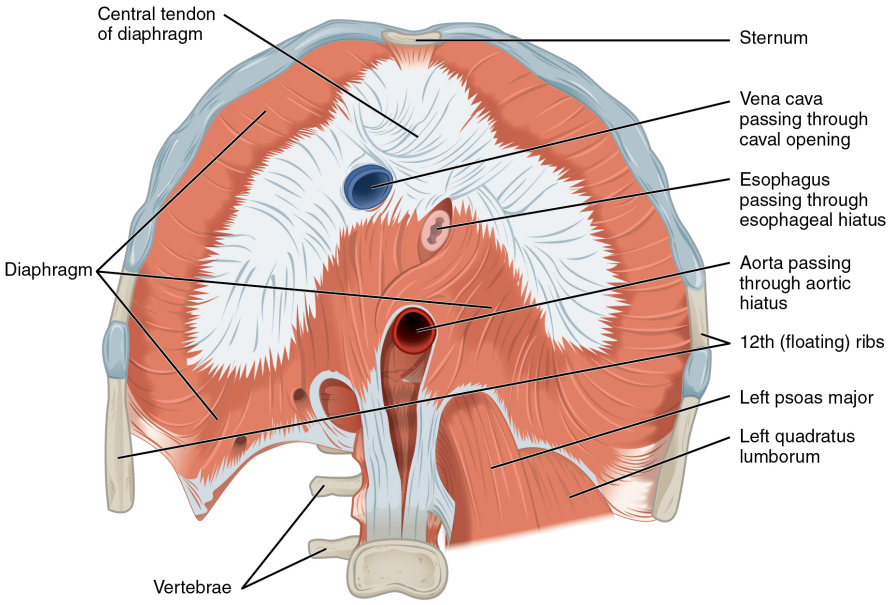


FIGURE 11.17 Muscles of the Diaphragm The diaphragm separates the thoracic and abdominal cavities.

Defecating, urination, and even childbirth involve cooperation between the diaphragm and abdominal muscles (this cooperation is referred to as the "Valsalva maneuver"). You hold your breath by a steady contraction of the diaphragm; this stabilizes the volume and pressure of the peritoneal cavity. When the abdominal muscles contract, the pressure cannot push the diaphragm up, so it increases pressure on the intestinal tract (defecation), urinary tract (urination), or reproductive tract (childbirth).

The inferior surface of the pericardial sac and the inferior surfaces of the pleural membranes (parietal pleura) fuse onto the central tendon of the diaphragm. To the sides of the tendon are the skeletal muscle portions of the diaphragm, which insert into the tendon while having a number of origins including the xiphoid process of the sternum anteriorly, the inferior six ribs and their cartilages laterally, and the lumbar vertebrae and 12th ribs posteriorly.

The diaphragm also includes three openings for the passage of structures between the thorax and the abdomen. The inferior vena cava passes through the **caval opening**, and the esophagus and attached nerves pass through the esophageal hiatus. The aorta, thoracic duct, and azygous vein pass through the aortic hiatus of the posterior diaphragm.

The Intercostal Muscles

There are three sets of muscles, called **intercostal muscles**, which span each of the intercostal spaces. The principal role of the intercostal muscles is to assist in breathing by changing the dimensions of the rib cage (Figure 11.18).

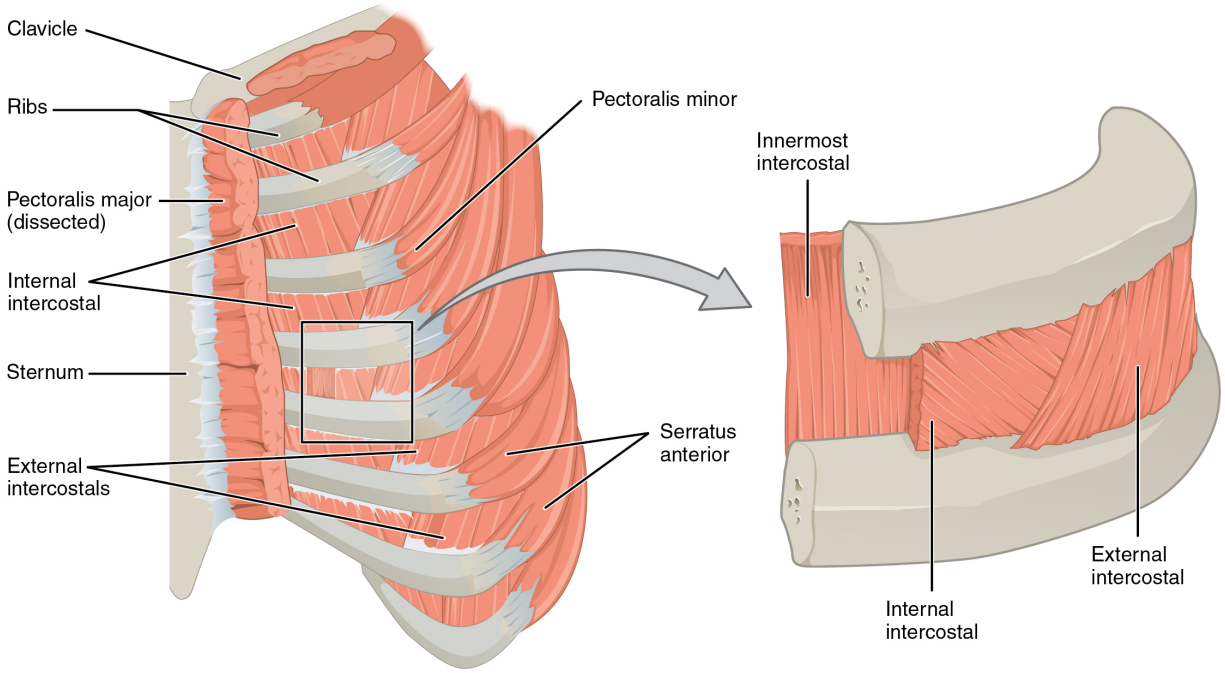


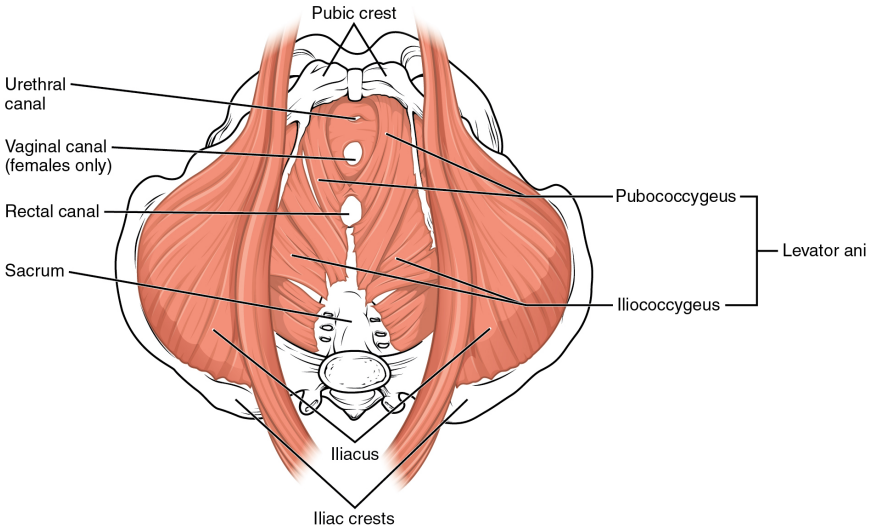
FIGURE 11.18 Intercostal Muscles The external intercostals are located laterally on the sides of the body. The internal intercostals are located medially near the sternum. The innermost intercostals are located deep to both the internal and external intercostals.

The 11 pairs of superficial **external intercostal** muscles aid in inspiration of air during breathing because when they contract, they raise the rib cage, which expands it. The 11 pairs of **internal intercostal** muscles, just under the externals, are used for expiration because they draw the ribs together to constrict the rib cage. The **innermost intercostal** muscles are the deepest, and they act as synergists for the action of the internal intercostals.

Muscles of the Pelvic Floor and Perineum

The pelvic floor is a muscular sheet that defines the inferior portion of the pelvic cavity. The **pelvic diaphragm**, spanning anteriorly to posteriorly from the pubis to the coccyx, comprises the levator ani and the ischiococcygeus. Its openings include the anal canal and urethra, and the vagina in females.

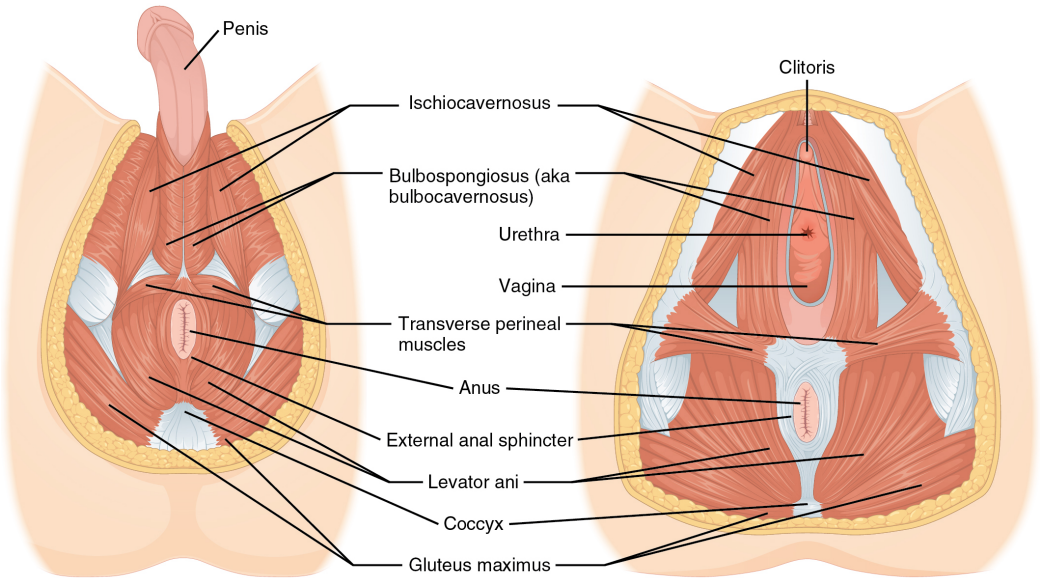
The large **levator ani** consists of two skeletal muscles, the **pubococcygeus** and the **iliococcygeus** (Figure 11.19). The levator ani is considered the most important muscle of the pelvic floor because it supports the pelvic viscera. It resists the pressure produced by contraction of the abdominal muscles so that the pressure is applied to the colon to aid in defecation and to the uterus to aid in childbirth (assisted by the **ischiococcygeus**, which pulls the coccyx anteriorly). This muscle also creates skeletal muscle sphincters at the urethra and anus.



Pelvic diaphragm (superior view)

FIGURE 11.19 Muscles of the Pelvic Floor The pelvic floor muscles support the pelvic organs, resist intra-abdominal pressure, and work as sphincters for the urethra, rectum, and vagina.

The **perineum** is the diamond-shaped space between the pubic symphysis (anteriorly), the coccyx (posteriorly), and the ischial tuberosities (laterally), lying just inferior to the pelvic diaphragm (levator ani and coccygeus). Divided transversely into triangles, the anterior is the **urogenital triangle**, which includes the external genitals. The posterior is the **anal triangle**, which contains the anus (Figure 11.20). The perineum is also divided into superficial and deep layers with some of the muscles common to people of any sex (Figure 11.21). Females also have the **compressor urethrae** and the **sphincter urethrovaginalis**, which function to close the vagina. In males, there is the **deep transverse perineal** muscle that plays a role in ejaculation.



Male perineal muscles: inferior view

Female perineal muscles: inferior view

FIGURE 11.20 Muscles of the Perineum The perineum muscles play roles in urination in both sexes, ejaculation in males, and vaginal contraction in females.

Movement	Target	Target motion direction	Prime mover	Origin	Insertion
Defecation; urination; birth; coughing	Abdominal cavity	Superior (resists pressure during abdominal compression)	Levator ani pubococcygeus; levator ani iliococcygeus	Pubis; ischium	Urethra; anal canal; perineal body; coccyx
Superficial muscles					
None—supports perineal body maintaining anus at center of perineum	Perineal body	None	Superficial transverse perineal	Ischium	Perineal body
Involuntary response that compresses urethra when excreting urine in both sexes or while ejaculating in males; also aids in erection of penis in males	Urethra	Compression	Bulbospongiosus	Perineal body	Perineal membrane; corpus spongiosum of penis; deep fascia of penis; clitoris in female
Compresses veins to maintain erection of penis in males; erection of clitoris in females	Veins of penis and clitoris	Compression	Ischiocavernosus	Ischium; ischial rami; pubic rami	Pubic symphysis; corpus cavernosum of penis in male; clitoris of female
Deep muscles					
Voluntarily compresses urethra during urination	Urethra	Compression	External urethral sphincter	Ischial rami; pubic rami	Male: median raphe; female: vaginal wall
Closes anus	Anus	Sphincter	External anal sphincter	Anococcygeal ligament	Perineal body

FIGURE 11.21 Muscles of the Perineum Common to All Humans

11.5 Muscles of the Pectoral Girdle and Upper Limbs

LEARNING OBJECTIVES

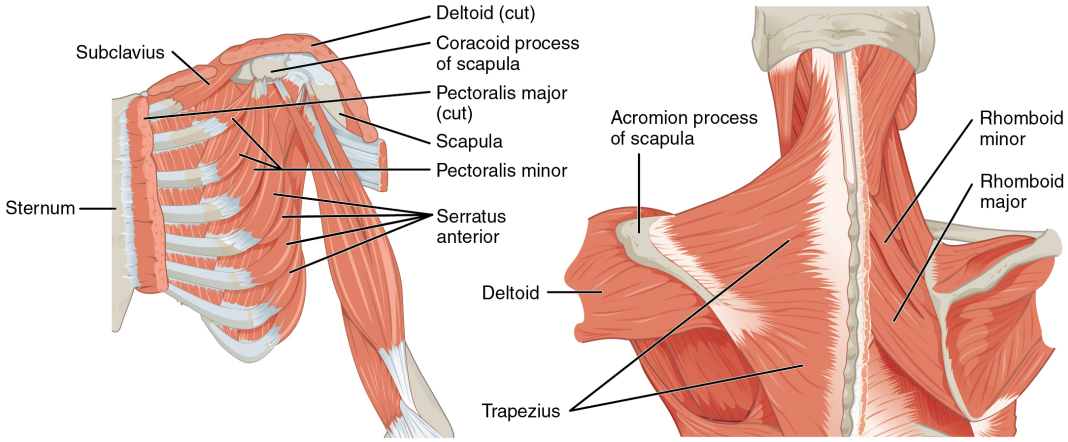
By the end of this section, you will be able to:

- Identify the muscles of the pectoral girdle and upper limbs
- Identify the movement and function of the pectoral girdle and upper limbs

Muscles of the shoulder and upper limb can be divided into four groups: muscles that stabilize and position the pectoral girdle, muscles that move the arm, muscles that move the forearm, and muscles that move the wrists, hands, and fingers. The **pectoral girdle**, or shoulder girdle, consists of the lateral ends of the clavicle and scapula, along with the proximal end of the humerus, and the muscles covering these three bones to stabilize the shoulder joint. The girdle creates a base from which the head of the humerus, in its ball-and-socket joint with the glenoid fossa of the scapula, can move the arm in multiple directions.

Muscles That Position the Pectoral Girdle

Muscles that position the pectoral girdle are located either on the anterior thorax or on the posterior thorax (Figure 11.22 and Table 11.8). The anterior muscles include the **subclavius**, **pectoralis minor**, and **serratus anterior**. The posterior muscles include the **trapezius**, **rhomboid major**, and **rhomboid minor**. When the rhomboids are contracted, your scapula moves medially, which can pull the shoulder and upper limb posteriorly.



Pectoral girdle muscle (left anterior lateral view) Pectoral girdle muscles (posterior view)

FIGURE 11.22 Muscles That Position the Pectoral Girdle The muscles that stabilize the pectoral girdle make it a steady base on which other muscles can move the arm. Note that the pectoralis major and deltoid, which move the humerus, are cut here to show the deeper positioning muscles.

Muscles that Position the Pectoral Girdle

Position in the thorax	Movement	Target	Target motion direction	Prime mover	Origin	Insertion
Anterior thorax	Stabilizes clavicle during movement by depressing it	Clavicle	Depression	Subclavius	First rib	Inferior surface of clavicle
Anterior thorax	Rotates shoulder anteriorly (throwing motion); assists with inhalation	Scapula; ribs	Scapula: depresses; ribs: elevates	Pectoralis minor	Anterior surfaces of certain ribs (2–4 or 3–5)	Coracoid process of scapula
Anterior thorax	Moves arm from side of body to front of body; assists with inhalation	Scapula; ribs	Scapula: protracts; ribs: elevates	Serratus anterior	Muscle slips from certain ribs (1–8 or 1–9)	Anterior surface of vertebral border of scapula
Posterior thorax	Elevates shoulders (shrugging); pulls shoulder blades together; tilts head backwards	Scapula; cervical spine	Scapula: rotests inferiorly, retracts, elevates, and depresses; spine: extends	Trapezius	Skull; vertebral column	Acromion and spine of scapula; clavicle

TABLE 11.8

Position in the thorax	Movement	Target	Target motion direction	Prime mover	Origin	Insertion
Posterior thorax	Stabilizes scapula during pectoral girdle movement	Scapula	Retracts; rotates inferiorly	Rhomboid major	Thoracic vertebrae (T2–T5)	Medial border of scapula
Posterior thorax	Stabilizes scapula during pectoral girdle movement	Scapula	Retracts; rotates inferiorly	Rhomboid minor	Cervical and thoracic vertebrae (C7 and T1)	Medial border of scapula

TABLE 11.8

Muscles That Move the Humerus

Similar to the muscles that position the pectoral girdle, muscles that cross the shoulder joint and move the humerus bone of the arm include both axial and scapular muscles (Figure 11.23 and Figure 11.24). The two axial muscles are the pectoralis major and the latissimus dorsi. The **pectoralis major** is thick and fan-shaped, covering much of the superior portion of the anterior thorax. The broad, triangular **latissimus dorsi** is located on the inferior part of the back, where it inserts into a thick connective tissue sheath called an aponeurosis.

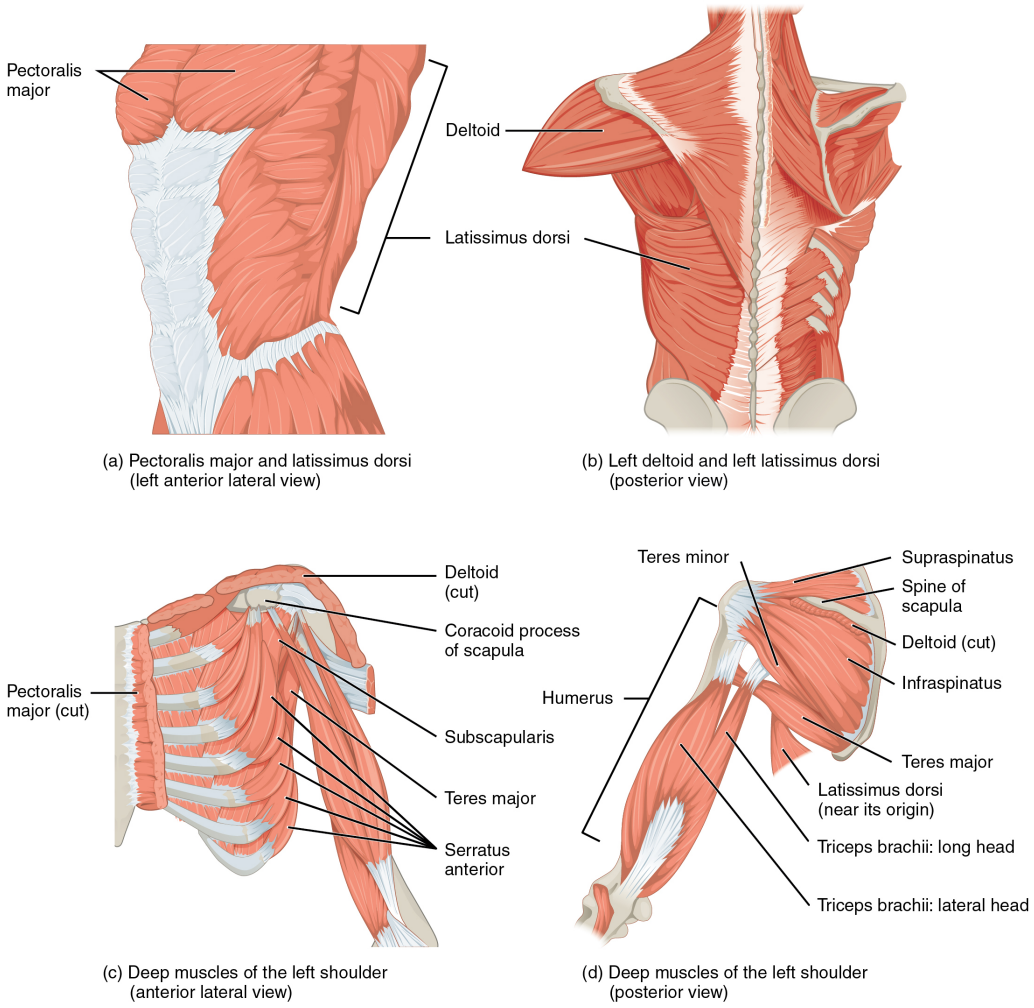


FIGURE 11.23 Muscles That Move the Humerus (a, c) The muscles that move the humerus anteriorly are generally located on the anterior side of the body and originate from the sternum (e.g., pectoralis major) or the anterior side of the scapula (e.g., subscapularis). (b) The muscles that move the humerus superiorly generally originate from the superior surfaces of the scapula and/or the clavicle (e.g., deltoids). The muscles that move the humerus inferiorly generally originate from middle or lower back (e.g., latissiumus dorsi). (d) The muscles that move the humerus posteriorly are generally located on the posterior side of the body and insert into the scapula (e.g., infraspinatus).

Movement	Target	Target motion direction	Prime mover	Origin	Insertion
Axial muscles					
Brings elbows together; moves elbow up (as during an uppercut punch)	Humerus	Flexion; adduction; medial rotation	Pectoralis major	Clavicle; sternum; cartilage of certain ribs (1–6 or 1–7); aponeurosis of external oblique muscle	Greater tubercle of humerus
Moves elbow back (as in elbowing someone standing behind you); spreads elbows apart	Humerus; scapula	Humerus: extension, adduction, and medial rotation; scapula: depression	Latissimus dorsi	Thoracic vertebrae (T7–T12); lumbar vertebrae; lower ribs (9–12); iliac crest	Intertubercular sulcus of humerus
Scapular muscles					
Lifts arms at shoulder	Humerus	Abduction; flexion; extension; medial and lateral rotation	Deltoid	Trapezius; clavicle; acromion; spine of scapula	Deltoid tuberosity of humerus
Assists pectoralis major in bringing elbows together and stabilizes shoulder joint during movement of the pectoral girdle	Humerus	Medial rotation	Subscapularis	Subscapular fossa of scapula	Lesser tubercle of humerus
Rotates elbow outwards, as during a tennis swing	Humerus	Abduction	Supraspinatus	Supraspinous fossa of scapula	Greater tubercle of humerus
Rotates elbow outwards, as during a tennis swing	Humerus	Extension; adduction	Infraspinatus	Infraspinous fossa of scapula	Greater tubercle of humerus
Assists with medial rotation at the shoulder	Humerus	Extension; adduction	Teres major	Posterior surface of scapula	Intertubercular sulcus of humerus
Assists infraspinatus in rotating elbow outwards	Humerus	Extension; adduction	Teres minor	Lateral border of dorsal scapular surface	Greater tubercle of humerus
Moves elbow up and across body, as when putting hand on chest	Humerus	Flexion; adduction	Coracobra chialis	Coracoid process of scapula	Medial surface of humerus shaft

FIGURE 11.24 Muscles That Move the Humerus

The rest of the shoulder muscles originate on the scapula. The anatomical and ligamental structure of the shoulder joint and the arrangements of the muscles covering it, allows the arm to carry out different types of movements. The **deltoid**, the thick muscle that creates the rounded lines of the shoulder is the major abductor of the arm, but it also facilitates flexing and medial rotation, as well as extension and lateral rotation. The **subscapularis** originates on the anterior scapula and medially rotates the arm. Named for their locations, the **supraspinatus** (superior to the spine of the scapula) and the **infraspinatus** (inferior to the spine of the scapula) abduct the arm, and laterally rotate the arm, respectively. The thick and flat **teres major** is inferior to the teres minor and extends the arm, and assists in adduction and medial rotation of it. The long **teres minor** laterally rotates and extends the arm. Finally, the **coracobrachialis** flexes and adducts the arm.

The tendons of the deep subscapularis, supraspinatus, infraspinatus, and teres minor connect the scapula to the humerus, forming the **rotator cuff** (musculotendinous cuff), the circle of tendons around the shoulder joint. When baseball pitchers undergo shoulder surgery, it is usually on the rotator cuff, which becomes pinched and inflamed and may tear away from the bone due to the repetitive motion of bringing the arm overhead to throw a fast pitch.

Muscles That Move the Forearm

The forearm, made of the radius and ulna bones, has four main types of action at the hinge of the elbow joint:

flexion, extension, pronation, and supination. The forearm flexors include the biceps brachii, brachialis, and brachioradialis. The extensors are the **triceps brachii** and **anconeus**. The pronators are the **pronator teres** and the **pronator quadratus**, and the **supinator** is the only one that turns the forearm anteriorly. When the forearm faces anteriorly, it is supinated. When the forearm faces posteriorly, it is pronated.

The biceps brachii, brachialis, and brachioradialis flex the forearm. The two-headed **biceps brachii** crosses the shoulder and elbow joints to flex the forearm, also taking part in supinating the forearm at the radioulnar joints and flexing the arm at the shoulder joint. Deep to the biceps brachii, the **brachialis** provides additional power in flexing the forearm. Finally, the **brachioradialis** can flex the forearm quickly or help lift a load slowly. These muscles and their associated blood vessels and nerves form the **anterior compartment of the arm** (anterior flexor compartment of the arm) (Figure 11.25 and Figure 11.26).

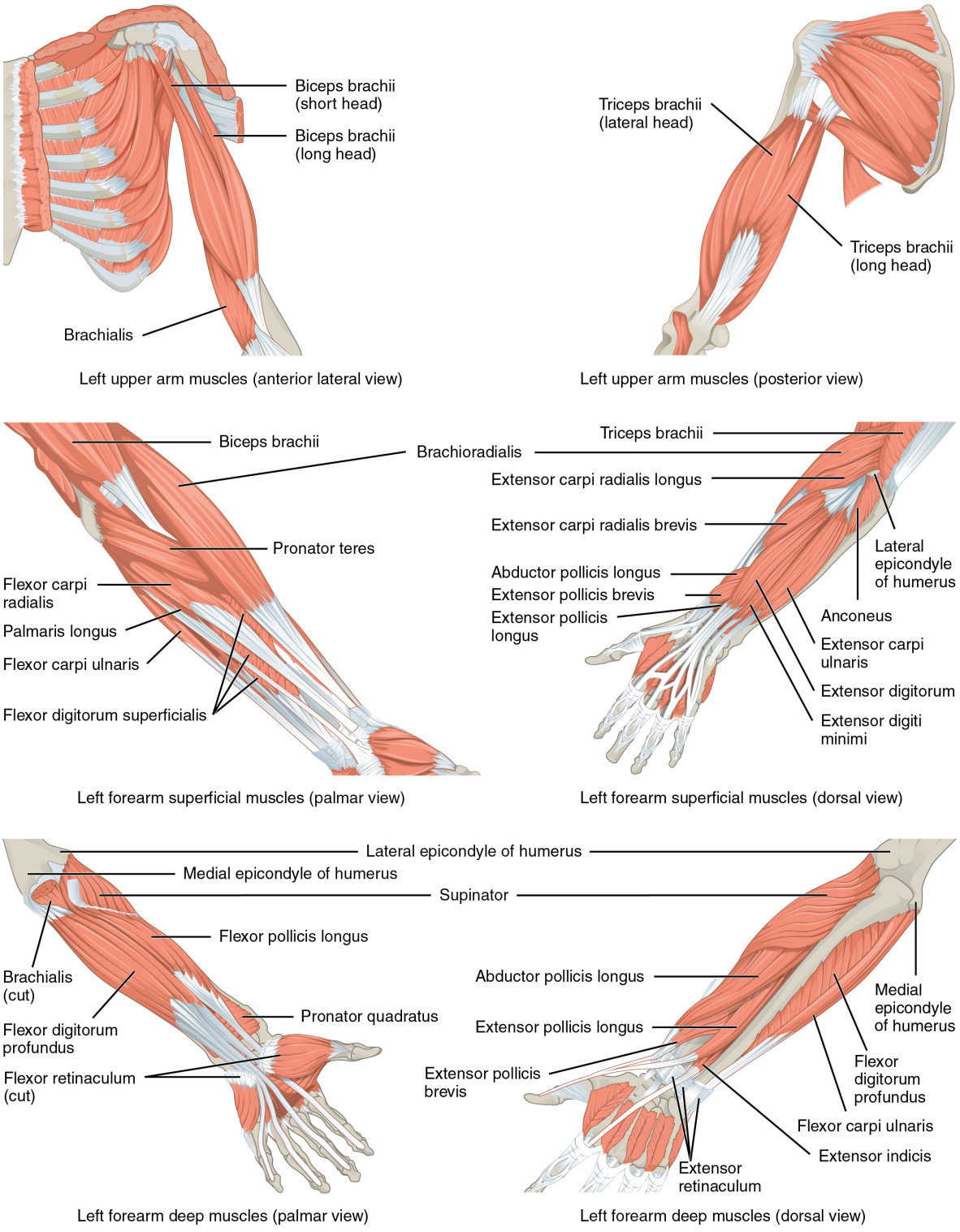


FIGURE 11.25 Muscles That Move the Forearm The muscles originating in the upper arm flex, extend, pronate, and supinate the forearm. The muscles originating in the forearm move the wrists, hands, and fingers.

Movement	Target	Target motion direction	Prime mover	Origin	Insertion
Anterior muscles (flexion)					
Performs a bicep curl; also allows palm of hand to point toward body while flexing	Forearm	Flexion; supination	Biceps brachii	Coracoid process; tubercle above glenoid cavity	Radial tuberosity
	Forearm	Flexion	Brachialis	Front of distal humerus	Coronoid process of ulna
Assists and stabilizes elbow during bicep-curl motion	Forearm	Flexion	Brachioradialis	Lateral supracondylar ridge at distal end of humerus	Base of styloid process of radius
Posterior muscles (extension)					
Extends forearm, as during a punch	Forearm	Extension	Triceps brachii	Infraglenoid tubercle of scapula; posterior shaft of humerus; posterior humeral shaft distal to radial groove	Olecranon process of ulna
Assists in extending forearm; also allows forearm to extend away from body	Forearm	Extension; abduction	Anconeus	Lateral epicondyle of humerus	Lateral aspect of olecranon process of ulna
Anterior muscles (pronation)					
Turns hand palm-down	Forearm	Pronation	Pronator teres	Medial epicondyle of humerus; coronoid process of ulna	Lateral radius
Assists in turning hand palm-down	Forearm	Pronation	Pronator quadratus	Distal portion of anterior ulnar shaft	Distal surface of anterior radius
Posterior muscles (supination)					
Turns hand palm-up	Forearm	Supination	Supinator	Lateral epicondyle of humerus; proximal ulna	Proximal end of radius

FIGURE 11.26 Muscles That Move the Forearm

Muscles That Move the Wrist, Hand, and Fingers

Wrist, hand, and finger movements are facilitated by two groups of muscles. The forearm is the origin of the **extrinsic muscles of the hand**. The palm is the origin of the intrinsic muscles of the hand.

Muscles of the Arm That Move the Wrists, Hands, and Fingers

The muscles in the **anterior compartment of the forearm** (anterior flexor compartment of the forearm) originate on the humerus and insert onto different parts of the hand. These make up the bulk of the forearm. From lateral to medial, the **superficial anterior compartment of the forearm** includes the **flexor carpi radialis**, **palmaris longus**, **flexor carpi ulnaris**, and **flexor digitorum superficialis**. The flexor digitorum superficialis flexes the hand as well as the digits at the knuckles, which allows for rapid finger movements, as in typing or playing a musical instrument (see Figure 11.27 and Table 11.9). However, poor ergonomics can irritate the tendons of these muscles as they slide back and forth with the carpal tunnel of the anterior wrist and pinch the median nerve, which also travels through the tunnel, causing Carpal Tunnel Syndrome. The **deep anterior compartment** produces flexion and bends fingers to make a fist. These are the **flexor pollicis longus** and the **flexor digitorum profundus**.

The muscles in the **superficial posterior compartment of the forearm** (superficial posterior extensor compartment of the forearm) originate on the humerus. These are the **extensor radialis longus**, **extensor carpi radialis brevis**, **extensor digitorum**, **extensor digiti minimi**, and the **extensor carpi ulnaris**.

The muscles of the **deep posterior compartment of the forearm** (deep posterior extensor compartment of the forearm) originate on the radius and ulna. These include the **abductor pollicis longus**, **extensor pollicis brevis**,

extensor pollicis longus, and **extensor indicis** (see Figure 11.27).

Movement	Target	Target motion direction	Prime mover	Origin	Insertion
Superficial anterior compartment of forearm					
Bends wrist toward body; tilts hand to side away from body	Wrist; hand	Flexion; abduction	Flexor carpi radialis	Medial epicondyle of humerus	Base of second and third metacarpals
Assists in bending hand up toward shoulder	Wrist	Flexion	Palmaris longus	Medial epicondyle of humerus	Palmar aponeurosis; skin and fascia of palm
Assists in bending hand up toward shoulder; tilts hand to side away from body; stabilizes wrist	Wrist; hand	Flexion, adduction	Flexor carpi ulnaris	Medial epicondyle of humerus; olecranon process; posterior surface of ulna	Pisiform, hamate bones, and base of fifth metacarpal
Bends fingers to make a fist	Wrist; fingers 2–5	Flexion	Flexor digitorum superficialis	Medial epicondyle of humerus; coronoid process of ulna; shaft of radius	Middle phalanges of fingers 2–5
Deep anterior compartment of forearm					
Bends tip of thumb	Thumb	Flexion	Flexor pollicis longus	Anterior surface of radius; interosseous membrane	Distal phalanx of thumb
Bends fingers to make a fist; also bends wrist toward body	Wrist; fingers	Flexion	Flexor digitorum profundus	Coronoid process; anteromedial surface of ulna; interosseous membrane	Distal phalanges of fingers 2–5
Superficial posterior compartment of forearm					
Straightens wrist away from body; tilts hand to side away from body	Wrist	Extension; abduction	Extensor radialis longus	Lateral supracondylar ridge of humerus	Base of second metacarpal
Assists extensor radialis longus in extending and abducting wrist; also stabilizes hand during finger flexion.	Wrist	Extension, abduction	Extensor carpi radialis brevis	Lateral epicondyle of humerus	Base of third metacarpal
Opens fingers and moves them sideways away from the body	Wrist; fingers	Extension; abduction	Extensor digitorum	Lateral epicondyle of humerus	Extensor expansions; distal phalanges of fingers
Extends little finger	Little finger	Extension	Extensor digiti minimi	Lateral epicondyle of humerus	Extensor expansion; distal phalanx of finger 5
Straightens wrist away from body; tilts hand to side toward body	Wrist	Extension; adduction	Extensor carpi ulnaris	Lateral epicondyle of humerus; posterior border of ulna	Base of fifth metacarpal
Deep posterior compartment of forearm					
Moves thumb sideways toward body; extends thumb; moves hand sideways toward body	Wrist; thumb	Thumb: abduction, extension; wrist: abduction	Abductor pollicis longus	Posterior surface of radius and ulna; interosseous membrane	Base of first metacarpal; trapezium
Extends thumb	Thumb	Extension	Extensor pollicis brevis	Dorsal shaft of radius and ulna; interosseous membrane	Base of proximal phalanx of thumb
Extends thumb	Thumb	Extension	Extensor pollicis longus	Dorsal shaft of radius and ulna; interosseous membrane	Base of distal phalanx of thumb
Extends index finger; straightens wrist away from body	Wrist; index finger	Extension	Extensor indicis	Posterior surface of distal ulna; interosseous membrane	Tendon of extensor digitorum of index finger

FIGURE 11.27 Muscles That Move the Wrist, Hands, and Forearm

The tendons of the forearm muscles attach to the wrist and extend into the hand. Fibrous bands called **retinacula** sheath the tendons at the wrist. The **flexor retinaculum** extends over the palmar surface of the hand while the **extensor retinaculum** extends over the dorsal surface of the hand.

Intrinsic Muscles of the Hand

The **intrinsic muscles of the hand** both originate and insert within it (Figure 11.28). These muscles allow your fingers to also make precise movements for actions, such as typing or writing. These muscles are divided into three

groups. The **thenar** muscles are on the radial aspect of the palm. The **hypothenar** muscles are on the medial aspect of the palm, and the **intermediate** muscles are midpalmar.

The thenar muscles include the **abductor pollicis brevis**, **opponens pollicis**, **flexor pollicis brevis**, and the **adductor pollicis**. These muscles form the **thenar eminence**, the rounded contour of the base of the thumb, and all act on the thumb. The movements of the thumb play an integral role in most precise movements of the hand.

The hypothenar muscles include the **abductor digiti minimi**, **flexor digiti minimi brevis**, and the **opponens digiti minimi**. These muscles form the **hypothenar eminence**, the rounded contour of the little finger, and as such, they all act on the little finger. Finally, the intermediate muscles act on all the fingers and include the **lumbrical**, the **palmar interossei**, and the **dorsal interossei**.

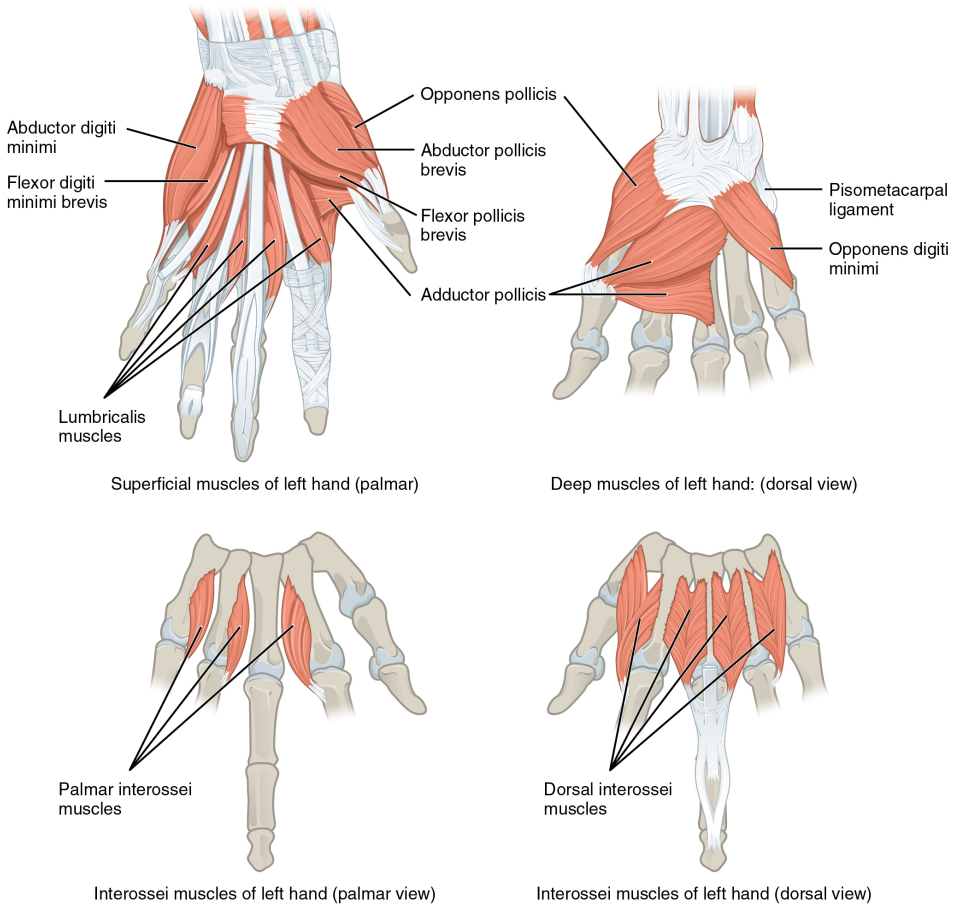


FIGURE 11.28 Intrinsic Muscles of the Hand The intrinsic muscles of the hand both originate and insert within the hand. These muscles provide the fine motor control of the fingers by flexing, extending, abducting, and adducting the more distal finger and thumb segments.

Intrinsic Muscles of the Hand

Muscle	Movement	Target	Target motion direction	Prime mover	Origin	Insertion
Thenar muscles	Moves thumb away from body	Thumb	Abduction	Abductor pollicis brevis	Flexor retinaculum; and nearby carpals	Lateral base of proximal phalanx of thumb
Thenar muscles	Moves thumb across palm to touch other fingers	Thumb	Opposition	Opponens pollicis	Flexor retinaculum; trapezium	Anterior of first metacarpal
Thenar muscles	Flexes thumb	Thumb	Flexion	Flexor pollicis brevis	Flexor retinaculum; trapezium	Lateral base of proximal phalanx of thumb
Thenar muscles	Moves thumb toward body	Thumb	Adduction	Adductor pollicis	Capitate bone; bases of metacarpals 2–4; front of metacarpal 3	Medial base of proximal phalanx of thumb
Hypothenar muscles	Moves little finger away from body	Little finger	Abduction	Abductor digiti minimi	Pisiform bone	Medial side of proximal phalanx of little finger
Hypothenar muscles	Flexes little finger	Little finger	Flexion	Flexor digiti minimi brevis	Hamate bone; flexor retinaculum	Medial side of proximal phalanx of little finger
Hypothenar muscles	Moves little finger across palm to touch thumb	Little finger	Opposition	Opponens digiti minimi	Hamate bone; flexor retinaculum	Medial side of fifth metacarpal
Intermediate muscles	Flexes each finger at metacarpo-phalangeal joints; extends each finger at interphalangeal joints	Fingers	Flexion	Lumbricals	Palm (lateral sides of tendons in flexor digitorum profundus)	Fingers 2–5 (lateral edges of extensional expansions on first phalanges)

TABLE 11.9

Muscle	Movement	Target	Target motion direction	Prime mover	Origin	Insertion
Intermediate muscles	Adducts and flexes each finger at metacarpo-phalangeal joints; extends each finger at interphalangeal joints	Fingers	Adduction; flexion; extension	Palmar interossei	Side of each metacarpal that faces metacarpal 3 (absent from metacarpal 3)	Extensor expansion on first phalanx of each finger (except finger 3) on side facing finger 3
Intermediate muscles	Abducts and flexes the three middle fingers at metacarpo-phalangeal joints; extends the three middle fingers at interphalangeal joints	Fingers	Abduction; flexion; extension	Dorsal interossei	Sides of metacarpals	Both sides of finger 3; for each other finger, extensor expansion over first phalanx on side opposite finger 3

TABLE 11.9

11.6 Appendicular Muscles of the Pelvic Girdle and Lower Limbs

LEARNING OBJECTIVES

By the end of this section, you will be able to:

- Identify the appendicular muscles of the pelvic girdle and lower limb
- Identify the movement and function of the pelvic girdle and lower limb

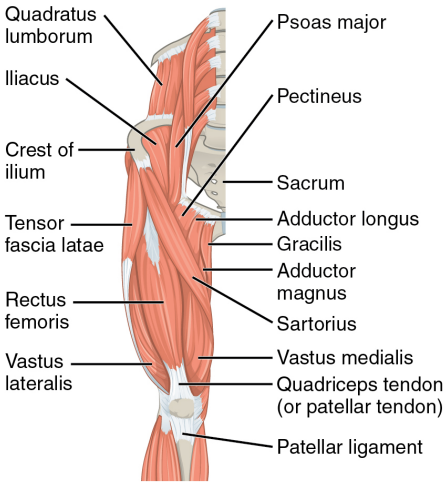
The appendicular muscles of the lower body position and stabilize the **pelvic girdle**, which serves as a foundation for the lower limbs. Comparatively, there is much more movement at the pectoral girdle than at the pelvic girdle. There is very little movement of the pelvic girdle because of its connection with the sacrum at the base of the axial skeleton. The pelvic girdle has less range of motion because it was designed to stabilize and support the body.

Muscles of the Thigh

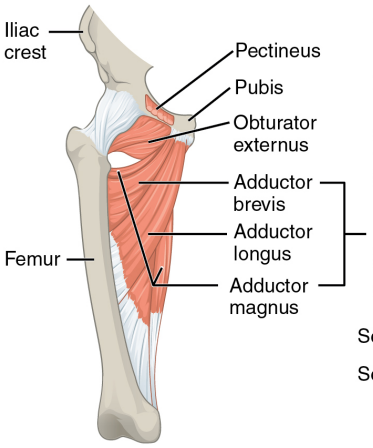
What would happen if the pelvic girdle, which attaches the lower limbs to the torso, were capable of the same range of motion as the pectoral girdle? For one thing, walking would expend more energy if the heads of the femurs were not secured in the acetabula of the pelvis. The body's center of gravity is in the area of the pelvis. If the center of gravity were not to remain fixed, standing up would be difficult as well. Therefore, what the leg muscles lack in range of motion and versatility, they make up for in size and power, facilitating the body's stabilization, posture, and movement.

Gluteal Region Muscles That Move the Femur

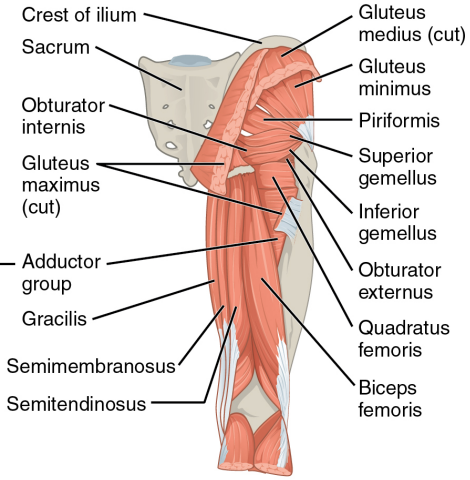
Most muscles that insert on the femur (the thigh bone) and move it, originate on the pelvic girdle. The **psoas major** and **iliacus** make up the **iliopsoas group**. Some of the largest and most powerful muscles in the body are the gluteal muscles or **gluteal group**. The **gluteus maximus** is the largest; deep to the gluteus maximus is the **gluteus medius**, and deep to the gluteus medius is the **gluteus minimus**, the smallest of the trio (Figure 11.29 and Figure 11.30).



Superficial pelvic and thigh muscles of right leg (anterior view)



Deep pelvic and thigh muscles of right leg (anterior view)



Pelvic and thigh muscles of right leg (posterior view)

FIGURE 11.29 Hip and Thigh Muscles The large and powerful muscles of the hip that move the femur generally originate on the pelvic girdle and insert into the femur. The muscles that move the lower leg typically originate on the femur and insert into the bones of the knee joint. The anterior muscles of the femur extend the lower leg but also aid in flexing the thigh. The posterior muscles of the femur flex the lower leg but also aid in extending the thigh. A combination of gluteal and thigh muscles also adduct, abduct, and rotate the thigh and lower leg.

Movement	Target	Target motion direction	Prime mover	Origin	Insertion
Iliopsoas group					
Raises knee at hip, as if performing a knee attack; assists lateral rotators in twisting thigh (and lower leg) outward; assists with bending over, maintaining posture	Femur	Thigh: flexion and lateral rotation; torso: flexion	Psoas major	Lumbar vertebrae (L1–L5); thoracic vertebra (T12)	Lesser trochanter of femur
Raises knee at hip, as if performing a knee attack; assists lateral rotators in twisting thigh (and lower leg) outward; assists with bending over, maintaining posture	Femur	Thigh: flexion and lateral rotation; torso: flexion	Iliacus	Iliac fossa; iliac crest; lateral sacrum	Lesser trochanter of femur
Gluteal group					
Lowers knee and moves thigh back, as when getting ready to kick a ball	Femur	Extension	Gluteus maximus	Dorsal ilium; sacrum; coccyx	Gluteal tuberosity of femur; iliotibial tract
Opens thighs, as when doing a split	Femur	Abduction	Gluteus medius	Lateral surface of ilium	Greater trochanter of femur
Brings the thighs back together	Femur	Abduction	Gluteus minimus	External surface of ilium	Greater trochanter of femur
Assists with raising knee at hip and opening thighs; maintains posture by stabilizing the iliotibial track, which connects to the knee	Femur	Flexion; abduction	Tensor fascia lata	Anterior aspect of iliac crest; anterior superior iliac spine	Iliotibial tract
Lateral rotators					
Twists thigh (and lower leg) outward; maintains posture by stabilizing hip joint	Femur	Lateral rotation	Piriformis	Anterolateral surface of sacrum	Greater trochanter of femur
Twists thigh (and lower leg) outward; maintains posture by stabilizing hip joint	Femur	Lateral rotation	Obutrator internus	Inner surface of obturator membrane; greater sciatic notch; margins of obturator foramen	Greater trochanter in front of piriformis
Twists thigh (and lower leg) outward; maintains posture by stabilizing hip joint	Femur	Lateral rotation	Obturator externus	Outer surfaces of obturator membrane, pubic, and ischium; margins of obturator foramen	Trochanteric fossa of posterior femur
Twists thigh (and lower leg) outward; maintains posture by stabilizing hip joint	Femur	Lateral rotation	Superior gemellus	Ischial spine	Greater trochanter of femur
Twists thigh (and lower leg) outward; maintains posture by stabilizing hip joint	Femur	Lateral rotation	Inferior gemellus	Ischial tuberosity	Greater trochanter of femur
Twists thigh (and lower leg) outward; maintains posture by stabilizing hip joint	Femur	Lateral rotation	Quadratus femoris	Ischial tuberosity	Trochanteric crest of femur
Adductors					
Brings the thighs back together; assists with raising the knee	Femur	Adduction; flexion	Adductor longus	Pubis near pubic symphysis	Linea aspera
Brings the thighs back together; assists with raising the knee	Femur	Adduction; flexion	Adductor brevis	Body of pubis; inferior ramus of pubis	Linea aspera above adductor longus
Brings the thighs back together; assists with raising the knee and moving the thigh back	Femur	Adduction; flexion; extension	Adductor magnus	Ischial rami; pubic rami; ischial tuberosity	Linea aspera; adductor tubercle of femur
Opens thighs; assists with raising the knee and turning the thigh (and lower leg) inward	Femur	Adduction; flexion; medial rotation	Pectineus	Pectineal line of pubis	Lesser trochanter to linea aspera of posterior aspect of femur

FIGURE 11.30 Gluteal Region Muscles That Move the Femur

The **tensor fascia latae** is a thick, squarish muscle in the superior aspect of the lateral thigh. It acts as a synergist of the gluteus medius and iliopsoas in flexing and abducting the thigh. It also helps stabilize the lateral aspect of the

knee by pulling on the **iliotibial tract** (band), making it taut. Deep to the gluteus maximus, the **piriformis**, **obturator internus**, **obturator externus**, **superior gemellus**, **inferior gemellus**, and **quadratus femoris** laterally rotate the femur at the hip.

The **adductor longus**, **adductor brevis**, and **adductor magnus** can both medially and laterally rotate the thigh depending on the placement of the foot. The adductor longus flexes the thigh, whereas the adductor magnus extends it. The **pectineus** adducts and flexes the femur at the hip as well. The pectineus is located in the **femoral triangle**, which is formed at the junction between the hip and the leg and also includes the femoral nerve, the femoral artery, the femoral vein, and the deep inguinal lymph nodes.

Thigh Muscles That Move the Femur, Tibia, and Fibula

Deep fascia in the thigh separates it into medial, anterior, and posterior compartments (see Figure 11.29 and Figure 11.31). The muscles in the **medial compartment of the thigh** are responsible for adducting the femur at the hip. Along with the adductor longus, adductor brevis, adductor magnus, and pectineus, the strap-like **gracilis** adducts the thigh in addition to flexing the leg at the knee.

Movement	Target	Target motion direction	Prime mover	Origin	Insertion
Medial compartment of thigh					
Moves back of lower legs up toward buttocks, as when kneeling; assists in opening thighs	Femur; tibia/fibula	Tibia/fibula: flexion; thigh: adduction	Gracilis	Inferior ramus; body of pubis; ischial ramus	Medial surface of tibia
Anterior compartment of thigh: Quadriceps femoris group					
Moves lower leg out in front of body, as when kicking; assists in raising the knee	Femur; tibia/fibula	Tibia/fibula: extension; thigh: flexion	Rectus femoris	Anterior inferior iliac spine; superior margin of acetabulum	Patella; tibial tuberosity
Moves lower leg out in front of body, as when kicking	Tibia/fibula	Extension	Vastus lateralis	Greater trochanter; intertrochanteric line; linea aspera	Patella; tibial tuberosity
Moves lower leg out in front of body, as when kicking	Tibia/fibula	Extension	Vastus medialis	Linea aspera; intertrochanteric line	Patella; tibial tuberosity
Moves lower leg out in front of body, as when kicking	Tibia/fibula	Extension	Vastus intermedius	Proximal femur shaft	Patella; tibial tuberosity
Moves back of lower legs up and back toward the buttocks, as when kneeling; assists in moving thigh diagonally upward and outward as when mounting a bike	Femur; tibia/fibula	Tibia: flexion; thigh: flexion, abduction, lateral rotation	Sartorius	Anterior superior iliac spine	Medial aspect of proximal tibia
Posterior compartment of thigh: Hamstring group					
Moves back of lower legs up and back toward the buttocks, as when kneeling; moves thigh down and back; twists the thigh (and lower leg) outward	Femur; tibia/fibula	Tibia/fibula: flexion; thigh: extension, lateral rotation	Biceps femoris	Ischial tuberosity; linea aspera; distal femur	Head of fibula; lateral condyle of tibia
Moves back of lower legs up toward buttocks, as when kneeling; moves thigh down and back; twists the thigh (and lower leg) inward	Femur; tibia/fibula	Tibia/fibula: flexion; thigh: extension, medial rotation	Semitendinosus	Ischial tuberosity	Upper tibial shaft
Moves back of lower legs up and back toward the buttocks as when kneeling; moves thigh down and back; twists the thigh (and lower leg) inward	Femur; tibia/fibula	Tibia/fibula: flexion; thigh: extension, medial rotation	Semi-membranosus	Ischial tuberosity	Medial condyle of tibia; lateral condyle of femur

FIGURE 11.31 Thigh Muscles That Move the Femur, Tibia, and Fibula

The muscles of the **anterior compartment of the thigh** flex the thigh and extend the leg. This compartment contains the **quadriceps femoris group**, which actually comprises four muscles that extend and stabilize the knee. The **rectus femoris** is on the anterior aspect of the thigh, the **vastus lateralis** is on the lateral aspect of the thigh, the **vastus medialis** is on the medial aspect of the thigh, and the **vastus intermedius** is between the vastus lateralis and vastus medialis and deep to the rectus femoris. The tendon common to all four is the **quadriceps tendon** (patellar tendon), which inserts into the patella and continues below it as the **patellar ligament**. The patellar ligament attaches to the tibial tuberosity. In addition to the quadriceps femoris, the **sartorius** is a band-like muscle that extends from the anterior superior iliac spine to the medial side of the proximal tibia. This versatile muscle flexes the leg at the knee and flexes, abducts, and laterally rotates the leg at the hip. This muscle allows us to sit

cross-legged.

The **posterior compartment of the thigh** includes muscles that flex the leg and extend the thigh. The three long muscles on the back of the knee are the **hamstring group**, which flexes the knee. These are the **biceps femoris**, **semitendinosus**, and **semimembranosus**. The tendons of these muscles form the **popliteal fossa**, the diamond-shaped space at the back of the knee.

Muscles That Move the Feet and Toes

Similar to the thigh muscles, the muscles of the leg are divided by deep fascia into compartments, although the leg has three: anterior, lateral, and posterior (Figure 11.32 and Figure 11.33).

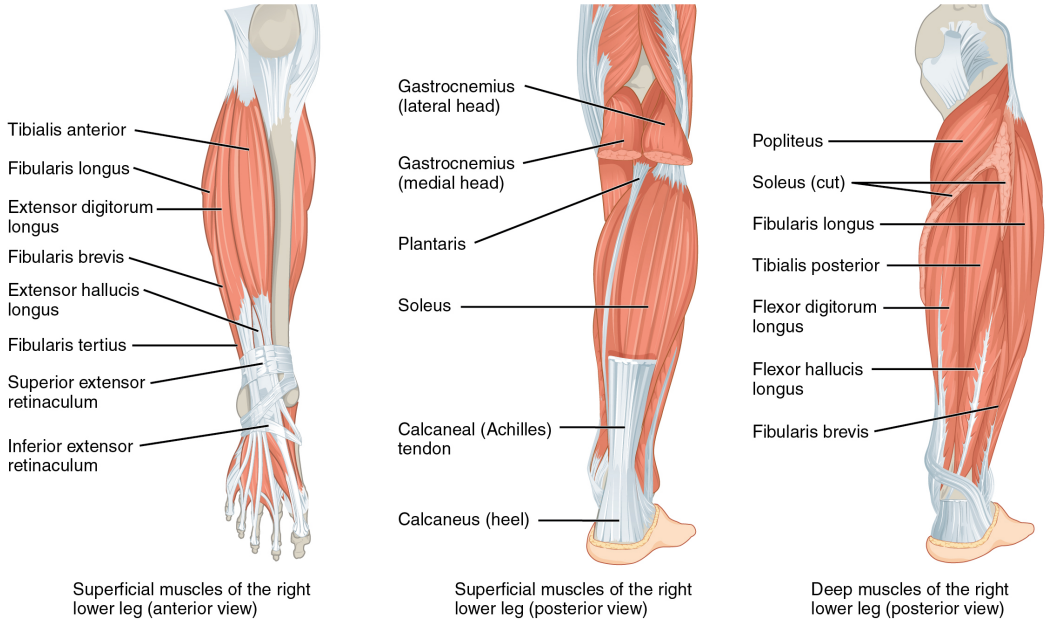


FIGURE 11.32 Muscles of the Lower Leg The muscles of the anterior compartment of the lower leg are generally responsible for dorsiflexion, and the muscles of the posterior compartment of the lower leg are generally responsible for plantar flexion. The lateral and medial muscles in both compartments invert, evert, and rotate the foot.

Movement	Target	Target motion direction	Prime mover	Origin	Insertion
Anterior compartment of leg					
Raises the sole of the foot off the ground, as when preparing to foot-tap; bends the inside of the foot upwards, as when catching your balance while falling laterally toward the opposite side as the balancing foot	Foot	Dorsiflexion; inversion	Tibialis anterior	Lateral condyle and upper tibial shaft; interosseous membrane	Interior surface of medial cuneiform; First metatarsal bone
Raises the sole of the foot off the ground, as when preparing to foot-tap; extends the big toe	Foot; big toe	Foot: dorsiflexion; big toe: extension	Extensor hallucis longus	Anteromedial fibula shaft; interosseous membrane	Distal phalanx of big toe
Raises the sole of the foot off the ground, as when preparing to foot-tap; extends toes	Foot; toes 2–5	Foot: dorsiflexion; toes: extension	Extensor digitorum longus	Lateral condyle of tibia; proximal portion of fibula; interosseous membrane	Middle and distal phalanges of toes 2–5
Lateral compartment of leg					
Lowers the sole of the foot to the ground, as when foot-tapping or jumping; bends the inside of the foot downwards, as when catching your balance while falling laterally toward the same side as the balancing foot	Foot	Plantar flexion and eversion	Fibularis longus	Upper portion of lateral fibula	First metatarsal; medial cuneiform
Lowers the sole of the foot to the ground, as when foot-tapping or jumping; bends the inside of the foot downward, as when catching your balance while falling laterally toward the same side as the balancing foot	Foot	Plantar flexion and eversion	Fibularis (peroneus) brevis	Distal fibula shaft	Proximal end of fifth metatarsal
Posterior compartment of leg: Superficial muscles					
Lowers the sole of the foot to the ground, as when foot-tapping or jumping; assists in moving the back of the lower legs up and back toward the buttocks	Foot; tibia/ fibula	Foot: plantar flexion; tibia/fibula: flexion	Gastrocnemius	Medial and lateral condyles of femur	Posterior calcaneus
Lowers the sole of the foot to the ground, as when foot-tapping or jumping; maintains posture while walking	Foot	Plantar flexion	Soleus	Superior tibia; fibula; interosseous membrane	Posterior calcaneus
Lowers the sole of the foot to the ground, as when foot-tapping or jumping; assists in moving the back of the lower legs up and back toward the buttocks	Foot; tibia/ fibula	Foot: plantar flexion; tibia/fibula: flexion	Plantaris	Posterior femur above lateral condyle	Calcaneus or calcaneus tendon
Lowers the sole of the foot to the ground, as when foot-tapping or jumping	Foot	Plantar flexion	Tibialis posterior	Superior tibia and fibula; interosseous membrane	Several tarsals and metatarsals 2–4
Posterior compartment of leg: Deep muscles					
Moves the back of the lower legs up and back toward the buttocks; assists in rotation of the leg at the knee and thigh	Tibia/ fibula	Tibia/fibula: flexion thigh and lower leg: medial and lateral rotation	Popliteus	Lateral condyle of femur; lateral meniscus	Proximal tibia
Lowers the sole of the foot to the ground, as when foot-tapping or jumping; bends the inside of the foot upward and flexes toes	Foot; toes 2–5	Foot: plantar flexion and inversion toes: flexion	Flexor digitorum longus	Posterior tibia	Distal phalanges of toes 2–5
Flexes the big toe	Big toe; foot	Big toe: flexion foot: plantar flexion	Flexor hallucis longus	Midshaft of fibula; interosseous membrane	Distal phalanx of big toe

FIGURE 11.33 Muscles That Move the Feet and Toes

The muscles in the **anterior compartment of the leg**: the **tibialis anterior**, a long and thick muscle on the lateral surface of the tibia, the **extensor hallucis longus**, deep under it, and the **extensor digitorum longus**, lateral to it, all contribute to raising the front of the foot when they contract. The **fibularis tertius**, a small muscle that originates on the anterior surface of the fibula, is associated with the extensor digitorum longus and sometimes fused to it, but is not present in all people. Thick bands of connective tissue called the **superior extensor retinaculum** (transverse ligament of the ankle) and the **inferior extensor retinaculum**, hold the tendons of these muscles in place during dorsiflexion.

The **lateral compartment of the leg** includes two muscles: the **fibularis longus** (peroneus longus) and the **fibularis brevis** (peroneus brevis). The superficial muscles in the **posterior compartment of the leg** all insert onto the **calcaneal tendon** (Achilles tendon), a strong tendon that inserts into the calcaneal bone of the ankle. The muscles in this compartment are large and strong and keep humans upright. The most superficial and visible muscle of the calf is the **gastrocnemius**. Deep to the gastrocnemius is the wide, flat **soleus**. The **plantaris** runs obliquely between the two; some people may have two of these muscles, whereas no plantaris is observed in about seven percent of other cadaver dissections. The plantaris tendon is a desirable substitute for the fascia lata in hernia repair, tendon transplants, and repair of ligaments. There are four deep muscles in the posterior compartment of the leg as well: the **popliteus**, **flexor digitorum longus**, **flexor hallucis longus**, and **tibialis posterior**.

The foot also has intrinsic muscles, which originate and insert within it (similar to the intrinsic muscles of the hand). These muscles primarily provide support for the foot and its arch, and contribute to movements of the toes (Figure 11.34 and Figure 11.35). The principal support for the longitudinal arch of the foot is a deep fascia called **plantar aponeurosis**, which runs from the calcaneus bone to the toes (inflammation of this tissue is the cause of "plantar fasciitis," which can affect runners. The intrinsic muscles of the foot consist of two groups. The **dorsal group** includes only one muscle, the **extensor digitorum brevis**. The second group is the **plantar group**, which consists of four layers, starting with the most superficial.

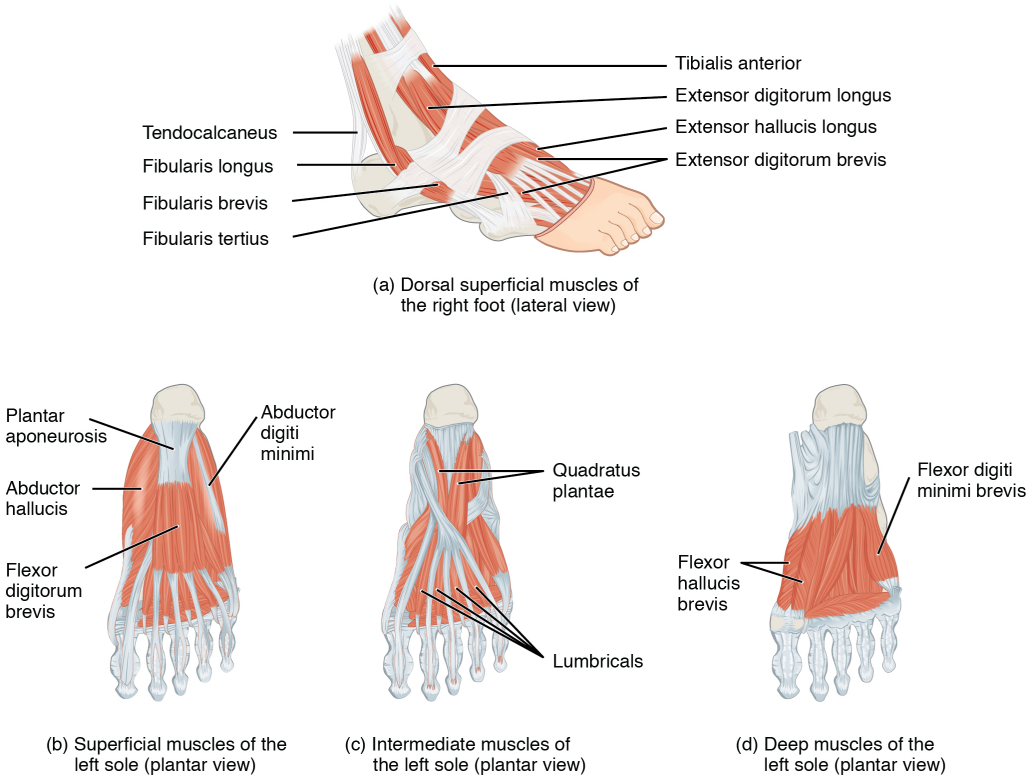


FIGURE 11.34 Intrinsic Muscles of the Foot The muscles along the dorsal side of the foot (a) generally extend the toes while the muscles of the plantar side of the foot (b, c, d) generally flex the toes. The plantar muscles exist in four layers, providing the foot the strength to counterbalance the weight of the body. In this diagram, three of the layers are shown from a plantar view beginning with the bottom-most layer just under the plantar skin of the foot (b) and ending with the top-most layer (d) located just inferior to the foot and toe bones.

Movement	Target	Target motion direction	Prime mover	Origin	Insertion
Dorsal group					
Extends toes 2–5	Toes 2–5	Extension	Extensor digitorum brevis	Calcaneus; extensor retinaculum	Base of proximal phalanx of big toe; extensor expansions on toes 2–5
Plantar group (layer 1)					
Abducts and flexes big toe	Big toe	Adduction; flexion	Abductor hallucis	Calcaneal tuberosity; flexor retinaculum	Proximal phalanx of big toe
Flexes toes 2–4	Middle toes	Flexion	Flexor digitorum brevis	Calcaneal tuberosity	Middle phalanx of toes 2–4
Abducts and flexes small toe	Toe 5	Abduction; flexion	Abductor digiti minimi	Calcaneal tuberosity	Proximal phalanx of little toe
Plantar group (layer 2)					
Assists in flexing toes 2–5	Toes 2–5	Flexion	Quadratus plantae	Medial and lateral sides of calcaneus	Tendon of flexor digitorum longus
Extends toes 2–5 at the interphalangeal joints; flexes the small toes at the metatarsophalangeal joints	Toes 2–5	Extension; flexion	Lumbricals	Tendons of flexor digitorum longus	Medial side of proximal phalanx of toes 2–5
Plantar group (layer 3)					
Flexes big toe	Big toe	Flexion	Flexor hallucis brevis	Lateral cuneiform; cuboid bones	Base of proximal phalanx of big toe
Adducts and flexes big toe	Big toe	Adduction; flexion	Adductor hallucis	Bases of metatarsals 2–4; fibularis longus tendon sheath; ligament across metatarsophalangeal joints	Base of proximal phalanx of big toe
Flexes small toe	Little toe	Flexion	Flexor digiti minimi brevis	Base of metatarsal 5; tendon sheath of fibularis longus	Base of proximal phalanx of little toe
Plantar group (layer 4)					
Abducts and flexes middle toes at metatarsophalangeal joints; extends middle toes at interphalangeal joints	Middle toes	Abduction; flexion; extension	Dorsal interossei	Sides of metatarsals	Both sides of toe 2; for each other toe, extensor expansion over first phalanx on side opposite toe 2
Abducts toes 3–5; flexes proximal phalanges and extends distal phalanges	Small toes	Abduction; flexion; extension	Plantar interossei	Side of each metatarsal that faces metatarsal 2 (absent from metatarsal 2)	Extensor expansion on first phalanx of each toe (except to 2) on side facing toe 2

FIGURE 11.35 Intrinsic Muscles in the Foot

Key Terms

abduct move away from midline in the sagittal plane
abductor moves the bone away from the midline
abductor digiti minimi muscle that abducts the little finger
abductor pollicis brevis muscle that abducts the thumb
abductor pollicis longus muscle that inserts into the first metacarpal
adductor moves the bone toward the midline
adductor brevis muscle that adducts and medially rotates the thigh
adductor longus muscle that adducts, medially rotates, and flexes the thigh
adductor magnus muscle with an anterior fascicle that adducts, medially rotates and flexes the thigh, and a posterior fascicle that assists in thigh extension
adductor pollicis muscle that adducts the thumb
agonist (also, prime mover) muscle whose contraction is responsible for producing a particular motion
anal triangle posterior triangle of the perineum that includes the anus
anconeus small muscle on the lateral posterior elbow that extends the forearm
antagonist muscle that opposes the action of an agonist
anterior compartment of the arm (anterior flexor compartment of the arm) the biceps brachii, brachialis, brachioradialis, and their associated blood vessels and nerves
anterior compartment of the forearm (anterior flexor compartment of the forearm) deep and superficial muscles that originate on the humerus and insert into the hand
anterior compartment of the leg region that includes muscles that dorsiflex the foot
anterior compartment of the thigh region that includes muscles that flex the thigh and extend the leg
anterior scalene a muscle anterior to the middle scalene
appendicular of the arms and legs
axial of the trunk and head
belly bulky central body of a muscle
bi two
biceps brachii two-headed muscle that crosses the shoulder and elbow joints to flex the forearm while assisting in supinating it and flexing the arm at the shoulder
biceps femoris hamstring muscle
bipennate pennate muscle that has fascicles that are located on both sides of the tendon
brachialis muscle deep to the biceps brachii that provides power in flexing the forearm.
brachioradialis muscle that can flex the forearm quickly or help lift a load slowly
brevis short
buccinator muscle that compresses the cheek
calcaneal tendon (also, Achilles tendon) strong tendon that inserts into the calcaneal bone of the ankle
caval opening opening in the diaphragm that allows the inferior vena cava to pass through; foramen for the vena cava
circular (also, sphincter) fascicles that are concentrically arranged around an opening
compressor urethrae deep perineal muscle in females
convergent fascicles that extend over a broad area and converge on a common attachment site
coracobrachialis muscle that flexes and adducts the arm
corrugator supercilii prime mover of the eyebrows
deep anterior compartment flexor pollicis longus, flexor digitorum profundus, and their associated blood vessels and nerves
deep posterior compartment of the forearm (deep posterior extensor compartment of the forearm) the abductor pollicis longus, extensor pollicis brevis, extensor pollicis longus, extensor indicis, and their associated blood vessels and nerves
deep transverse perineal deep perineal muscle in males
deglutition swallowing
deltoid shoulder muscle that abducts the arm as well as flexes and medially rotates it, and extends and laterally rotates it
diaphragm skeletal muscle that separates the thoracic and abdominal cavities and is dome-shaped at rest
digastric muscle that has anterior and posterior bellies and elevates the hyoid bone and larynx when one swallows; it also depresses the mandible
dorsal group region that includes the extensor digitorum brevis
dorsal interossei muscles that abduct and flex the three middle fingers at the metacarpophalangeal joints and extend them at the interphalangeal joints
epicranial aponeurosis (also, galea aponeurosis) flat broad tendon that connects the frontalis and occipitalis
erector spinae group large muscle mass of the back; primary extensor of the vertebral column

extensor muscle that increases the angle at the joint
extensor carpi radialis brevis muscle that extends and abducts the hand at the wrist
extensor carpi ulnaris muscle that extends and adducts the hand
extensor digiti minimi muscle that extends the little finger
extensor digitorum muscle that extends the hand at the wrist and the phalanges
extensor digitorum brevis muscle that extends the toes
extensor digitorum longus muscle that is lateral to the tibialis anterior
extensor hallucis longus muscle that is partly deep to the tibialis anterior and extensor digitorum longus
extensor indicis muscle that inserts onto the tendon of the extensor digitorum of the index finger
extensor pollicis brevis muscle that inserts onto the base of the proximal phalanx of the thumb
extensor pollicis longus muscle that inserts onto the base of the distal phalanx of the thumb
extensor radialis longus muscle that extends and abducts the hand at the wrist
extensor retinaculum band of connective tissue that extends over the dorsal surface of the hand
external intercostal superficial intercostal muscles that raise the rib cage
external oblique superficial abdominal muscle with fascicles that extend inferiorly and medially
extrinsic eye muscles originate outside the eye and insert onto the outer surface of the white of the eye, and create eyeball movement
extrinsic muscles of the hand muscles that move the wrists, hands, and fingers and originate on the arm
fascicle muscle fibers bundled by perimysium into a unit
femoral triangle region formed at the junction between the hip and the leg and includes the pectineus, femoral nerve, femoral artery, femoral vein, and deep inguinal lymph nodes
fibularis brevis (also, peroneus brevis) muscle that plantar flexes the foot at the ankle and everts it at the intertarsal joints
fibularis longus (also, peroneus longus) muscle that plantar flexes the foot at the ankle and everts it at the intertarsal joints
fibularis tertius small muscle that is associated with the extensor digitorum longus
fixator synergist that assists an agonist by preventing or reducing movement at another joint, thereby stabilizing the origin of the agonist
flexion movement that decreases the angle of a joint
flexor muscle that decreases the angle at the joint
flexor carpi radialis muscle that flexes and abducts the hand at the wrist
flexor carpi ulnaris muscle that flexes and adducts the hand at the wrist
flexor digiti minimi brevis muscle that flexes the little finger
flexor digitorum longus muscle that flexes the four small toes
flexor digitorum profundus muscle that flexes the phalanges of the fingers and the hand at the wrist
flexor digitorum superficialis muscle that flexes the hand and the digits
flexor hallucis longus muscle that flexes the big toe
flexor pollicis brevis muscle that flexes the thumb
flexor pollicis longus muscle that flexes the distal phalanx of the thumb
flexor retinaculum band of connective tissue that extends over the palmar surface of the hand
frontalis front part of the occipitofrontalis muscle
fusiform muscle that has fascicles that are spindle-shaped to create large bellies
gastrocnemius most superficial muscle of the calf
genioglossus muscle that originates on the mandible and allows the tongue to move downward and forward
geniohyoid muscle that depresses the mandible, and raises and pulls the hyoid bone anteriorly
gluteal group muscle group that extends, flexes, rotates, adducts, and abducts the femur
gluteus maximus largest of the gluteus muscles that extends the femur
gluteus medius muscle deep to the gluteus maximus that abducts the femur at the hip
gluteus minimus smallest of the gluteal muscles and deep to the gluteus medius
gracilis muscle that adducts the thigh and flexes the leg at the knee
hamstring group three long muscles on the back of the leg
hyoglossus muscle that originates on the hyoid bone to move the tongue downward and flatten it
hypothenar group of muscles on the medial aspect of the palm
hypothenar eminence rounded contour of muscle at the base of the little finger
iliacus muscle that, along with the psoas major, makes up the iliopsoas
iliococcygeus muscle that makes up the levator ani along with the pubococcygeus
iliocostalis cervicis muscle of the iliocostalis group associated with the cervical region
iliocostalis group laterally placed muscles of the

erector spinae

iliocostalis lumborum muscle of the iliocostalis group associated with the lumbar region

iliocostalis thoracis muscle of the iliocostalis group associated with the thoracic region

iliopsoas group muscle group consisting of iliacus and psoas major muscles, that flexes the thigh at the hip, rotates it laterally, and flexes the trunk of the body onto the hip

iliotibial tract muscle that inserts onto the tibia; made up of the gluteus maximus and connective tissues of the tensor fasciae latae

inferior extensor retinaculum cruciate ligament of the ankle

inferior gemellus muscle deep to the gluteus maximus on the lateral surface of the thigh that laterally rotates the femur at the hip

infrahyoid muscles anterior neck muscles that are attached to, and inferior to the hyoid bone

infraspinatus muscle that laterally rotates the arm

innermost intercostal the deepest intercostal muscles that draw the ribs together

insertion end of a skeletal muscle that is attached to the structure (usually a bone) that is moved when the muscle contracts

intercostal muscles muscles that span the spaces between the ribs

intermediate group of midpalmar muscles

internal intercostal muscles the intermediate intercostal muscles that draw the ribs together

internal oblique flat, intermediate abdominal muscle with fascicles that run perpendicular to those of the external oblique

intrinsic muscles of the hand muscles that move the wrists, hands, and fingers and originate in the palm

ischiococcygeus muscle that assists the levator ani and pulls the coccyx anteriorly

lateral compartment of the leg region that includes the fibularis (peroneus) longus and the fibularis (peroneus) brevis and their associated blood vessels and nerves

lateral pterygoid muscle that moves the mandible from side to side

lateralis to the outside

latissimus dorsi broad, triangular axial muscle located on the inferior part of the back

levator ani pelvic muscle that resists intra-abdominal pressure and supports the pelvic viscera

linea alba white, fibrous band that runs along the midline of the trunk

longissimus capitis muscle of the longissimus group associated with the head region

longissimus cervicis muscle of the longissimus group associated with the cervical region

longissimus group intermediately placed muscles of the erector spinae

longissimus thoracis muscle of the longissimus group associated with the thoracic region

longus long

lumbrical muscle that flexes each finger at the metacarpophalangeal joints and extend each finger at the interphalangeal joints

masseter main muscle for chewing that elevates the mandible to close the mouth

mastication chewing

maximus largest

medial compartment of the thigh a region that includes the adductor longus, adductor brevis, adductor magnus, pectineus, gracilis, and their associated blood vessels and nerves

medial pterygoid muscle that moves the mandible from side to side

medialis to the inside

medius medium

middle scalene longest scalene muscle, located between the anterior and posterior scalenes

minimus smallest

multifidus muscle of the lumbar region that helps extend and laterally flex the vertebral column

multipennate pennate muscle that has a tendon branching within it

mylohyoid muscle that lifts the hyoid bone and helps press the tongue to the top of the mouth

oblique at an angle

obturator externus muscle deep to the gluteus maximus on the lateral surface of the thigh that laterally rotates the femur at the hip

obturator internus muscle deep to the gluteus maximus on the lateral surface of the thigh that laterally rotates the femur at the hip

occipitalis posterior part of the occipitofrontalis muscle

occipitofrontalis muscle that makes up the scalp with a frontal belly and an occipital belly

omohyoid muscle that has superior and inferior bellies and depresses the hyoid bone

opponens digiti minimi muscle that brings the little finger across the palm to meet the thumb

opponens pollicis muscle that moves the thumb across the palm to meet another finger

orbicularis oculi circular muscle that closes the eye

orbicularis oris circular muscle that moves the lips

origin end of a skeletal muscle that is attached to another structure (usually a bone) in a fixed position

palatoglossus muscle that originates on the soft palate to elevate the back of the tongue

palmar interossei muscles that abduct and flex each finger at the metacarpophalangeal joints and extend each finger at the interphalangeal joints
palmaris longus muscle that provides weak flexion of the hand at the wrist
parallel fascicles that extend in the same direction as the long axis of the muscle
patellar ligament extension of the quadriceps tendon below the patella
pectineus muscle that abducts and flexes the femur at the hip
pectoral girdle shoulder girdle, made up of the clavicle and scapula
pectoralis major thick, fan-shaped axial muscle that covers much of the superior thorax
pectoralis minor muscle that moves the scapula and assists in inhalation
pelvic diaphragm muscular sheet that comprises the levator ani and the ischiococcygeus
pelvic girdle hips, a foundation for the lower limb
pennate fascicles that are arranged differently based on their angles to the tendon
perineum diamond-shaped region between the pubic symphysis, coccyx, and ischial tuberosities
piriformis muscle deep to the gluteus maximus on the lateral surface of the thigh that laterally rotates the femur at the hip
plantar aponeurosis muscle that supports the longitudinal arch of the foot
plantar group four-layered group of intrinsic foot muscles
plantaris muscle that runs obliquely between the gastrocnemius and the soleus
popliteal fossa diamond-shaped space at the back of the knee
popliteus muscle that flexes the leg at the knee and creates the floor of the popliteal fossa
posterior compartment of the leg region that includes the superficial gastrocnemius, soleus, and plantaris, and the deep popliteus, flexor digitorum longus, flexor hallucis longus, and tibialis posterior
posterior compartment of the thigh region that includes muscles that flex the leg and extend the thigh
posterior scalene smallest scalene muscle, located posterior to the middle scalene
prime mover (also, agonist) principle muscle involved in an action
pronator quadratus pronator that originates on the ulna and inserts on the radius
pronator teres pronator that originates on the humerus and inserts on the radius
psoas major muscle that, along with the iliacus, makes up the iliopsoas
pubococcygeus muscle that makes up the levator ani along with the iliococcygeus
quadratus femoris muscle deep to the gluteus maximus on the lateral surface of the thigh that laterally rotates the femur at the hip
quadratus lumborum posterior part of the abdominal wall that helps with posture and stabilization of the body
quadriceps femoris group four muscles, that extend and stabilize the knee
quadriceps tendon (also, patellar tendon) tendon common to all four quadriceps muscles, inserts into the patella
rectus straight
rectus abdominis long, linear muscle that extends along the middle of the trunk
rectus femoris quadricep muscle on the anterior aspect of the thigh
rectus sheaths tissue that makes up the linea alba
retinacula fibrous bands that sheath the tendons at the wrist
rhomboid major muscle that attaches the vertebral border of the scapula to the spinous process of the thoracic vertebrae
rhomboid minor muscle that attaches the vertebral border of the scapula to the spinous process of the thoracic vertebrae
rotator cuff (also, musculotendinous cuff) the circle of tendons around the shoulder joint
sartorius band-like muscle that flexes, abducts, and laterally rotates the leg at the hip
scalene muscles flex, laterally flex, and rotate the head; contribute to deep inhalation
segmental muscle group interspinales and intertransversarii muscles that bring together the spinous and transverse processes of each consecutive vertebra
semimembranosus hamstring muscle
semispinalis capitis transversospinales muscle associated with the head region
semispinalis cervicis transversospinales muscle associated with the cervical region
semispinalis thoracis transversospinales muscle associated with the thoracic region
semitendinosus hamstring muscle
serratus anterior large and flat muscle that originates on the ribs and inserts onto the scapula
soleus wide, flat muscle deep to the gastrocnemius
sphincter urethrovaginalis deep perineal muscle in females
spinalis capitis muscle of the spinalis group associated with the head region

spinalis cervicis muscle of the spinalis group associated with the cervical region
spinalis group medially placed muscles of the erector spinae
spinalis thoracis muscle of the spinalis group associated with the thoracic region
splenius posterior neck muscles; includes the splenius capitis and splenius cervicis
splenius capitis neck muscle that inserts into the head region
splenius cervicis neck muscle that inserts into the cervical region
sternocleidomastoid major muscle that laterally flexes and rotates the head
sternohyoid muscle that depresses the hyoid bone
sternothyroid muscle that depresses the larynx's thyroid cartilage
styloglossus muscle that originates on the styloid bone, and allows upward and backward motion of the tongue
stylohyoid muscle that elevates the hyoid bone posteriorly
subclavius muscle that stabilizes the clavicle during movement
subscapularis muscle that originates on the anterior scapula and medially rotates the arm
superficial anterior compartment of the forearm flexor carpi radialis, palmaris longus, flexor carpi ulnaris, flexor digitorum superficialis, and their associated blood vessels and nerves
superficial posterior compartment of the forearm extensor radialis longus, extensor carpi radialis brevis, extensor digitorum, extensor digiti minimi, extensor carpi ulnaris, and their associated blood vessels and nerves
superior extensor retinaculum transverse ligament of the ankle
superior gemellus muscle deep to the gluteus maximus on the lateral surface of the thigh that laterally rotates the femur at the hip
supinator muscle that moves the palm and forearm anteriorly
suprahyoid muscles neck muscles that are superior to the hyoid bone
supraspinatus muscle that abducts the arm
synergist muscle whose contraction helps a prime mover in an action
temporalis muscle that retracts the mandible
tendinous intersections three transverse bands of collagen fibers that divide the rectus abdominis into segments
tensor fascia lata muscle that flexes and abducts the thigh
teres major muscle that extends the arm and assists in adduction and medial rotation of it
teres minor muscle that laterally rotates and extends the arm
thenar group of muscles on the lateral aspect of the palm
thenar eminence rounded contour of muscle at the base of the thumb
thyrohyoid muscle that depresses the hyoid bone and elevates the larynx's thyroid cartilage
tibialis anterior muscle located on the lateral surface of the tibia
tibialis posterior muscle that plantar flexes and inverts the foot
transversospinales muscles that originate at the transverse processes and insert at the spinous processes of the vertebrae
transversus abdominis deep layer of the abdomen that has fascicles arranged transversely around the abdomen
trapezius muscle that stabilizes the upper part of the back
tri three
triceps brachii three-headed muscle that extends the forearm
unipennate pennate muscle that has fascicles located on one side of the tendon
urogenital triangle anterior triangle of the perineum that includes the external genitals
vastus intermedius quadricep muscle that is between the vastus lateralis and vastus medialis and is deep to the rectus femoris
vastus lateralis quadricep muscle on the lateral aspect of the thigh
vastus medialis quadricep muscle on the medial aspect of the thigh

Chapter Review

11.1 Interactions of Skeletal Muscles, Their Fascicle Arrangement, and Their Lever Systems

Skeletal muscles each have an origin and an insertion. The end of the muscle that attaches to the bone being pulled is called the muscle's insertion and the end of the muscle attached to a fixed, or stabilized, bone is called the origin. The muscle primarily responsible for a movement is called the prime mover, and muscles that assist in this action are called synergists. A synergist that makes the insertion site more stable is

called a fixator. Meanwhile, a muscle with the opposite action of the prime mover is called an antagonist. Several factors contribute to the force generated by a skeletal muscle. One is the arrangement of the fascicles in the skeletal muscle. Fascicles can be parallel, circular, convergent, pennate, fusiform, or triangular. Each arrangement has its own range of motion and ability to do work.

11.2 Naming Skeletal Muscles

Muscle names are based on many characteristics. The location of a muscle in the body is important. Some muscles are named based on their size and location, such as the gluteal muscles of the buttocks. Other muscle names can indicate the location in the body or bones with which the muscle is associated, such as the tibialis anterior. The shapes of some muscles are distinctive; for example, the direction of the muscle fibers is used to describe muscles of the body midline. The origin and/or insertion can also be features used to name a muscle; examples are the biceps brachii, triceps brachii, and the pectoralis major.

11.3 Axial Muscles of the Head, Neck, and Back

Muscles are either axial muscles or appendicular. The axial muscles are grouped based on location, function, or both. Some axial muscles cross over to the appendicular skeleton. The muscles of the head and neck are all axial. The muscles in the face create facial expression by inserting into the skin rather than onto bone. Muscles that move the eyeballs are extrinsic, meaning they originate outside of the eye and insert onto it. Tongue muscles are both extrinsic and intrinsic. The genioglossus depresses the tongue and moves it anteriorly; the styloglossus lifts the tongue and retracts it; the palatoglossus elevates the back of the tongue; and the hyoglossus depresses and flattens it. The muscles of the anterior neck facilitate swallowing and speech, stabilize the hyoid bone and position the larynx. The muscles of the neck stabilize and move the head. The sternocleidomastoid divides the neck into anterior and posterior triangles.

The muscles of the back and neck that move the vertebral column are complex, overlapping, and can be divided into five groups. The splenius group includes the splenius capitis and the splenius cervicis. The erector spinae has three subgroups. The iliocostalis group includes the iliocostalis cervicis, the iliocostalis thoracis, and the iliocostalis lumborum. The longissimus group includes the longissimus capitis, the longissimus cervicis, and the longissimus thoracis. The spinalis group includes the spinalis capitis, the spinalis cervicis, and the spinalis thoracis. The transversospinales include the semispinalis capitis, semispinalis cervicis, semispinalis thoracis, multifidus, and rotatores. The segmental muscles include the interspinales and intertransversarii. Finally, the scalenes include the anterior scalene, middle scalene, and posterior scalene.

11.4 Axial Muscles of the Abdominal Wall, and Thorax

Made of skin, fascia, and four pairs of muscle, the anterior abdominal wall protects the organs located in the abdomen and moves the vertebral column. These muscles include the rectus abdominis, which extends through the entire length of the trunk, the external oblique, the internal oblique, and the transversus abdominis. The quadratus lumborum forms the posterior abdominal wall.

The muscles of the thorax play a large role in breathing, especially the dome-shaped diaphragm. When it contracts and flattens, the volume inside the pleural cavities increases, which decreases the pressure within them. As a result, air will flow into the lungs. The external and internal intercostal muscles span the space between the ribs and help change the shape of the rib cage and the volume-pressure ratio inside the pleural cavities during inspiration and expiration.

The perineum muscles play roles in urination in both sexes, ejaculation in males, and vaginal contraction in females. The pelvic floor muscles support the pelvic organs, resist intra-abdominal pressure, and work as sphincters for the urethra, rectum, and vagina.

11.5 Muscles of the Pectoral Girdle and Upper Limbs

The clavicle and scapula make up the pectoral girdle, which provides a stable origin for the muscles that move the humerus. The muscles that position and stabilize the pectoral girdle are located on the thorax. The anterior thoracic muscles are the subclavius, pectoralis minor, and the serratus anterior. The posterior thoracic muscles are the trapezius, levator scapulae, rhomboid major, and rhomboid minor. Nine muscles cross the shoulder joint to move the humerus. The ones that originate on the axial skeleton are the pectoralis major and the latissimus dorsi. The deltoid, subscapularis, supraspinatus, infraspinatus, teres major, teres minor, and coracobrachialis originate on the scapula.

The forearm flexors include the biceps brachii, brachialis, and brachioradialis. The extensors are the

triceps brachii and anconeus. The pronators are the pronator teres and the pronator quadratus. The supinator is the only one that turns the forearm anteriorly.

The extrinsic muscles of the hands originate along the forearm and insert into the hand in order to facilitate crude movements of the wrists, hands, and fingers. The superficial anterior compartment of the forearm produces flexion. These muscles are the flexor carpi radialis, palmaris longus, flexor carpi ulnaris, and the flexor digitorum superficialis. The deep anterior compartment produces flexion as well. These are the flexor pollicis longus and the flexor digitorum profundus. The rest of the compartments produce extension. The extensor carpi radialis longus, extensor carpi radialis brevis, extensor digitorum, extensor digiti minimi, and extensor carpi ulnaris are the muscles found in the superficial posterior compartment. The deep posterior compartment includes the abductor longus, extensor pollicis brevis, extensor pollicis longus, and the extensor indicis.

Finally, the intrinsic muscles of the hands allow our fingers to make precise movements, such as typing and writing. They both originate and insert within the hand. The thenar muscles, which are located on the lateral part of the palm, are the abductor pollicis brevis, opponens pollicis, flexor pollicis brevis, and adductor pollicis. The hypothenar muscles, which are located on the medial part of the palm, are the abductor digiti minimi, flexor digiti minimi brevis, and opponens digiti minimi. The intermediate muscles, located in the middle of the palm, are the lumbricals, palmar interossei, and dorsal interossei.

11.6 Appendicular Muscles of the Pelvic Girdle and Lower Limbs

The pelvic girdle attaches the legs to the axial skeleton. The hip joint is where the pelvic girdle and the leg come together. The hip is joined to the pelvic girdle by many muscles. In the gluteal region, the psoas major and iliacus form the iliopsoas. The large and strong gluteus maximus, gluteus medius, and gluteus minimus extend and abduct the femur. Along with the gluteus maximus, the tensor fascia lata muscle forms the iliotibial tract. The lateral rotators of the femur at the hip are the piriformis, obturator internus, obturator externus, superior gemellus, inferior gemellus, and quadratus femoris. On the medial part of the thigh, the adductor longus, adductor brevis, and adductor magnus adduct the thigh and medially rotate it. The pectineus muscle adducts and flexes the femur at the hip.

The thigh muscles that move the femur, tibia, and fibula are divided into medial, anterior, and posterior compartments. The medial compartment includes the adductors, pectineus, and the gracilis. The anterior compartment comprises the quadriceps femoris, quadriceps tendon, patellar ligament, and the sartorius. The quadriceps femoris is made of four muscles: the rectus femoris, the vastus lateralis, the vastus medius, and the vastus intermedius, which together extend the knee. The posterior compartment of the thigh includes the hamstrings: the biceps femoris, semitendinosus, and the semimembranosus, which all flex the knee.

The muscles of the leg that move the foot and toes are divided into anterior, lateral, superficial- and deep-posterior compartments. The anterior compartment includes the tibialis anterior, the extensor hallucis longus, the extensor digitorum longus, and the fibularis (peroneus) tertius. The lateral compartment houses the fibularis (peroneus) longus and the fibularis (peroneus) brevis. The superficial posterior compartment has the gastrocnemius, soleus, and plantaris; and the deep posterior compartment has the popliteus, tibialis posterior, flexor digitorum longus, and flexor hallucis longus.

Review Questions

1. Which of the following is unique to the muscles of facial expression?
   a. They all originate from the scalp musculature.
   b. They insert onto the cartilage found around the face.
   c. They only insert onto the facial bones.
   d. They insert into the skin.

2. Which of the following helps an agonist work?
   a. a synergist
   b. a fixator
   c. an insertion
   d. an antagonist

3. Which of the following statements is correct about what happens during flexion?
   a. The angle between bones is increased.
   b. The angle between bones is decreased.
   c. The bone moves away from the body.
   d. The bone moves toward the center of the body.

4. Which is moved the *least* during muscle contraction?
   a. the origin
   b. the insertion
   c. the ligaments
   d. the joints

5. Which muscle has a convergent pattern of fascicles?
   a. biceps brachii
   b. gluteus maximus
   c. pectoralis major
   d. rectus femoris

6. A muscle that has a pattern of fascicles running along the long axis of the muscle has which of the following fascicle arrangements?
   a. circular
   b. pennate
   c. parallel
   d. rectus

7. Which arrangement *best* describes a bipennate muscle?
   a. The muscle fibers feed in on an angle to a long tendon from both sides.
   b. The muscle fibers feed in on an angle to a long tendon from all directions.
   c. The muscle fibers feed in on an angle to a long tendon from one side.
   d. The muscle fibers on one side of a tendon feed into it at a certain angle and muscle fibers on the other side of the tendon feed into it at the opposite angle.

8. The location of a muscle's insertion and origin can determine _____.
   a. action
   b. the force of contraction
   c. muscle name
   d. the load a muscle can carry

9. Where is the temporalis muscle located?
   a. on the forehead
   b. in the neck
   c. on the side of the head
   d. on the chin

10. Which muscle name does *not* make sense?
   a. extensor digitorum
   b. gluteus minimus
   c. biceps femoris
   d. extensor minimus longus

11. Which of the following terms would be used in the name of a muscle that moves the leg away from the body?
   a. flexor
   b. adductor

c. extensor
d. abductor

12. Which of the following is a prime mover in head flexion?
a. occipitofrontalis
b. corrugator supercilii
c. sternocleidomastoid
d. masseter

13. Where is the inferior oblique muscle located?
a. in the abdomen
b. in the eye socket
c. in the anterior neck
d. in the face

14. What is the action of the masseter?
a. swallowing
b. chewing
c. moving the lips
d. closing the eye

15. The names of the extrinsic tongue muscles commonly end in _____.
a. -glottis
b. -glossus
c. -gluteus
d. -hyoid

16. What is the function of the erector spinae?
a. movement of the arms
b. stabilization of the pelvic girdle
c. postural support
d. rotating of the vertebral column

17. Which of the following abdominal muscles is not a part of the anterior abdominal wall?
a. quadratus lumborum
b. rectus abdominis
c. interior oblique
d. exterior oblique

18. Which muscle pair plays a role in respiration?
a. intertransversarii, interspinales
b. semispinalis cervicis, semispinalis thoracis
c. trapezius, rhomboids
d. diaphragm, scalene

19. What is the linea alba?
a. a small muscle that helps with compression of the abdominal organs
b. a long tendon that runs down the middle of the rectus abdominis
c. a long band of collagen fibers that connects the hip to the knee
d. another name for the tendinous inscription

20. The rhomboid major and minor muscles are deep to the _____.
a. rectus abdominis

b. scalene muscles
c. trapezius
d. ligamentum nuchae

21. Which muscle extends the forearm?
a. biceps brachii
b. triceps brachii
c. brachialis
d. deltoid

22. What is the origin of the wrist flexors?
a. the lateral epicondyle of the humerus
b. the medial epicondyle of the humerus
c. the carpal bones of the wrist
d. the deltoid tuberosity of the humerus

23. Which muscles stabilize the pectoral girdle?
a. axial and scapular
b. axial
c. appendicular
d. axial and appendicular

24. The large muscle group that attaches the leg to the pelvic girdle and produces extension of the hip joint is the _____ group.
a. gluteal
b. obturator
c. adductor
d. abductor

25. Which muscle produces movement that allows you to cross your legs?
a. the gluteus maximus
b. the piriformis
c. the gracilis
d. the sartorius

26. What is the largest muscle in the lower leg?
a. soleus
b. gastrocnemius
c. tibialis anterior
d. tibialis posterior

27. The vastus intermedius muscle is deep to which of the following muscles?
a. biceps femoris
b. rectus femoris
c. vastus medialis
d. vastus lateralis

Critical Thinking Questions

28. What effect does fascicle arrangement have on a muscle's action?

29. Movements of the body occur at joints. Describe how muscles are arranged around the joints of the body.

30. Explain how a synergist assists an agonist by being a fixator.

31. Describe the different criteria that contribute to

how skeletal muscles are named.

32. Explain the difference between axial and appendicular muscles.

33. Describe the muscles of the anterior neck.

34. Why are the muscles of the face different from typical skeletal muscle?

35. Describe the fascicle arrangement in the muscles of the abdominal wall. How do they relate to each other?

36. What are some similarities and differences between the diaphragm and the pelvic diaphragm?

37. The tendons of which muscles form the rotator cuff? Why is the rotator cuff important?

38. List the general muscle groups of the shoulders and upper limbs as well as their subgroups.

39. Which muscles form the hamstrings? How do they function together?

40. Which muscles form the quadriceps? How do they function together?