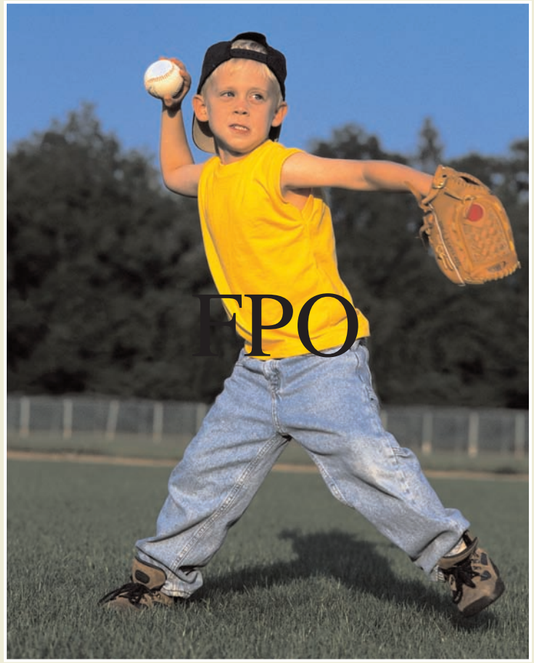
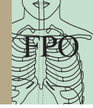
13 Muscles of the Upper Limb

Muscles of the upper limb (extremity) are amazingly diverse in form and function. Some span large areas while others are quite small. The actions of these muscles are complex because many muscles cross more than one joint and therefore contraction can move one bone or the other or perhaps both bones at once. Therefore many muscles may work together to stabilize one bone to provide a large variety of individual movements or combined movements. The shoulder is *flexible,* being attached by a bony girdle and supported mainly by muscle. This allows the arm and hand a huge range of motion required for activities such as throwing a baseball. This to some degree compromises the strength of the shoulder (versus other joints such as the hip). However, the shoulder is still quite *strong* and provides the stability required for lifting heavy objects while moving at the same time.



CONTENTS AT A GLANCE

EXHIBIT 13.1 Muscles of the Thorax (Chest) That Move the Pectoral Girdle (Clavicle and Scapula)



OBJECTIVE

- Describe the origin, insertion, action, and innervation of the muscles that move the pectoral girdle.

Muscles of the upper limb are arranged in diverse groups; muscles are superficial, deep, or very deep. Four muscles, the pectoralis major, deltoid, trapezius, and latissimus dorsi muscles, are not only superficial but also have a large surface area and dominate the superficial musculature of the shoulder region. The concept of **reverse muscle action** (**RMA**), described previously in Section XX.X, is well illustrated in particular muscles of the upper limb and will be described in this chapter.

The main action of the muscles that move the pectoral girdle is to stabilize the scapula so it can function as a steady origin for most of the muscles that move the humerus. Because scapular movements usually accompany humeral movements in the same direction, the muscles also move the scapula to increase the range of motion of the humerus. For example, it would not be possible to raise the arm above the head if the scapula did not move with the humerus. During abduction, the scapula follows the humerus by rotating upward.

Muscles that move the pectoral girdle can be classified into two groups based on their location in the thorax: **anterior** and **posterior thoracic muscles** (Figure 13.1). The anterior thoracic muscles are the subclavius, pectoralis minor, and serratus anterior. The **subclavius** is a small, cylindrical muscle under the clavicle that extends from the clavicle to the first rib. It steadies the clavicle during movements of the pectoral girdle. It also helps hold the only bony articulation of the upper limb with the axial skeleton (the sternoclavicular joint) when, for example, hanging from a bar.

The **pectoralis minor** is a thin, flat, triangular muscle that is deep to the pectoralis major (Figure 13.1a). This muscle causes, among other actions, protraction of the scapula. The scapulae of persons who spend a lot of time with their arms in front of them, such as pianists, factory workers, and those who use computers, may develop chronically contracted pectoralis minor muscles. As described previously (see Section

MUSCLE	ORIGIN	INSERTION	ACTION	INNERVATION
ANTERIOR THORACIC MUSCLES				
Subclavius (sub-KLĀ-vē-us; *sub-* = under; *clavius* = clavical)	First rib.	Clavicle.	Depresses and moves clavicle anteriorly (protraction) and helps stabilize pectoral girdle.	Subclavian nerve.
Pectoralis minor (pek′-tō-RĀ-lis; *pector-* = the breast, chest, thorax; *minor* = lesser)	Usually ribs 3–5.	Coracoid process of scapula.	Abducts scapula and rotates it downward. RMA: Elevates third through fifth ribs during forced inhalation when scapula is fixed.	Medial pectoral nerve.
Serratus anterior (ser-Ā-tus; *serratus* = saw-toothed; *anterior* = front)	Usually ribs 1–8.	Vertebral border and inferior angle of anterior surface of scapula.	Abducts scapula and rotates it upward. RMA: Elevates ribs when scapula is stabilized; known as "boxer's muscle" because it is important in horizontal arm movements such as punching and pushing.	Long thoracic nerve.
POSTERIOR THORACIC MUSCLES				
Trapezius (tra-PĒ-zē-us = trapezoid-shaped)	Superior nuchal line of occipital bone, ligamentum nuchae, and spines of C7–T12.	Clavicle and acromion and spine of scapula.	Superior fibers elevate scapula; middle fibers adduct scapula; inferior fibers depress scapula; superior and inferior fibers together rotate scapula upward; stabilizes scapula. RMA: Superior fibers can help extend head.	Accessory (XI) nerve and cervical spinal nerves C3–C5.
Levator scapulae (le-VĀ-tor SKA-pū-lē; *levator* = raises; *scapulae* = of the scapula)	Transverse processes of C1–C4.	Superior vertebral border of scapula.	Elevates scapula and rotates it downward.	Dorsal scapular nerve and cervical spinal nerves C3–C5.
Rhomboid major (rom-BOYD = rhomboid or diamond-shaped)	Spines of T2–T5.	Vertebral border of scapula inferior to spine.	Elevates and adducts scapula and rotates it downward; stabilizes scapula.	Dorsal scapular nerve.
Rhomboid minor (rom-BOYD)	Spines of C7–T1.	Vertebral border of scapula near spine.	Elevates and adducts scapula and rotates it downward; stabilizes scapula.	Dorsal scapular nerve.

CONTINUES

XX.X), contracted muscles become shorter and wider. Moreover, the brachial plexus runs between the pectoralis minor and the rib cage. Chronic contraction of this muscle can thus compress nerves and emulate the symptoms of carpal tunnel syndrome (see Exhibit 13.4). Besides its role in movements of the scapula, the pectoralis minor muscle assists in forced inhalation.

The **serratus anterior** is a large, flat, fan-shaped muscle between the ribs and scapula. It is so named because of the saw-toothed appearance of its origins on the ribs. This muscle can be highly developed in body builders and athletes (Figure 13.1a–d). It is an antagonist of the rhomboids and is responsible for abduction of the scapula. A large portion of the belly is deep to the anterior scapula. The muscle is thus riding over the rib cage. The production of hydrogen bonds during the aging process, as discussed in Section X.X, often causes the serratus anterior of elderly persons to become "cemented" between the rib cage and the scapula. Range of motion of the scapula is thus often greatly reduced as the aging process continues. The lateral and inferior portion of the breast lies superficial to the serratus anterior muscle.

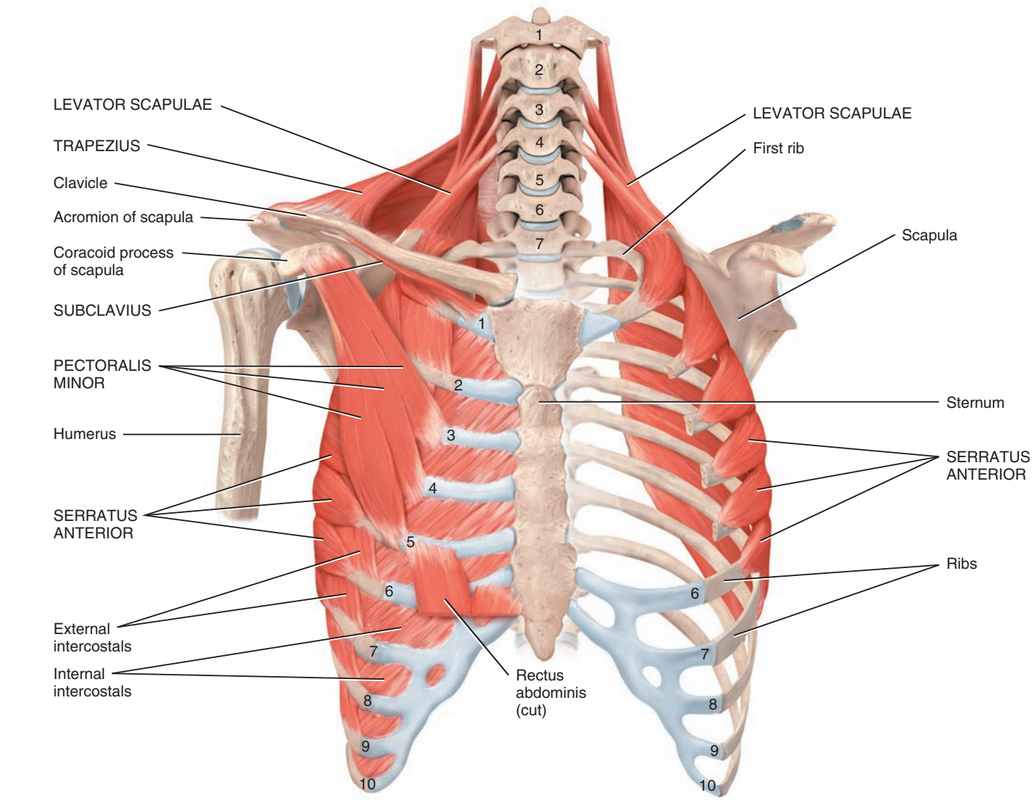
The posterior thoracic muscles are the trapezius, levator scapulae, rhomboid major, and rhomboid minor.

The **trapezius** is a large, flat, triangular sheet of muscle extending from the skull and vertebral column medially to the pectoral girdle laterally. It is the most superficial back muscle and covers the posterior neck region and superior portion of the trunk. The two trapezius muscles form a trapezoid (diamond-shaped quadrangle), hence its name. Discounting body builders and professional athletes, the trapezius muscle of most persons is less than 0.25 in. thick. The three sets of fibers (superior, middle, and inferior) enable this muscle to cause multiple actions (Figure 13.1c). The superior fibers extend the head and neck. The weight of the head (about 12 pounds) is functionally doubled with each inch that the head flexes from the neutral position (directly over the atlas). For example, for the person who has a head-forward posture of 2 in. from neutral, the trapezius and smaller muscles of the posterior neck need to contract as though the head weighed 36 pounds. The trapezius is thus overworked in such persons and becomes painful. The head-forward position is usually a habit that the patient can correct with practice.

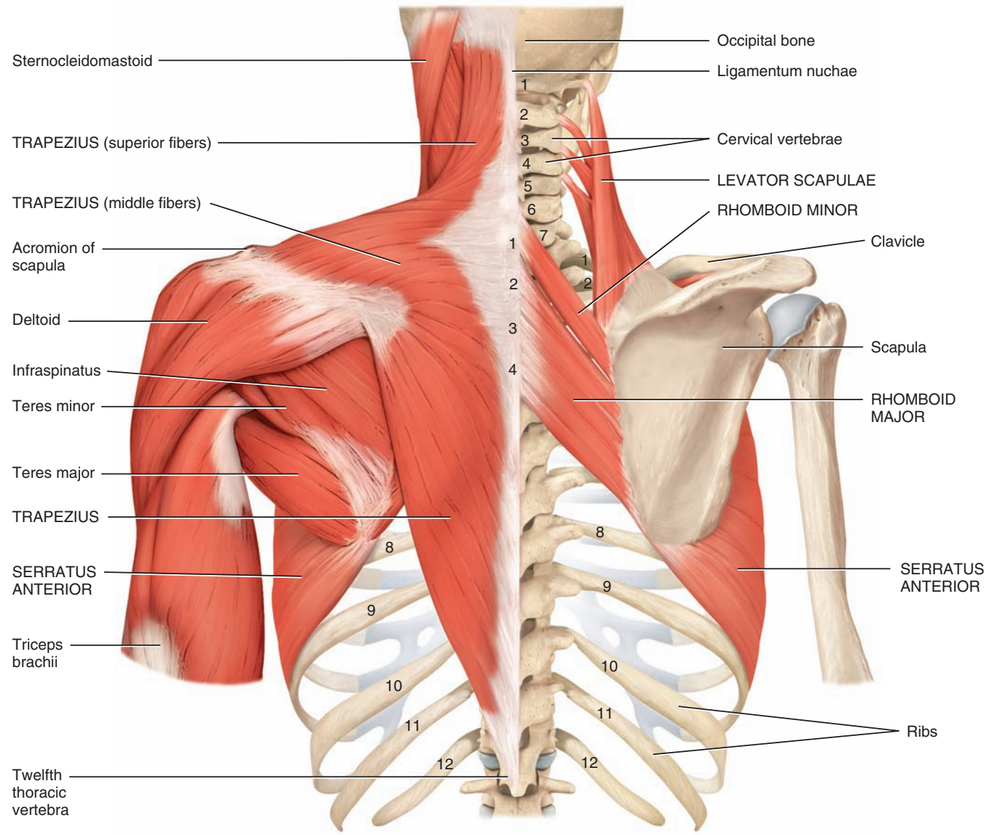
The **levator scapulae** is a narrow, elongated muscle in the posterior portion of the neck. It is deep to the sternocleidomastoid and trapezoid muscles. This muscle contains a twist in the belly (Figure 13.1d). The twist inverts the superior and inferior fibers as they approach the insertion and increases the leverage of each fiber. The fibers become untwisted and stretched as a bone is moved away from the anatomical or neutral position. A muscle that is twisted has the ability to contract with greater force. The insertion is on and near the superior angle of the scapula and pain of the muscle is usually perceived here. The origin, however, goes as high as the atlas, and therefore the belly is longer than one might think. As its name suggests, one of its actions is to elevate the scapula. Its reverse muscle action (RMA), when the origin and insertion are switched, is to pull posteriorly on (extend) the neck, particularly when the person has a head-forward posture, as demonstrated in Figure 13.2. Normal alignment of the body includes positioning of the external auditory meatus directly superior to the acromion process of the scapula. As discussed in Chapter 10, chronic shortening of any muscle can reset the tone of the muscle spindles, and the muscle can therefore develop a compromised blood supply and become painful.

Figure 13.1 Muscles of the thorax (chest) that move the pectoral girdle (clavicle and scapula).

Muscles that move the pectoral girdle originate on the axial skeleton and insert on the clavicle or scapula.



(a) Anterior deep view (b) Anterior deeper view



(c) Posterior superficial view (d) Posterior deep view

What is the main action of the muscles that move the pectoral girdle?

CONTINUES

Persons who wish to have both hands free and hold a telephone cradle by elevating the shoulder are also likely to develop a chronically shortened levator scapulae muscle and thus experience pain near the superior angle of the scapula and an inability to fully turn their neck when checking the blind spot while driving.

The **rhomboid major** and **rhomboid minor** lie deep to the trapezius and are not always distinct from each other (Figure 13.1d). They appear as parallel bands that pass inferiorly and laterally from the vertebrae to the scapula. Their names are based on their shape, that is, a rhomboid (an oblique parallelogram). The rhomboid major is about two times wider than the rhomboid minor. The two muscles are often identified by their attachments. The muscles lie deep to the trapezius and superficial to the erector spinae. The rhomboids and the trapezius are functionally the only muscles holding the upper limb to the posterior axial skeleton. The rhomboids are usually very thin and are easily overworked by lifting or repetitive movements of the upper limbs; thus pain and a burning sensation between the shoulder blades is common for many people. Both muscles are used when forcibly lowering the raised upper limbs, as in driving a stake with a sledgehammer. Emotional stress can also cause spasm of the rhomboids in many people. Manual therapists who develop pain in the rhomboids sometimes back up to a corner of a refrigerator or a wall and lean themselves backward such that the corner presses into the rhomboids and helps to relieve the pain.

Movements of the Scapula

To understand the actions of muscles that move the scapula, it is first helpful to review the various movements of the scapula:

- **Elevation:** Superior movement of the scapula, such as shrugging the shoulders or lifting a weight over the head.
- **Depression:** Inferior movement of the scapula, as in pulling down on a rope attached to a pulley.
- **Abduction (protraction):** Movement of the scapula laterally and anteriorly, as in doing a push-up or punching.
- **Adduction (retraction):** Movement of the scapula medially and posteriorly, as in pulling the oars in a rowboat.
- **Upward rotation:** Movement of the inferior angle of the scapula laterally so that the glenoid cavity is moved upward. This movement is required to move the humerus past the horizontal as in raising the arms in a jumping jack.
- **Downward rotation:** Movement of the inferior angle of the scapula medially so that the glenoid cavity is moved downward. This movement is seen when a gymnast on parallel bars supports the weight of the body on the hands.

Relating Muscles to Movements

Arrange the muscles in this exhibit according to the following actions on the scapula: (1) depression, (2) elevation, (3) abduction, (4) adduction, (5) upward rotation, and (6) downward rotation. The same muscle may be mentioned more than once.

MANUAL THERAPY APPLICATION

Structural and Functional Analysis

Structural analysis includes visual and palpatory assessment of a patient while he is sitting, standing, or lying without movement. For example, a manual therapist might position herself behind the patient who is standing and observe the heights of the two scapulae. If the heights are different, the therapist would attempt to determine what would contribute to a height discrepancy. Pain in the shoulder region or the back may result from such misalignments of the skeleton.

Functional analysis includes palpating the structure during motion to assess the functioning of the involved musculature and joints. For example, a manual therapist might stand behind the patient who is standing and ask her to place her hands (palms out) on her lower back. The manual therapist would observe the movement of the scapulae for symmetry of motion. If one scapula is "winged out," meaning that the medial edge of the scapula has moved posteriorly and is no longer near the rib cage, the therapist might conclude that the action may have been the result of a whiplash injury in the past. The serratus anterior muscle helps hold the scapula against the rib cage and is innervated by the long thoracic nerve that arises from spinal nerves C5–C7. A whiplash injury involving this part of the cervical region may compromise this nerve and reduce the strength of the serratus anterior muscle, thus causing the winged appearance of the scapula. Such an injury would be confirmed by, or added to, the written history of the patient. It should be noted that during the intake history, many patients inadvertently forget to mention such injuries, which could have occurred years ago.

CHECKPOINT

What muscles in this exhibit are used to raise your shoulders, lower your shoulders, join your hands behind your back, and join your hands in front of your chest?

OBJECTIVE

- Describe the origin, insertion, action, and innervation of the muscles that move the humerus.

Of the nine muscles that cross the shoulder joint, all except the pectoralis major and latissimus dorsi originate on the scapula. The pectoralis major and latissimus dorsi thus are called **axial muscles** because they originate on the axial skeleton. The remaining seven muscles, the **scapular muscles,** arise from the scapula (see Exhibit 13.1).

Of the two axial muscles that move the humerus, the **pectoralis major** is a large, thick, fan-shaped muscle that covers the superior part of the thorax and forms the anterior fold of the axilla. When this muscle and the latissimus dorsi are well developed, the axilla is deepened. By placing the thumb in the axilla of the patient, manual therapists are able to place the fingers on the belly of the muscle and thus massage both surfaces simultaneously. The pectoralis major has a twist in it that improves its contraction strength; the clavicular head inserts more distally and the sternocostal head inserts more proximally.

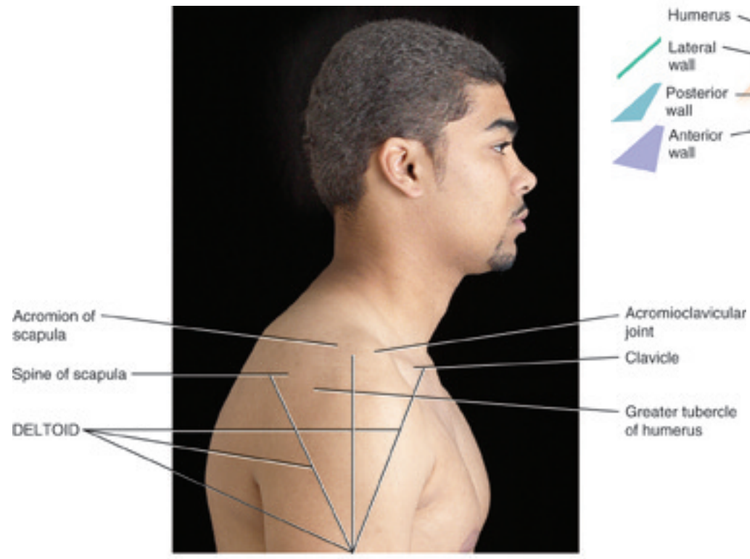
The **latissimus dorsi** is a broad, triangular muscle located on the inferior part of the back (Figure 13.4b,c). The muscle forms most of the posterior wall of the axilla. The reverse muscle action (RMA) of the latissimus dorsi enables the spine and torso to be elevated. It is commonly called the "swimmer's muscle" because its many actions are used while swimming; consequently, many competitive swimmers have well-developed "lats." These movements are seen in a paraplegic when transferring from a wheelchair. Similarly, if the arm is stabilized, as when hanging from a bar, latissimus dorsi will assist in extension of the spine. Like the pectoralis major and levator scapulae muscles, latissimus dorsi has a twist in it near the insertion that increases its contraction effectiveness.

Among the scapular muscles, the **deltoid** is a thick, powerful shoulder muscle that covers the shoulder joint and forms the rounded contour of the shoulder. This muscle is a frequent site of intramuscular injections. As you study the deltoid, note that its fascicles originate from three different points and that each group of fascicles moves the humerus differently. These points of insertion are the clavicle, acromion, and spine of the scapula (Figure 13.4a,b); they are the same three points as the insertions of the trapezius. The muscle has three sets of fibers (anterior, middle, and posterior) that enable it to function as three distinct muscles that are used in flexion, abduction, rotation, or extension of the humerus; see the photo of the arm that shows the deltoid in Figure 13.2.

The **subscapularis** is a large triangular muscle that fills the subscapular fossa of the scapula and forms a small part in the apex of the posterior wall of the axilla (see Figure 13.3). The **supraspinatus,** a rounded muscle named for its location in the supraspinous fossa of the scapula, lies deep to the trapezius and has a belly that is about the size of your thumb (Figure 13.4c–e). The tendon of insertion slides back

Figure 13.2 Surface anatomy of the shoulder.

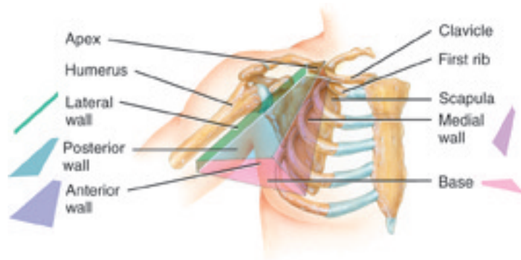
6 The deltoid muscle gives the shoulder its rounded prominence.



Right Lateral View

? Which structure forms the top of the shoulder?

Figure 13.3 Axilla schematic.



Location and parts of the axilla

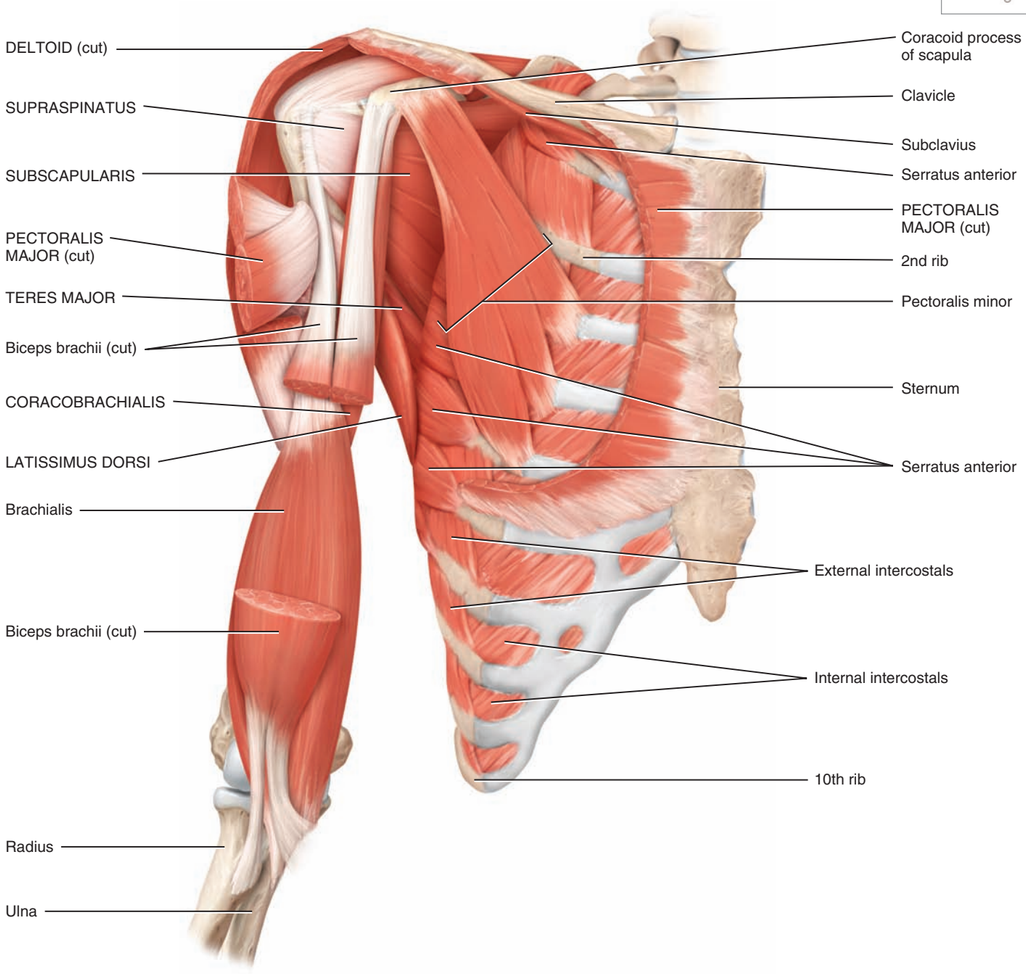
CONTINUES

and forth beneath the acromion; inflammation can thus cause swelling and pain. See the discussion on impingement in the Clinical Connection in this exhibit. The supraspinatus is responsible for the first 15° of abduction of the humerus; the middle fibers of the deltoid do not cause the beginning of abduction. The supraspinatus has therefore been called the "suitcase muscle" since it is essentially acting alone to keep a suitcase from rubbing your leg as you carry it. No wonder travel through a large airport is so exhausting and painful for your shoulder.

The **infraspinatus** is a triangular muscle, also named for its location in the infraspinous fossa of the scapula. A portion of the muscle is superficial and other portions are deep to the trapezius and to the deltoid (see Figure 13.4c,e). Thick fascial layers cause the infraspinatus to feel more dense than surrounding muscles on palpation. This muscle often develops trigger points (knots) in the muscle or adheres to the glenohumeral joint capsule and results in a condition called adhesive capsulitis which limits movement of the arm dramatically.

Figure 13.4 Muscles of the thorax (chest) and shoulder that move the humerus (arm bone).

The strength and stability of the shoulder joint are provided by the tendons that form the rotator cuff.



(a) Anterior deep view (the intact pectoralis major muscle is shown in figure 12.01)

The **teres major** is a thick, flattened muscle inferior to the teres minor that also helps form part of the posterior wall of the axilla. It is also a synergist of the latissimus dorsi (Figure 13.4b,c). The two muscles have been called the "handcuff muscles" since their combined actions are to bring the arms into position behind the back. The teres major rotates the arm medially and the teres minor rotates it laterally.

The **teres minor** is a small, cylindrical, elongated muscle, located between the teres major and the infraspinatus muscles (Figure 13.4c,e). Its belly lies parallel to the inferior edge of the infraspinatus and is sometimes indistinguishable from the infraspinatus.

The **coracobrachialis** is an elongated, narrow muscle in the arm, located in the lateral wall of the axilla along with the biceps brachii (Figure 13.4a). Its point of origin, the coracoid process of the scapula, in many people is tender on palpation. Since three muscles are attached here, tenderness at the site implies a problem with one or more of three muscles: the coracobrachialis, pectoralis minor, or biceps brachii muscles.

Four deep muscles of the shoulder—supraspinatus, infraspinatus, teres minor, and subscapularis—strengthen and stabilize the shoulder joint. These muscles join the scapula to the humerus. Their flat tendons fuse to-

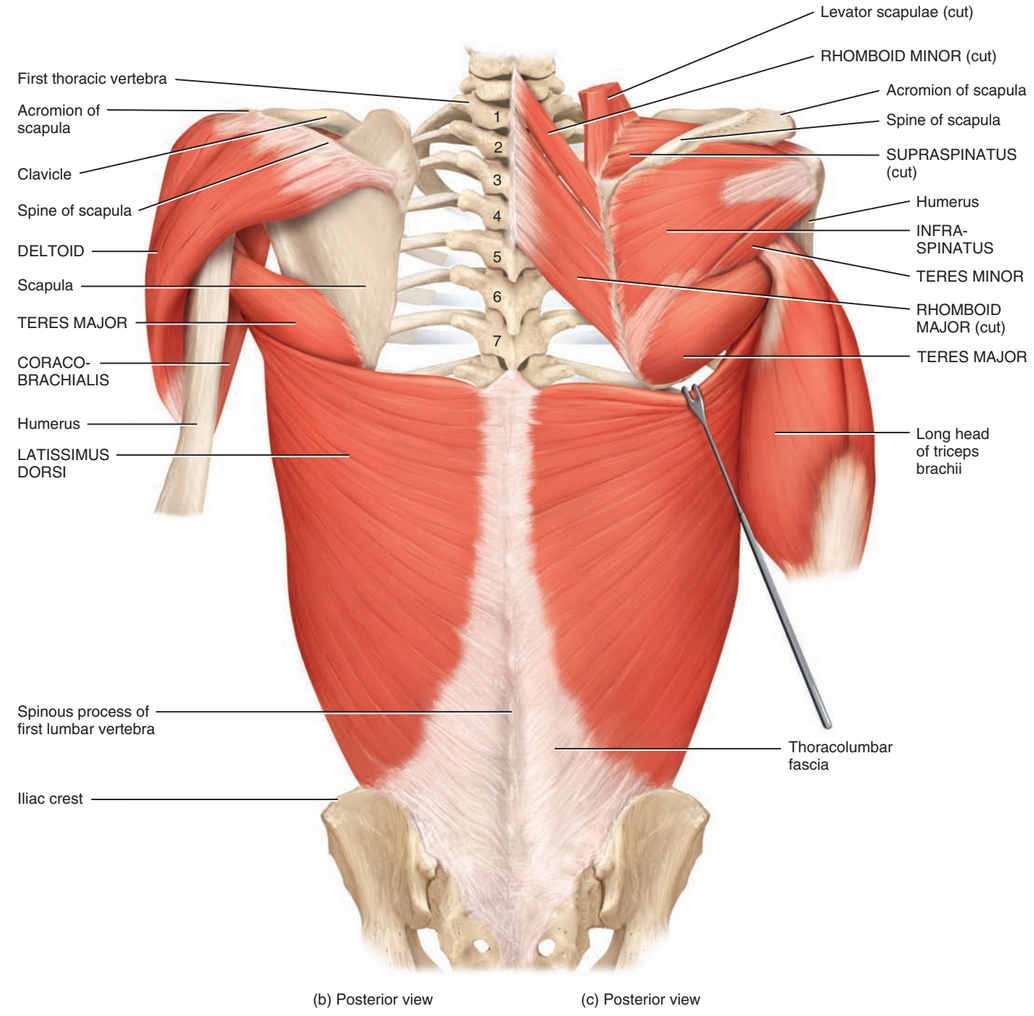


Figure 13.5 photo p-13.12a

(b) Posterior view (c) Posterior view

? Which of the rotator cuff muscles inserts on the anterior humerus?

CONTINUES

gether to form the **rotator (musculotendinous) cuff,** a nearly complete circle of tendons around the shoulder joint, like the cuff on a shirtsleeve. The four rotator cuff muscles are often described as the "SITS" muscles and this could serve as a mnemonic for remembering the names.

The supraspinatus muscle is especially subject to wear and tear because of its location between the head of the humerus and acromion of the scapula, which compress its tendon during shoulder movements, especially abduction of the arm. This is further aggravated by poor posture with slouched shoulders and medially rotated shoulders that also increase compression of the supraspinatus tendon.

The subscapularis is the only rotator cuff muscle that attaches to the lesser tubercle of the humerus; the other three attach to the greater tubercle. Sandwiched between the serratus anterior and subscapular fossa (on the anterior scapula), the subscapularis is difficult to access in many patients (Figure 13.4a,d). When the therapist places the fingers of one hand on the inferior vertebral border of the scapula, the other hand can pull the patient's shoulder over the fingers. This technique can be used to stretch some of the fibers of trapezius, the rhomboids, the serratus anterior, and the subscapularis simultaneously. As described in Section 10.X, hydrogen bonds within connective tissues commonly increase in number during the aging process and, with the lack of aerobic exercise, reduce the flexibility of the scapula.

MUSCLE	ORIGIN	INSERTION	ACTION	INNERVATION
AXIAL MUSCLES THAT MOVE THE HUMERUS				
Pectoralis major (pek′-tō-RĀ-lis; *pector-* = chest; *major* = larger) (see also Figure 12.1)	Clavicle (clavicular head), sternum, and costal cartilages of ribs 2–6 (sternocostal head).	Greater tubercle and lateral lip of the intertubercular sulcus of humerus.	As a whole, adducts and medially rotates arm at shoulder joint; clavicular head flexes arm, and sternocostal head extends the flexed arm to side of trunk.	Medial and lateral pectoral nerves.
Latissimus dorsi (la-TIS-i-mus DOR-sī; *latissimus* = widest; *dorsi* = of the back)	Spines of T7–L5, lumbar vertebrae, crests of sacrum and ilium, ribs 9–12 via thoracolumbar fascia.	Medial lip of intertubercular sulcus of humerus.	Extends, adducts, and medially rotates arm at shoulder joint; draws arm inferiorly and posteriorly.	Thoracodorsal nerve.
SCAPULAR MUSCLES THAT MOVE THE HUMERUS				
Deltoid (DEL-toyd = triangularly shaped)	Acromial extremity of clavicle (anterior fibers), acromion of scapula (lateral fibers), and spine of scapula (posterior fibers).	Deltoid tuberosity of humerus.	Lateral fibers abduct arm at shoulder joint; anterior fibers flex and medially rotate arm at shoulder joint; posterior fibers extend and laterally rotate arm at shoulder joint.	Axillary nerve.
Subscapularis (sub-scap′-ū-LĀ-ris; *sub-* = below; *scapularis* = scapula)	Subscapular fossa of scapula.	Lesser tubercle of humerus.	Medially rotates arm at shoulder joint.	Upper and lower subscapular nerve.
Supraspinatus (soo-pra-spī-NĀ-tus; *supra-* = above; *spina-* = spine of the scapula)	Supraspinous fossa of scapula.	Greater tubercle of humerus.	Assists deltoid muscle in abducting arm at shoulder joint.	Suprascapular nerve.
Infraspinatus (in′-fra-spī-NĀ-tus; *infra-* = below)	Infraspinous fossa of scapula.	Greater tubercle of humerus.	Laterally rotates arm at shoulder joint.	Suprascapular nerve.
Teres major (TE-rēz; *teres* = long and round)	Inferior angle of scapula.	Medial lip of intretubercular sulcus of humerus.	Extends arm at shoulder joint and assists in adduction and medial rotation of arm at shoulder joint.	Lower subscapular nerve.
Teres minor	Inferior lateral border of scapula.	Greater tubercle of humerus.	Laterally rotates and extends arm at shoulder joint.	Axillary nerve.
Coracobrachialis (kor′-a-kō-brā-kē-Ā-lis; *coraco-* = coracoid process of the scapula; *brachi-* = arm)	Coracoid process of scapula.	Middle of medial surface of shaft of humerus.	Flexes and adducts arm at shoulder joint.	Musculocutaneous nerve.

• CLINICAL CONNECTION | Rotator Cuff Injuries and Impingement Syndrome

Rotator cuff injury is common among baseball pitchers, volleyball players, racket sports players, and swimmers due to shoulder movements that involve vigorous circumduction. It also occurs as a result of wear and tear, trauma, and repetitive motions in certain occupations, such as painters or those required to place items on a shelf above the head. Although muscle bellies may be damaged, the tendon of one or more of the four muscles is usually partially or completely torn. Most often, there is tearing of the supraspinatus muscle tendon of the rotator cuff. This tendon is especially predisposed to wear-and-tear because of its location between the head of the humerus and acromion of the scapula, which compresses the tendon during shoulder movements. Treatment consists of resting the injured tendons, strengthening the shoulder through exercise, and surgery if the injury is particularly severe. During surgery, torn rotator cuff tendons may be trimmed and then reattached with sutures, anchors, or surgical tacks.

One of the most common causes of shoulder pain and dysfunction in athletes is known as **impingement syndrome.** The repetitive movement of the arm over the head that is common in baseball, overhead racquet sports, weight-lifting, volleyball, and swimming puts these athletes at risk. Impingement syndrome may also be caused by a direct blow or stretch injury. Continual pinching of the supraspinatus tendon as a result of overhead motions causes it to become inflamed and results in pain. If movement is continued despite the pain, the tendon may degenerate near the attachment to the humerus and ultimately may tear away from the bone (rotator cuff injury). Treatment consists of resting the injured tendons, strengthening the shoulder through exercise, massage therapy, and finally surgery if the injury is particularly severe. During surgery, an inflamed bursa may be removed, bone may be trimmed, and/or the coracoacromial ligament may be detached. These steps make more space, thus relieving pressure and allowing the arm to move freely. •

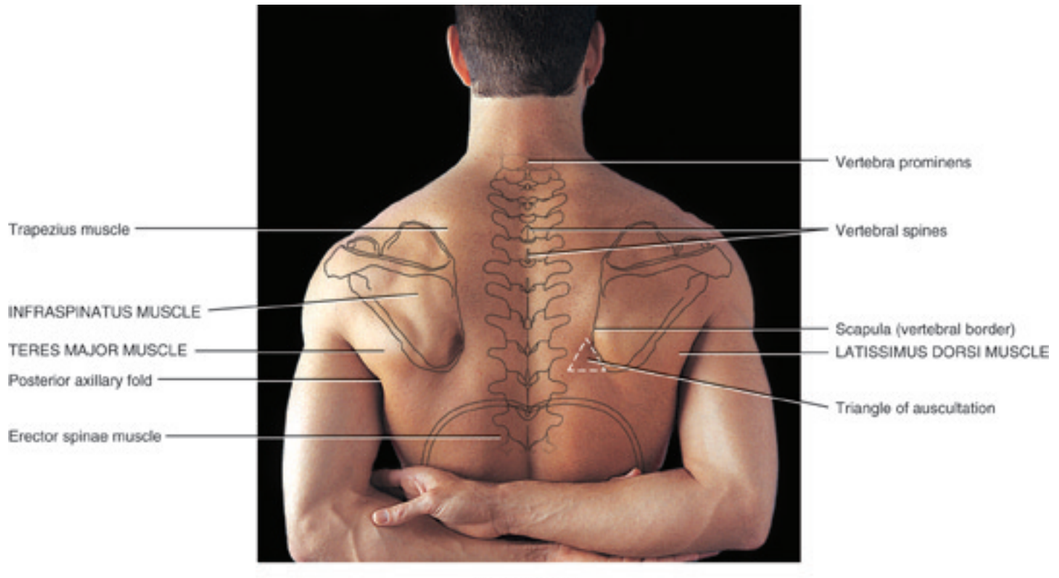
Surface Features of the Back

In addition to the muscles that we've discussed in detail, there are several other superficial bones and muscles that form the feature of the *back* (Figure 13.5).

- **Vertebral spines.** The spinous processes of vertebrae, especially the thoracic and lumbar vertebrae, are quite prominent when the vertebral column is flexed.
- **Scapulae.** These easily identifiable surface landmarks on the back

Figure 13.5 Surface anatomy of the back.

6 The posterior boundary of the axilla, the posterior axillary fold, is formed mainly by the latissimus dorsi and teres major muscles.



Posterior view

? What is the clinical significance of the triangle of auscultation?

CONTINUES

lie between ribs 2 and 7. In fact, it is also possible to palpate some ribs on the back. Depending on how lean a person is, it might be possible to palpate various parts of the scapula, such as the **vertebral border, axillary border, inferior angle,** spine, and **acromion.** The **spinous process of T3** is at about the same level as the spine of the scapula, and the spinous process of T7 is approximately opposite the inferior angle of the scapula.

- **Erector spinae (sacrospinalis) muscle.** Located on either side of the vertebral column between the skull and iliac crests.
- **Posterior axillary fold.** Formed by the latissimus dorsi and teres major muscles, the posterior axillary fold can be palpated between the fingers and thumb at the posterior aspect of the axilla (armpit region); forms the posterior wall of the axilla.
- **Triangle of auscultation** (aw-skul-TĀ-shun; *auscultо-* = listening). A triangular region of the back just medial to the inferior part of the scapula, where the rib cage is not covered by superficial muscles. It is bounded by the latissimus dorsi and trapezius muscles and vertebral border of the scapula. The triangle of auscultation is a landmark of clinical significance because in this area respiratory sounds can be heard clearly through a stethoscope pressed against the skin. If a patient folds the arms across the chest and bends forward, the lung sounds can be heard clearly in the intercostals space between ribs 6 and 7.

Relating Muscles to Movements

Arrange the muscles in this exhibit according to the following actions on the humerus at the shoulder joint: (1) flexion, (2) extension, (3) abduction, (4) adduction, (5) medial rotation, and (6) lateral rotation. The same muscle may be mentioned more than once.

CHECKPOINT

Why are the two muscles that cross the shoulder joint called axial muscles, and the seven others called scapular muscles?

OBJECTIVE

- Describe the origin, insertion, action, and innervation of the muscles that move the radius and ulna.

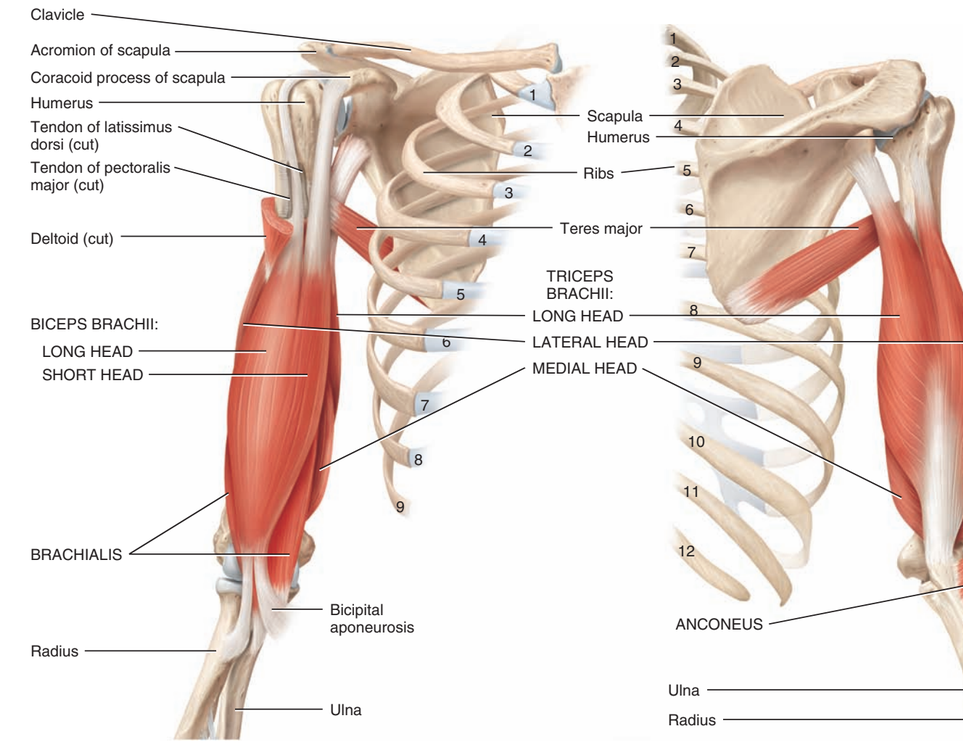
Most of the muscles that move the radius and ulna (forearm bones) cause flexion and extension at the elbow, which is a hinge joint. The biceps brachii, brachialis, and brachioradialis muscles are the flexor muscles. The extensor muscles are the triceps brachii and the anconeus (Figure 13.6b).

The **biceps brachii** is the large muscle located on the anterior surface of the arm. As indicated by its name, it has two heads of origin (long and short), both from the scapula. The muscle spans both the shoulder and elbow joints. In addition to its role in flexing the forearm at the elbow joint, it also supinates the forearm at the radioulnar joints and flexes the arm at the shoulder joint. The tendon of the distal muscle attaches to the radius and also becomes aponeurotic (meaning that the cross-sectional view changes from round to a flat, sheetlike aponeurosis) on the surface of the muscles of the forearm. The bicipital aponeurosis covers and helps protect the median nerve and the brachial artery. This aponeurotic sheet of fascia also tends to support a vein (see Chapter 23) by forming a sturdy platform, and the connective tissue fibers of the aponeurosis keep the vein from rolling. This site is thus a favorite of health-care professionals who wish to insert a needle into a vein for either withdrawal of blood or injection of medications. Since the biceps brachii is the primary supinator of the forearm, the belly is shorter and thicker when the forearm is supinated. Even children, when showing off their muscles, usually use this pose. Look at your biceps brachii muscle when the shoulder and elbow joints are flexed and when the forearm is pronated and then supinated.

The **brachialis** is deep to the biceps brachii muscle. It is the most powerful flexor of the forearm at the elbow joint. For this reason, it is called the "workhorse" of the elbow flexors. Its thick belly is wider than that of biceps brachii (Figure 13.6a,f). Sandwiched between the biceps brachii and triceps brachii, the lateral edge of the brachialis is usually distinguishable on palpation of the lateral arm.

Figure 13.6 Muscles of the arm that move the radius and ulna (forearm bones).

The anterior arm muscles flex the forearm, and the posterior arm muscles extend it.



(a) Anterior view (b) Posterior view

CONTINUES

The **brachioradialis** is located in the proximal half of the forearm (Figure 13.6g, 13.8a,d). Its belly is superficial and separates the bellies of the extensor muscles from those of the flexor muscles of the forearm. It flexes the forearm at the elbow joint, especially when a quick movement is required or when a weight is lifted slowly during flexion of the forearm, as well as in supination and pronation of the forearm. It is therefore well developed in mechanics or others who spend a lot of time using a screwdriver or a wrench.

The **triceps brachii** is the large muscle located on the posterior surface of the arm (Figure 13.6b). It is the only muscle belly of the posterior compartment of the arm. This muscle is the more powerful of the extensors of the forearm at the elbow joint and is an antagonist to the biceps brachii. As its name implies, it has three heads of origin, one from the scapula (long head) and two from the humerus (lateral and medial heads). The long head crosses the shoulder joint between teres major and teres minor; the other heads do not. The **anconeus** is a small muscle located in the posterior compartment of the forearm that assists the triceps brachii in extending the forearm at the elbow joint (Figure 13.6b,h).

Some muscles that move the radius and ulna are involved in pronation and supination at the radioulnar joints. The pronators, as suggested by their names, are the pronator teres and pronator quadratus muscles. **Pronator teres** (Figure 13.6i, 13.8a) is located in the proximal forearm between the brachioradialis and the forearm flexor muscles. In this region of the upper limb, it is the only muscle with obliquely running fibers. If this muscle impinges on the median nerve that runs deep to it, the patient may experience pronator teres syndrome. When these patients are asked to make a fist, they are able to flex only the fourth and fifth digits.

The **pronator quadratus** is flat and four-sided (*quadratus*); its fibers run transversely, at right angles to the radius and ulna. It is located in the distal forearm and is synergistic to the pronator teres. Both of the pronator muscles cause the radius to cross the ulna in the act of pronation of the forearm.

The supinator of the forearm is aptly named the **supinator** muscle (Figure 13.6h, 13.8b,c). Its thin muscle belly lies lateral to the elbow joint and is deep to the forearm extensor muscles. The supinator is antagonistic to both of the pronator muscles and pulls the radius into the anatomical position from pronation. You use the powerful action of the supinator when you twist a corkscrew or turn a screw with a screwdriver.

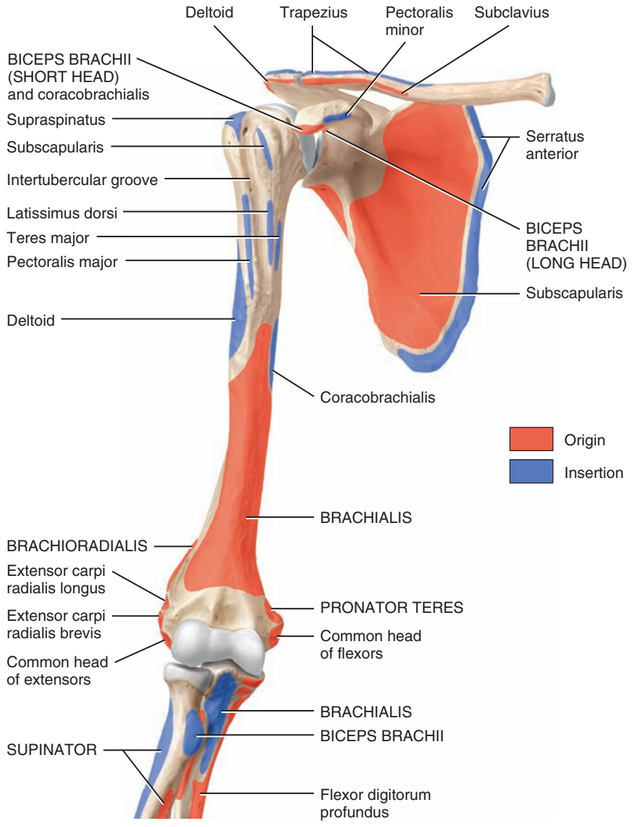
In the limbs, functionally related skeletal muscles and their associated blood vessels and nerves are grouped together by fascia into regions called **compartments** (Figure 13.6c). In the arm, the biceps brachii, brachialis, and coracobrachialis muscles make up the **anterior (flexor) compartment.** The triceps brachii muscle forms the **posterior (extensor) compartment.**

Surface Features of the Armpit

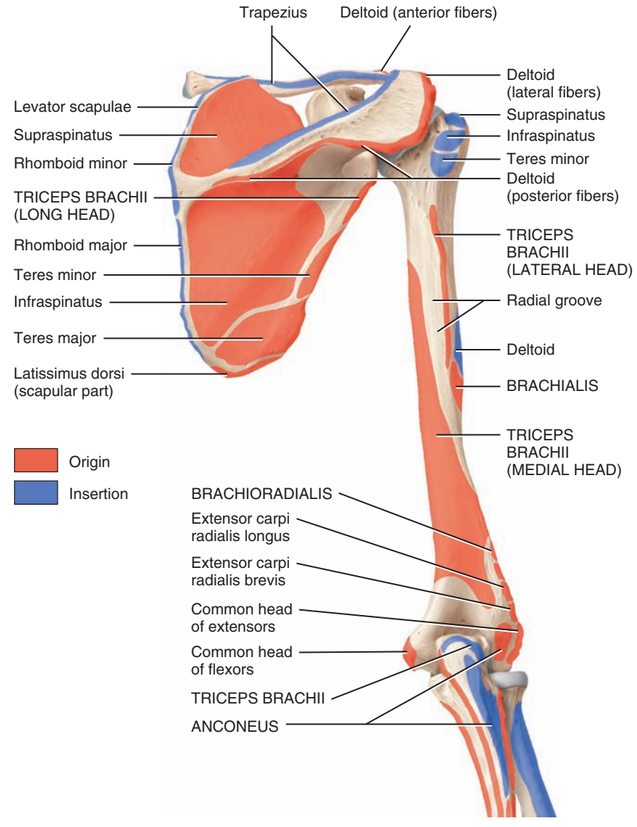
The armpit region, or ***axilla*,** is a pyramid-shaped area at the junction of the arm and the chest that enables blood vessels and nerves to pass between the neck and the free upper limbs (Figure 13.7a).

- **Anterior axillary fold.** The anterior wall of the axilla is composed mainly of the pectoralis major muscle (Figure 13.3).

Figure 13.6 (continued)



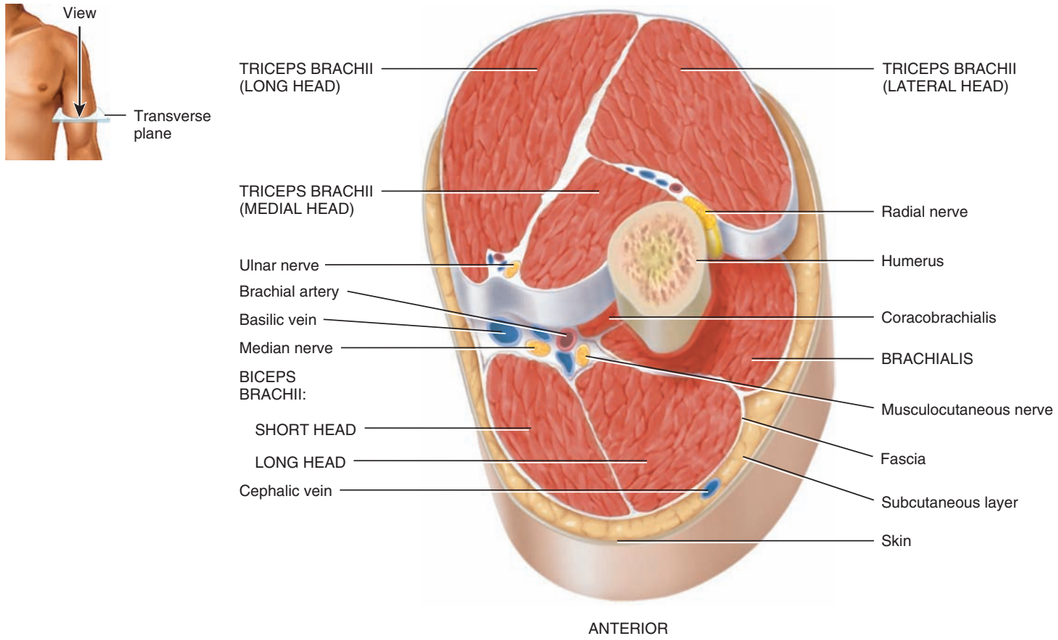
(c) Anterior view



(d) Posterior view

CONTINUES

Figure 13.6 (continued)



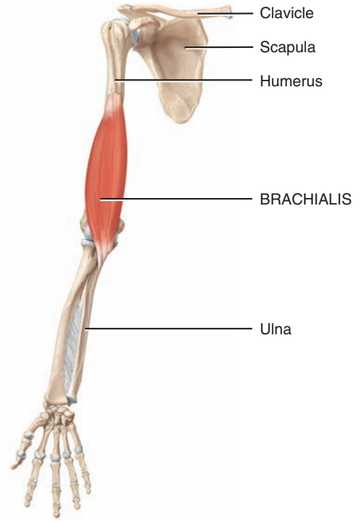
(e) Superior view of transverse section of arm

- **Posterior axillary fold.** The posterior wall of the axilla is formed mainly by the teres major and latissimus dorsi muscles.
- **Medial wall.** The medial wall of the axilla if formed by ribs 1–4 and their corresponding intercostals muscles, plus the overlying serratus anterior muscle (Figure 13.3).
- **Lateral wall.** Finally, the lateral wall of the axilla is formed by the coracobrachialis and biceps brachii muscles and the superior portion of the shaft of the humerus. Passing through the axilla are the axillary artery and vein, branches of the brachial plexus, and axillary lymph nodes. All these structures are surrounded by a considerable amount of axillary fat.

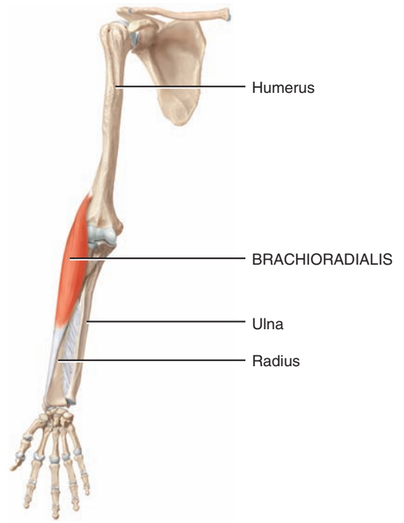
Surface Features of the Arm and Elbow

The ***arm,*** or *brachium*, is the region between the shoulder and elbow. The **elbow,** or *cubitus*, is the region where the arm and forearm join. The arm and elbow present several surface anatomy features (Figure 13.7).

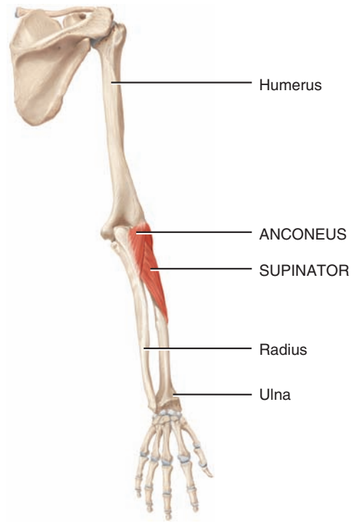
- **Humerus.** This arm bone may be palpated along its entire length, especially near the elbow (see descriptions of the medial and lateral epicondyles that follow).
- **Biceps brachii muscle.** Forms the bulk of the anterior surface of the arm. On the medial side of the muscle is a groove that contains the **brachial artery.**
- **Triceps brachii muscle.** Forms the bulk of the posterior surface of the arm.
- **Medial epicondyle.** Medial projection of the humerus near the elbow.
- **Lateral epicondyle.** Lateral projection of the humerus near the elbow.
- **Olecranon.** Projection of the proximal end of the ulna between and slightly superior to the epicondyles when the forearm is extended; it forms the elbow.
- **Ulnar nerve.** Can be palpated in a groove posterior to the medial epicondyle. The "funny bone" is the region where the ulnar nerve rests against the medial epicondyle. Hitting the nerve at this point produces a sharp pain along the medial side of the forearm that almost everyone would agree isn't very funny.
- **Cubital fossa.** Triangular space in the anterior region of the elbow bounded proximally by an imaginary line between the humeral epicondyles, laterally by the medial border of the brachioradialis muscle, and medially by the lateral border of the pronator teres muscle; contains the tendon of the biceps brachii muscle, the median cubital vein, brachial artery and its terminal branches (radial and ulnar arteries), and parts of the median and radial nerves.
- **Median cubital vein.** Crosses the cubital fossa obliquely and connects the lateral cephalic with the medial basilic veins of the arm.



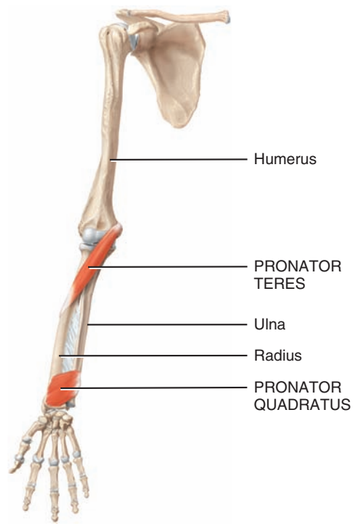
(f) Anterior deep view



(g) Anterior deep view



(h) Posterior deep view



(i) Anterior deep view

? **Which muscles are the most powerful flexor and the most powerful extensor of the forearm?**

CONTINUES

Muscles of the Arm That Move the Radius and Ulna (Forearm Bones) CONTINUED

MUSCLE	ORIGIN	INSERTION	ACTION	INNERVATION
ANTERIOR (FLEXOR) COMPARTMENT OF THE ARM				
Biceps brachii (BĪ-ceps BRĀ-kē-ī; *biceps* = two heads of origin; *brachii* = arm)	Long head: tubercle above glenoid cavity of scapula (supraglenoid tubercle); short head: coracoid process of scapula.	Radial tuberosity of radius and bicipital aponeurosis.*	Flexes forearm at elbow joint, supinates forearm at radioulnar joints, and flexes arm at shoulder joint.	Musculocutaneous nerve.
Brachialis (brā-kē-Ā-lis)	Distal, anterior surface of humerus.	Ulnar ruberosity and coronoid process of ulna.	Flexes forearm at elbow joint.	Musculocutaneous and radial nerves.
Brachioradialis (brā′-kē-ō-rā-dē-Ā-lis; *radi-* = radius)	Lateral border of distal end of humerus.	Superior to styloid process of radius.	Flexes forearm at elbow joint: supinates and pronates forearm at radioulnar joints to neutral position.	Radial nerve.
POSTERIOR (EXTENSOR) COMPARTMENT				
Triceps brachii (TRĪ -ceps = three heads of origin)	Long head: infraglenoid tubercle, a projection inferior to glenoid cavity of scapula; lateral head: lateral and posterior surface of humerus superior to radial groove; medial head: entire posterior surface of humerus inferior to a groove for the radial nerve.	Olecranon of ulna.	Extends forearm at elbow joint and extends arm at shoulder joint.	Radial nerve.
Anconeus (an-KŌ-nē-us = the elbow)	Lateral epicondyle of humerus.	Olecranon and superior portion of shaft of ulna.	Extends forearm at elbow joint.	Radial nerve.
FOREARM PRONATORS				
Pronator teres (PRŌ-nā-tor TE-rēz; *pronator* = turns palm posteriorly)	Medial epicondyle of humerus and coronoid process of ulna.	Midlateral surface of radius.	Pronates forearm at proximal radioulnar joint and weakly flexes forearm at elbow joint.	Median nerve.
Pronator quadratus (kwod-RĀ-tus = square, four-sided)	Distal portion of shaft of ulna.	Distal portion of shaft of raidus	Pronates forearm at distal radioulnar joint.	Median nerve.
FOREARM SUPINATOR				
Supinator (SOO-pi-nā-tor = turns palm anteriorly)	Lateral epicondyle of humerus and ridge near radial notch of ulna (supinator crest).	Lateral surface of proximal one-third of radius.	Supinates forearm at both radioulnar joints.	Deep radial nerve.

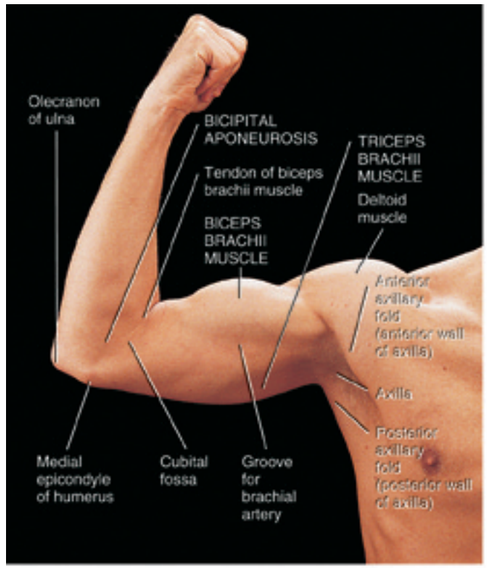
*The bicipital aponeurosis is a broad aponeurosis from the tendon of insertion of the biceps brachii muscle that descends medially across the brachial artery and fuses with deep fascia over the forearm flexor muscles. It also helps to protect the median nerve and brachial artery.

The median cubital vein is frequently used to withdraw blood from a vein for diagnostic purposes or to introduce substances into blood, such as medications, contrast media for radiographic procedures, nutrients, and blood cells and/or plasma for transfusion.

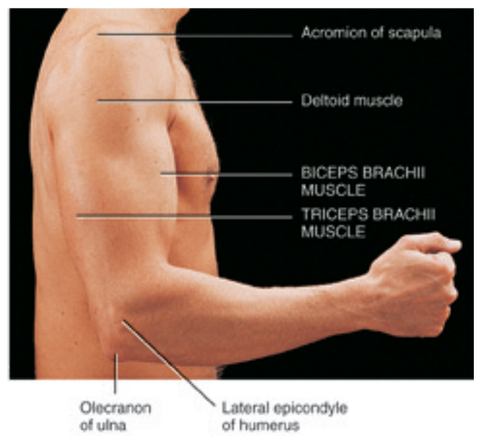
- **Brachial artery.** Continuation of the axillary artery that passes posterior to the coracobrachialis muscle and then medial to the biceps brachii muscle. It enters the middle of the cubital fossa and passes deep to the bicipital aponeurosis, which separates it from the median cubital vein. **Blood pressure** is usually measured in the brachial artery, when the cuff of a *sphygmomanometer* (blood pressure instrument) is wrapped around the arm and a stethoscope is placed over the brachial artery in the cubital fossa. Pulse can also be detected in the artery in the cubital fossa. However, blood pressure can be measured at any artery where you can obstruct blood flow. This becomes important in case the brachial artery cannot be utilized. In such situations, the radial or popliteal arteries might be used to obtain a blood pressure reading.
- **Bicipital aponeurosis.** An aponeurosis that inserts the biceps brachii muscle into the deep fascia in the medial aspect of the forearm. If can he felt when the muscle contracts.

Figure 13.7 Surface anatomy of the axilla, arm, and elbow.

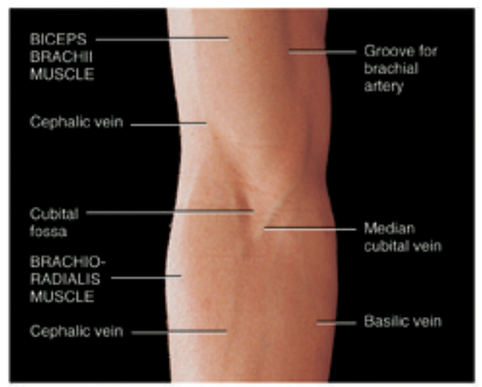
The location of the muscles that form the walls of the axilla are shown in Figure 13.4a.



(a) Medial view of arm



(b) Right lateral view of arm



(c) Anterior view of cubital fossa

? What muscles form the anterior and posterior axillary folds?

CONTINUES

MANUAL THERAPY APPLICATION

Tenosynovitis

Tenosynovitis (ten′-ō-sin-ō-VĪ-tis) is an inflammation of the tendons, tendon sheaths, and synovial membranes surrounding certain joints. The tendons most often affected are at the wrists, shoulders, elbows, finger joints, ankles, and feet. The affected sheaths sometimes become visibly swollen because of fluid accumulation. Tenderness and pain are frequently associated with movement of the body part. The condition often follows trauma, strain, excessive exercise, or other stressors. For example, tenosynovitis of the dorsum of the foot may also be caused by tying shoelaces too tightly. Gymnasts are prone to developing the condition as a result of chronic, repetitive, and maximum hyperextension at the wrists. Other repetitive movements involving activities such as typing, haircutting, carpentry, and assembly line work can also result in tenosynovitis. Manual therapy procedures can reduce swelling by moving venous blood through the affected area and can also enhance arterial blood flow that will facilitate healing.

Relating Muscles to Movements

Arrange the muscles in this exhibit according to the following actions on the elbow joint: (1) flexion and (2) extension; the following actions on the forearm at the radioulnar joints: (1) supination and (2) pronation; and the following actions on the humerus at the shoulder joint: (1) flexion and (2) extension. The same muscle may be mentioned more than once.

CHECKPOINT

Flex your arm. Which group of muscles is contracting? Which group of muscles must relax so that you can flex your arm?

EXHIBIT 13.4 Muscles of the Forearm That Move the Wrist, Hand, Thumb and Digits

OBJECTIVE

- Describe the origin, insertion, action, and innervation of the muscles that move the wrist, hand, thumb, and fingers.

Muscles of the forearm that move the wrist, hand, thumb, and fingers are many and varied (Figure 13.8a–e). Those in this group that act on the digits are known as **extrinsic muscles of the hand** (*ex-* = outside) because they originate *outside* the hand and insert within it. As you will see, the names for the muscles that move the wrist, hand, and digits give some indication of their origin, insertion, or action. Based on location and function, the muscles of the forearm are divided into two groups: (1) anterior compartment muscles and (2) posterior compartment muscles. The **anterior (flexor) compartment** muscles of the forearm originate on the humerus, typically insert on the carpals, metacarpals, and phalanges, and function as flexors. The bellies of these muscles form the bulk of the anterior forearm. One of the muscles in the superificial anterior compartment, the **palmaris longus** muscle, is missing in about 10% of individuals (usually in the left forearm) and is commonly used for tendon repair. The **posterior (extensor) compartment** muscles of the forearm originate on the humerus, insert on the metacarpals and phalanges, and function as extensors. Within each compartment, the muscles are grouped as superficial or deep.

The **superficial anterior compartment** muscles are arranged in the following order from lateral to medial: **flexor carpi radialis, palmaris longus,** and **flexor carpi ulnaris** (the ulnar nerve and artery are just lateral to the tendon of this muscle at the wrist). The **flexor digitorum superficialis** muscle is deep to the other three muscles and is the largest superficial muscle in the forearm. These muscles make up the fleshy mass that is deep to the hairless skin of the anterior forearm. The common origin is on the medial epicondyle. The palmaris longus muscle inserts into the thickened palmar aponeurosis. The tendons of the flexor digitorum superficialis and flexor digitorum profundus muscles pass through the carpal tunnel; the tendon of palmaris longus lies superficial to the flexor retinaculum.

The five superficial extensor muscles of the forearm all originate on or near the lateral epicondyle of the humerus. The bellies of these superficial muscles lie deep to the hairy skin of the posterior forearm. The tendons of extensor digitorum are easily seen beneath the skin on the dorsum of the hand.

The **deep anterior compartment** muscles are arranged in the following order from lateral to medial: **flexor pollicis longus** (the only flexor of the distal phalanx of the thumb) and **flexor digitorum profundus** (ends in four tendons that insert into the distal phalanges of the fingers).

The **superficial posterior compartment** muscles are arranged in the following order from lateral to medial: **extensor carpi radialis longus, extensor carpi radialis brevis, extensor digitiorum** (occupies most of the posterior surface of the forearm and divides into four

MUSCLE	ORIGIN	INSERTION	ACTION	INNERVATION
SUPERFICIAL ANTERIOR (FLEXOR) COMPARTMENT OF THE FOREARM				
Flexor carpi radialis (FLEK-sor KAR-pē-rā′-dē-Ā-lis; *flexor* = decreases angle at joint; *carpi* = of the wrist; *radi-* = radius)	Medial epicondyle of humerus.	Second and third metacarpals.	Flexes and abducts hand (radial deviation) at wrist joint.	Median nerve.
Palmaris longus (pal-MA-ris LON-gus; *palma-* = palm; *longus* = long)	Medial epicondyle of humerus.	Palmar aponeurosis (fascia in center of palm).	Weakly flexes hand at wrist joint.	Median nerve.
Flexor carpi ulnaris (ul-NAR-is = of the ulna)	Medial epicondyle of humerus and superior posterior border of ulna.	Pisiform, hamate, and base of fifth metacarpal.	Flexes and adducts hand (ulnar deviation) at wrist joint.	Ulnar nerve
Flexor digitorum superficialis (di-ji-TOR-um soo′-per-fish′-ē-Ā-lis; *digit* = finger or toe; *superficialis* = closer to surface)	Medial epicondyle of humerus, coronoid process of ulna, and a ridge along lateral margin or anterior surface (anterior oblique line) of radius.	Middle phalanx of each finger.*	Flexes middle phalanx of each finger at proximal interphalangeal joint, proximal phalanx of each finger at metacarpophalangeal joint, and hand at wrist joint.	Median nerve.
DEEP ANTERIOR (FLEXOR) COMPARTMENT OF THE FOREARM				
Flexor pollicis longus (POL-li-sis = of the thumb)	Anterior surface of radius and interosseous membrane (sheet of fibrous tissue that holds shafts of ulna and radius together).	Base of distal phalanx of thumb.	Flexes distal phalanx of thumb at interphalangeal joint.	Median nerve.
Flexor digitorum profundus (prō-FUN-dus = deep)	Anterior medial surface of body of ulna.	Base of distal phalanx of each finger.	Flexes distal and middle phalanges of each finger at interphalangeal joints, proximal phalanx of each finger at metacarpophalangeal joint, and hand at wrist joint.	Median and ulnar nerves.
SUPERFICIAL POSTERIOR (EXTENSOR) COMPARTMENT OF THE FOREARM				
Extensor carpi radialis longus (eks-TEN-sor increases angle at joint)	Lateral supracondylar ridge of humerus.	Second metacarpal.	Extends and abducts hand at wrist joint (radial deviation).	Radial nerve.
Extensor carpi radialis brevis (BREV-is = short)	Lateral epicondyle of humerus.	Third metacarpal.	Extends and abducts hand at wrist joints (ulnar deviation).	Radial nerve.
Extensor digitorum	Lateral epicondyle of humerus.	Distal and middle phalanges of each finger.	Extends distal and middle phalanges of each finger at interphalangeal joints, proximal phalanx of each finger at metacarpophalangeal joint, and hand at wrist joint.	Radial nerve.
Extensor digiti minimi (DIJ-i-tē MIN-i-mē; *digit* = finger or toe; *minimi* = smallest)	Lateral epicondyle of humerus.	Tendon of extensor digitorum on fifth phalanx.	Extends proximal phalanx of little finger at metacarpophalangeal joint and hand at wrist joint.	Deep radial nerve.
Extensor carpi ulnaris	Lateral epicondyle of humerus and posterior border of ulna.	Fifth metacarpal.	Extends and adducts hand at wrist joint (ulnar deviation).	Deep radial nerve.
DEEP POSTERIOR (EXTENSOR) COMPARTMENT OF THE FOREARM				
Abductor pollicis longus (ab -DUK-tor = moves part away from midline)	Posterior surface of middle of radius and ulna and interosseous membrane.	First metacarpal.	Abducts and extends thumb at carpometacarpal joint and abducts hand at wrist joint.	Deep radial nerve.
Extensor pollicis brevis	Posterior surface of middle of radius and interosseous membrane.	Base of proximal phalanx of thumb.	Extends proximal phalanx of thumb at metacarpophalangeal joint, first metacarpal of thumb at carpometacarpal joint, and hand at wrist joint.	Deep radial nerve.
Extensor pollicis longus	Posterior surface of middle of ulna and interosseous membrane.	Base of distal phalanx of thumb.	Extends distal phalanx of thumb at interphalangeal joint, first metacarpal of thumb at carpometacarpal joint, and abducts hand at wrist joint.	Deep radial nerve.
Extensor indicis (IN-di-kis = index)	Posterior surface of ulna and interosseous membrane.	Tendon of extensor digitorum of index finger.	Extends distal and middle phalanges of index finger at interphalangeal joints, proximal phalanx of index finger at metacarpophalangeal joint, and hand at wrist joint.	Deep radial nerve.

*Reminder: The thumb or pollex is the first digit and has two phalanges: proximal and distal. The remaining digits, the fingers, are numbered II–V (2–5), and each has three phalanges: proximal, middle, and distal.

CONTINUES

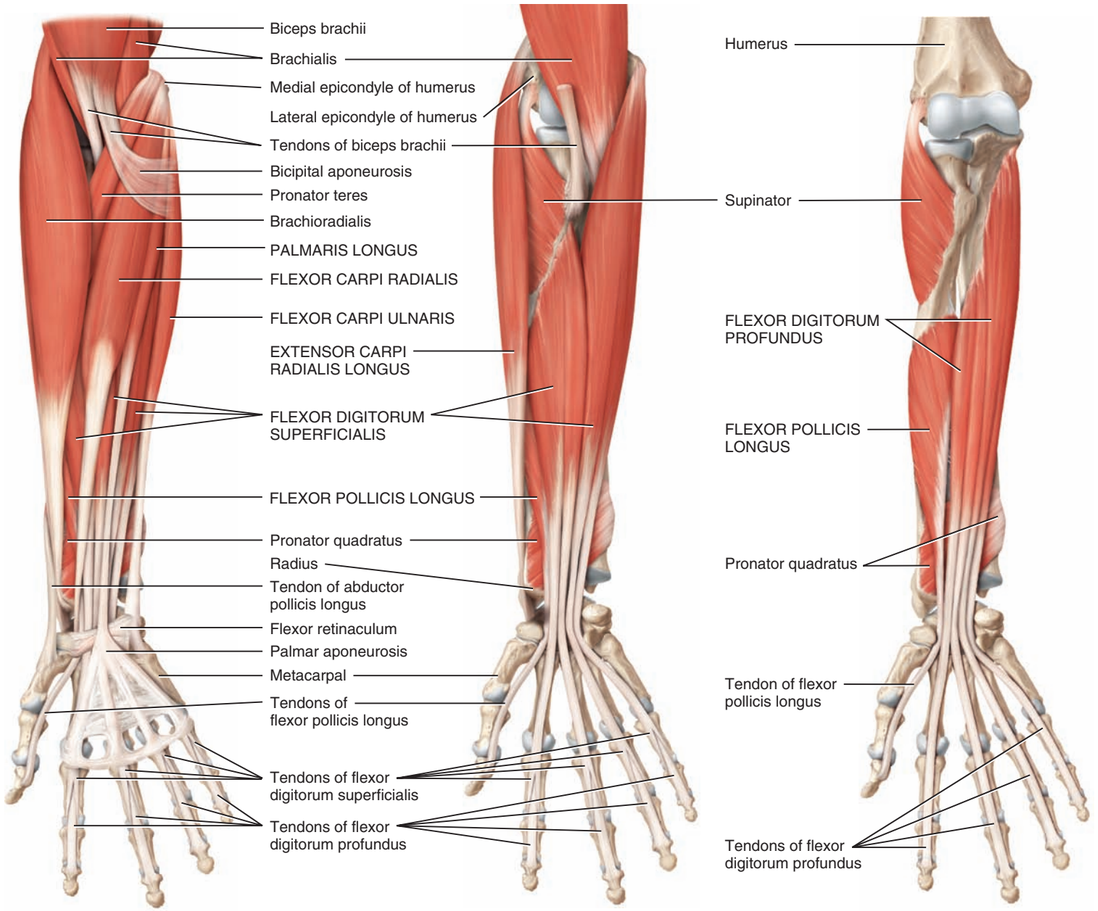
tendons that insert into the middle and distal phalanges of the fingers), **extensor digiti minimi** (a slender muscle usually connected to the extensor digitorum), and the **extensor carpi ulnaris.**

The **deep posterior compartment** muscles are arranged in the following order from lateral to medial: **abductor pollicis longus, extensor pollicis brevis, extensor pollicis longus,** and **extensor indicis.**

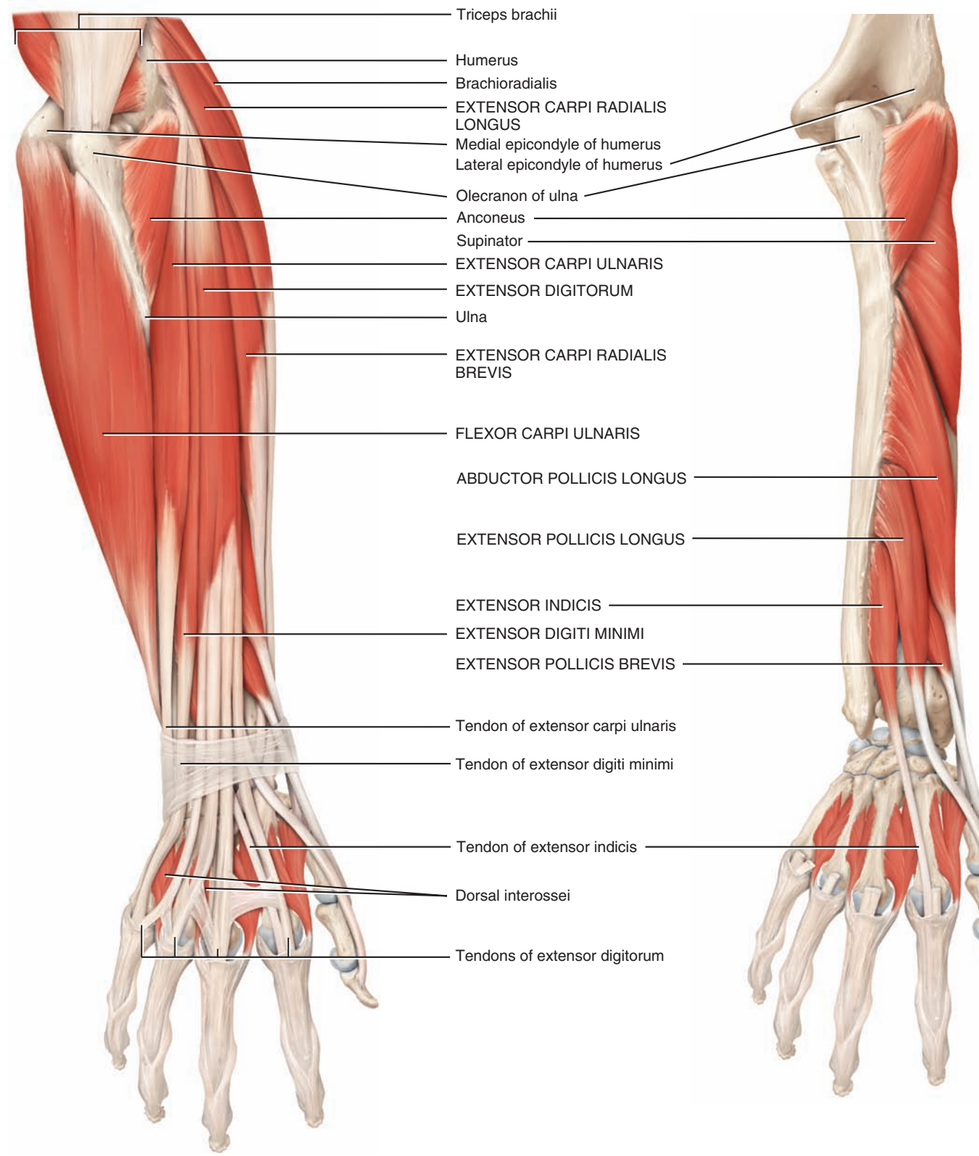
The tendons of the muscles of the forearm that attach to the wrist or continue into the hand, along with blood vessels and nerves, are held close to bones by strong fasciae. The tendons are also surrounded by tendon sheaths. At the wrist, the deep fascia is thickened into fibrous bands called **retinacula** (*retinacul* = a holdfast). The **flexor retinaculum** is located over the palmar surface of the carpal bones. The long flexor tendons of the digits and wrist and the median nerve pass deep to the flexor retinaculum (Figure 13.9). The **extensor retinaculum** is located over the dorsal surface of the carpal bones. The extensor tendons of the wrist and digits pass deep to it.

Figure 13.8 Muscles of the forearm that move the wrist, hand, thumb and digits.

The anterior compartment muscles function as flexors, adductors, and abductors. The posterior compartment muscles function as extensors, adductors, and abductors.



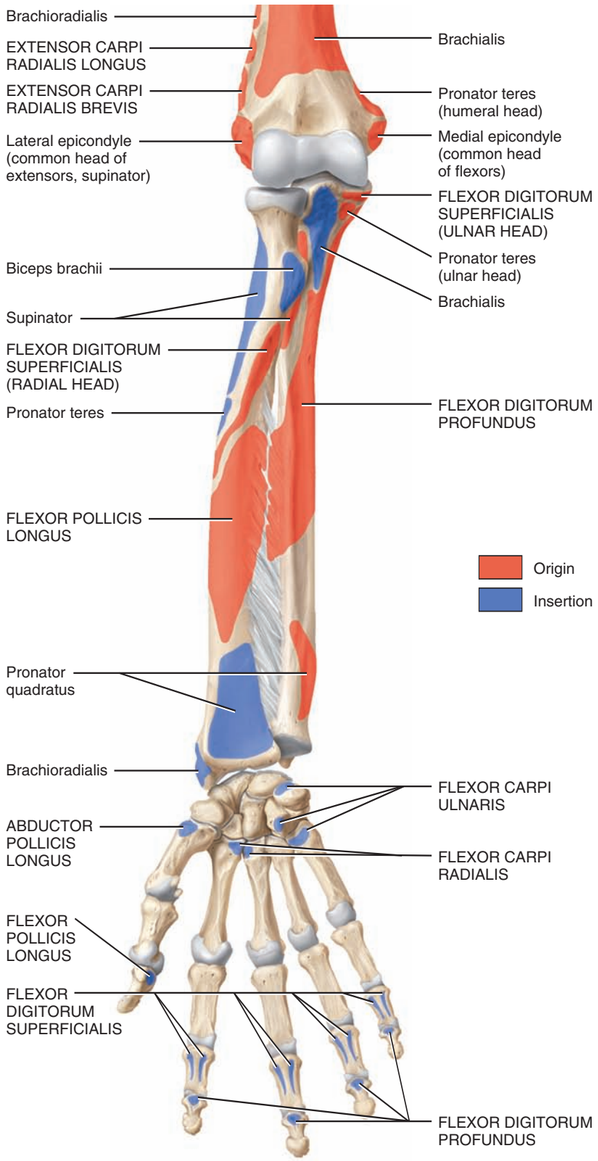
(a) Anterior superficial view (b) Anterior intermediate view (c) Anterior deep view



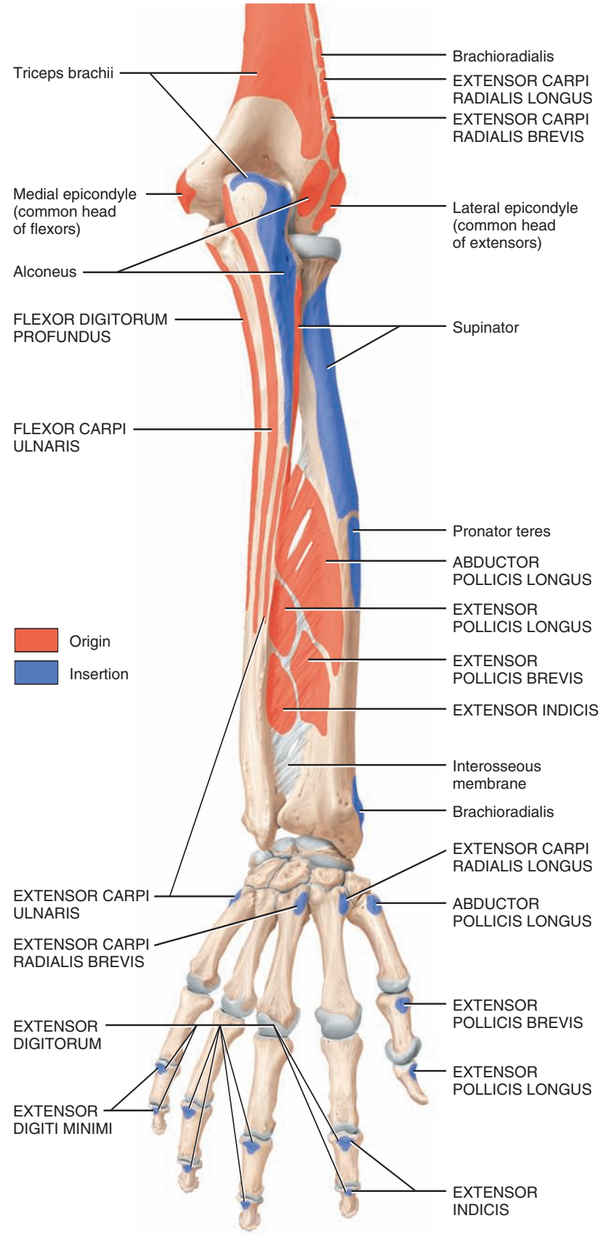
(d) Posterior superficial view (e) Posterior deep view

CONTINUES

Figure 13.8 (continued)



(f) Anterior view



(g) Posterior view

? **Which of the flexor muscles does not pass deep to the flexor retinaculum?**

CONTINUES

MANUAL THERAPY APPLICATION

Repetitive Strain Injuries

Repetitive strain or motion injuries (RSIs) include a large number of conditions resulting from overuse of equipment, poor posture, poor body mechanics, or activity that requires repeated movements; for example, various conditions of assembly line workers. Examples of overuse of equipment include overuse of a computer, hammer, guitar, or piano, to name a few.

Tennis elbow can be caused by strain of the extensor muscles of the forearm. It is so named because a series of forceful backhand strokes in tennis can cause pain of the lateral elbow joint (lateral epicondylitis). The extensor muscles strain or sprain, resulting in pain. Tennis elbow can be caused by a sudden trauma or repetitive actions in many types of daily activities.

Little-league elbow typically develops as a result of a heavy pitching schedule and/or a schedule that involves throwing curve balls, especially among youngsters. In this disorder, the elbow may enlarge, fragment, or separate.

Golfer's elbow can be caused by strain of the flexor muscles, especially flexor carpi radialis, as a result of repetitive movements such as swinging a golf club. Strain can, however, be caused by many actions. Pianists, violinists, movers, weight lifters, bikers, and those who use computers are among those who may develop pain near the medial epicondyle (medial epicondylitis).

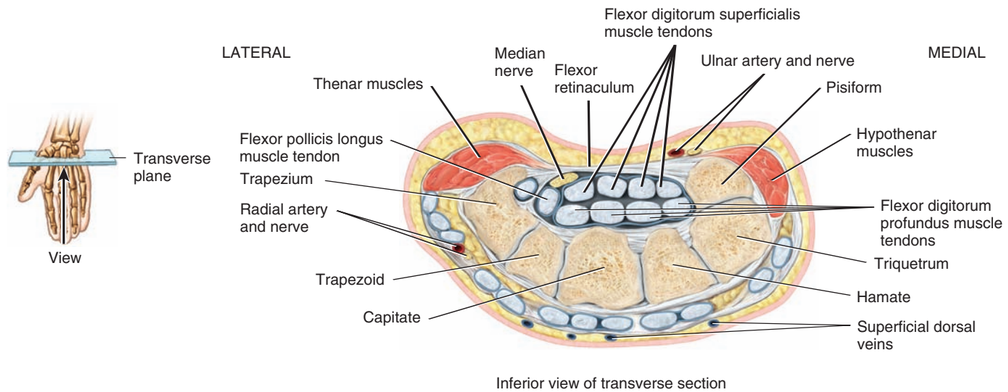
Carpal tunnel pain is caused by compression of the median nerve. The carpal tunnel is a narrow passageway formed anteriorly by the flexor retinaculum and posteriorly by the carpal bones. Through this tunnel pass the median nerve, the most superficial structure, and the long flexor tendons for the digits (Figure 13.9). Structures within the carpal tunnel, especially the median nerve, are vulnerable to compression, and the resulting condition is known as carpal tunnel syndrome. The person may experience numbness, tingling, or pain of the wrist and hand. Compression within the tunnel usually results from inflamed and thickened tendon sheaths of flexor tendons, fluid retention, excessive exercise, infection, trauma, and/or repetitive activities that involve flexion of the wrist such as keyboarding, cutting hair, and playing a piano.

Treatment may be progressive if the problem worsens. Initial treatment may include aspirin or ibuprofen (both are anti-inflammatory drugs). Treatment may progress to an injection of cortisone into the carpal tunnel. Persons may be asked to keep the wrist straight to minimize movement of the inflamed tendon sheaths; some type of splint or brace may be prescribed. Continued pain may necessitate surgery to cut (release) the transverse carpal ligament and thus relieve the compression of the nerve. It should be noted that "carpal tunnel pain" can also be caused by compression of the median nerve in two areas of the shoulder. When this occurs, carpal tunnel surgery will not alleviate the pain. Furthermore, scar tissue formed after the surgery may exacerbate the problem. Nerve compression in the shoulder area is discussed in Chapter 16.

Compression of the median nerve can also occur between the anterior and middle scalenes (see Figure X.X) or deep to the pectoralis minor (see Figure 12.X). Pain in the wrist or hand is perceived by the patient that is identical to the pain of true carpal tunnel syndrome. Massage of the scalenes and pectoralis minor can usually lengthen those muscles and thereby reduce impingement on the median nerve. By lengthening these muscles, a manual therapist can usually determine within minutes whether the pain of the wrist and hand may be a function of the **thoracic outlet.**

Figure 13.9 Cross section of wrist.

The structure of the carpal tunnel is illustrated in relation to the thenar and hypothenar muscles.



? What nerve may become compressed within the carpal tunnel?

Relating Muscles to Movements

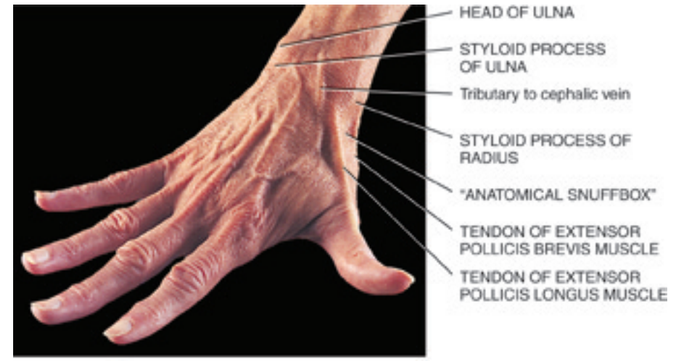
Arrange the muscles in this exhibit according to the following actions on the wrist joint: (1) flexion, (2) extension, (3) abduction, and (4) adduction; the following actions on the fingers at the metacarpophalangeal joints: (1) flexion and (2) extension; the following actions on the fingers at the interphalangeal joints: (1) flexion and (2) extension; the following actions on the thumb at the carpometacarpal, metacarpophalangeal, and interphalangeal joints: (1) extension and (2) abduction; and the following action on the thumb at the interphalangeal joint: flexion. The same muscle may be mentioned more than once.

CHECKPOINT

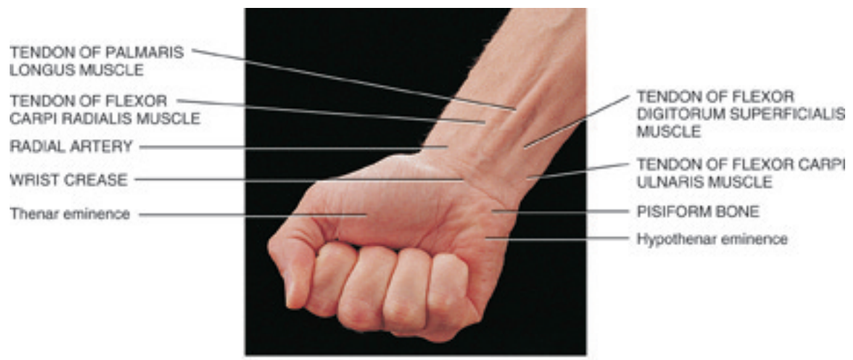
Which muscles and actions of the wrist, hand, and digits are used when writing?

Figure 13.10 Surface anatomy of the forearm and wrist.

Muscles of the forearm are most easily identified by locating their tendons near the wrist and tracing them proximally.



(a) Dorsum of wrist



(b) Anterior aspect of wrist

? What tendons form the boundaries of the "anatomical snuffbox"?

EXHIBIT 13.5 Muscles of the Palm That Move the Digits—Intrinsic Muscles of the Hand

OBJECTIVE

- Describe the origin, insertion, action, and innervation of the intrinsic muscles of the hand.

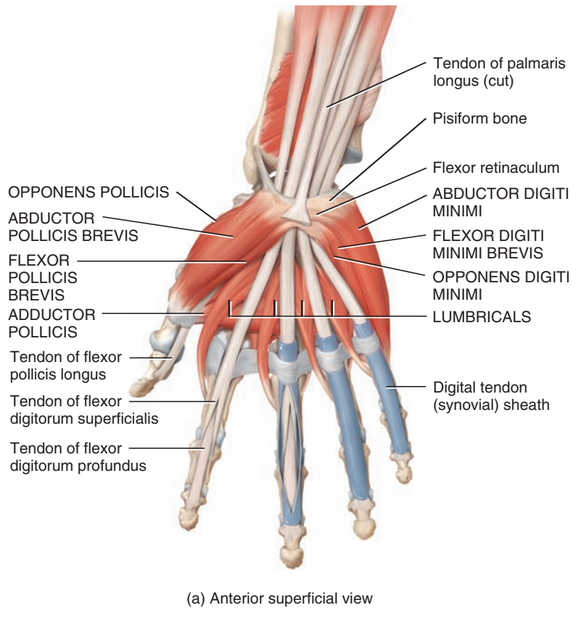
Several of the muscles discussed in Exhibit 13.4 move the digits in various ways and are known as extrinsic muscles of the hand. They produce the powerful but crude movements of the digits. The **intrinsic muscles of the hand** (Figure 13.11) in the palm produce the weak but intricate and precise movements of the digits that characterize the human hand. The muscles in this group are so named because their origins and insertions are *within* the hand.

The intrinsic muscles of the hand are divided into three group: (1) **thenar,** (2) **hypothenar,** and (3) **intermediate.** The thenar muscles include the abductor pollicis brevis, opponens pollicis, and flexor pollicis brevis. The **abductor pollicis brevis** is a thin, short, relatively broad superficial muscle on the lateral side of the thenar eminence. The **opponens pollicis** is a small, triangular muscle that is deep to the abductor pollicis brevis muscle. The **flexor pollicis brevis** is a short,

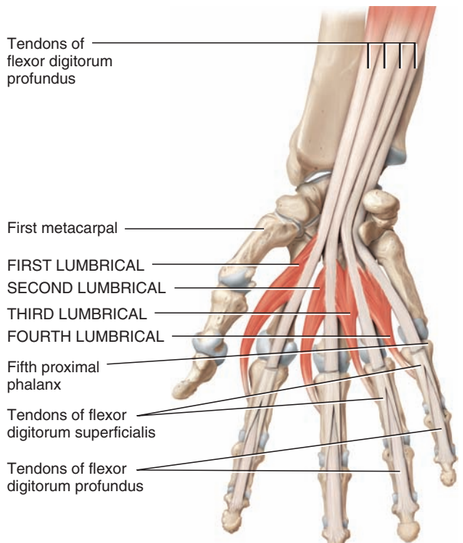
MUSCLE	ORIGIN	INSERTION	ACTION	INNERVATION
THENAR (LATERAL ASPECT OF PALM)				
Abductor pollicis brevis (ab-DUK-tor POL-li-sis BREV-is; *abductor* = moves part away from middle; *pollic-* = the thumb; *brevis* = short)	Flexor retinaculum, scaphoid, and trapezium.	Lateral side of proximal phalanx of thumb.	Abducts thumb at carpometacarpal joint.	Median nerve.
Opponens pollicis (op-PŌ-nenz = opposes)	Flexor retinaculum and trapezium.	Lateral side of first metacarpal (thumb).	Moves thumb across palm to meet any finger (opposition) at the carpometacarpal joint.	Median nerve.
Flexor pollicis brevis (FLEK-sor = decreases angle at joint)	Flexor retinaculum, trapezium, capitate, and trapezoid.	Lateral side of proximal phalanx of thumb.	Flexes thumb at carpometacarpal and metacarpophalangeal joints.	Median and ulnar nerves.
Adductor pollicis (ad-DUK-tor = moves part toward midline)	Oblique head: capitate and second and third metacarpals; transverse head: third metacarpal.	Medial side of proximal phalanx of thumb by a tendon containing a sesamoid bone.	Adducts thumb at carpometacarpal and metacarpophalangeal joints.	Ulnar nerve.
HYPOTHENAR (MEDIAL ASPECT OF PALM)				
Abductor digiti minimi (DIJ-ī-tē MIN-i-mē; *digit* = finger or toe; *minimi* = little)	Pisiform and tendon of flexor carpi ulnaris.	Medial side of proximal phalanx of little finger.	Abducts and flexes little finger at metacarpophalangeal joint.	Ulnar nerve.
Flexor digiti minimi brevis	Flexor retinaculum and hamate.	Medial side of proximal phalanx of little finger.	Flexes little finger at carpometacarpal and metacarpophalangeal joints.	Ulnar nerve.
Opponens digiti minimi	Flexor retinaculum and hamate.	Medial side of fifth metacarpal (little finger).	Moves little finger across palm to meet thumb (opposition) at the carpometacarpal joint.	Ulnar nerve.
INTERMEDIATE (MIDPALMAR)				
Lumbricals (LUM-bri-kals; *lumbric-* = earthworm) (four muscles)	Lateral sides of tendons and flexor digitorum profundus of each finger.	Lateral sides of tendons of extensor digitorum on proximal phalanges of each finger.	Flex each finger at metacarpophalangeal joints and extend each finger at interphalangeal joints.	Median and ulnar nerves.
Palmar interossei (PAL-mar in′-ter-OS-ē-ī; *palmar* = palm; *inter-* = between: *-ossei* = bones) (three muscles)	Sides of shafts of metacarpals of all digits (except the middle one).	Sides of bases of proximal phalanges of all digits (except the middle one).	Adduct each finger at metacarpophalangeal joints, flex each finger at metacarpophalangeal joints, and extend each finger at interphalangeal joints.	Ulnar nerve.
Dorsal interossei (DOR-sal in′-ter-OS-ē-ī; *dorsal* = back surface) (four muscles).	Adjacent sides of metacarpals.	Proximal phalanx of each finger.	Abduct fingers 2–4 at metacarpophalangeal joints, flex fingers 2–4 at metacarpophalangeal joints, and extend each finger at interphalangeal joints.	Ulnar nerve.

Figure 13.11 Muscles of the palm that move the digits—intrinsic muscles of the hand.

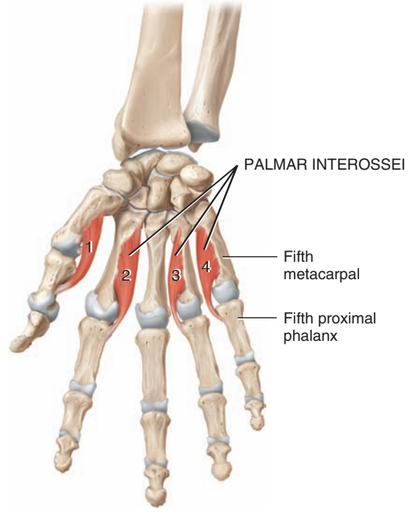
The intrinsic muscles of the hand produce the intricate and precise movements of the digits that characterize the human hand.



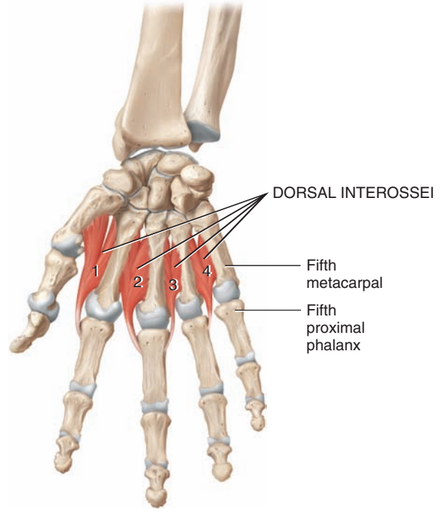
(a) Anterior superficial view



(b) Anterior intermediate view showing lumbricals



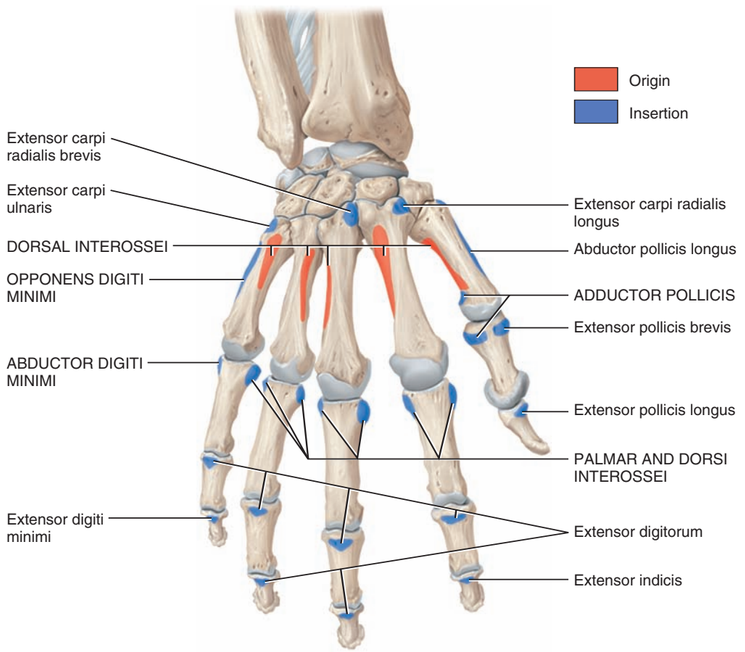
(c) Anterior deep view of palmar interossei



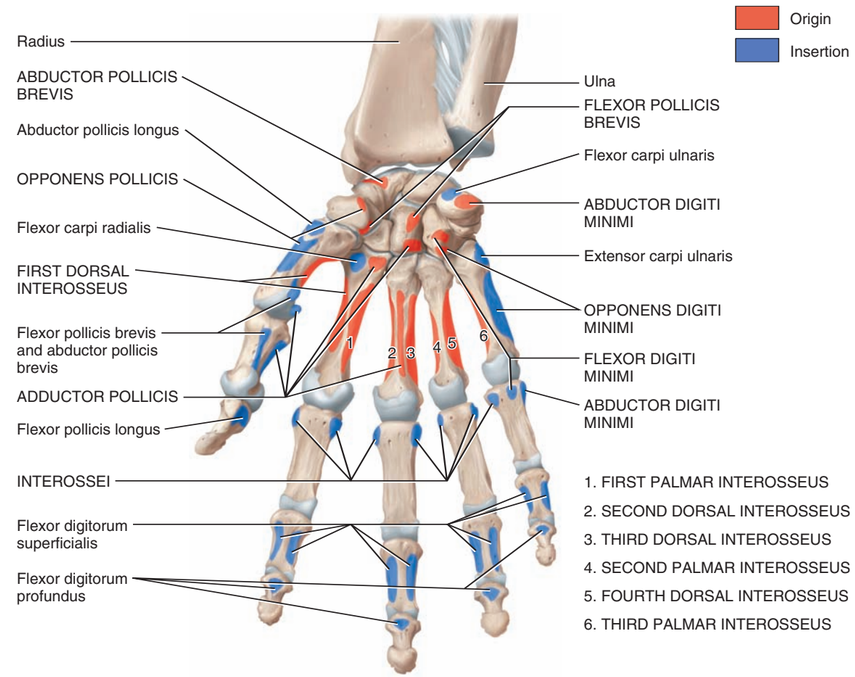
(d) Anterior deep view of dorsal interossei

CONTINUES

Figure 13.11 (continued)



(f) Posterior view



(e) Anterior view

(g) Movements of the thumb

? **Muscles of the thenar eminence act on which digit?**

wide muscle that is medial to the abductor pollicis brevis muscle. The three thenar muscles plus the adductor pollicis form the **thenar eminence,** the lateral rounded contour on the palm that is also called the *ball of the thumb.* The **adductor pollicis** also acts on the thumb. The muscle is fan-shaped and has two heads (oblique and transverse) separated by a gap through which the radial artery passes.

The three hypothenar muscles act on the little finger and form the **hypothenar eminence,** the medial rounded contour on the palm that is also called the *ball of the little finger.* The hypothenar muscles are the abductor digiti minimi, flexor digiti minimi brevis, and opponens digiti minimi. The **abductor digiti minimi** is a short, wide muscle and is the most superficial of the hypothenar muscles. It is a powerful muscle that plays an important role in grasping an object with outspread fingers. The **flexor digiti minimi brevis** muscle is also short and wide and is lateral to the abductor digiti minimi muscle. The **opponens digiti minimi** muscle is triangular and deep to the other two hypothenar muscles.

The 11 intermediate (midpalmar) muscles act on all the digits. The intermediate muscles include the lumbricals, palmar interossei, and dorsal interossei. The **lumbricals** (= worm-shaped), as their name indicates, are squiggly. They originate from and insert into the tendons of other muscles (flexor digitorum profundus and extensor digitorum). The **palmar interossei** are the smaller and more anterior of the interossei muscles. The **dorsal interossei** are the posterior interossei muscles. Both sets of interossei muscles are located between the metacarpals and are important in abduction, adduction, flexion, and extension of the fingers, and in movements in skilled activities such as writing, typing, and playing a piano.

The functional importance of the hand is readily apparent when you consider that certain hand injuries can result in permanent disability. Most of the dexterity of the hand depends on movements of the thumb. The general activities of the hand are free motion, power grip (forcible movement of the fingers and thumb against the palm, as in squeezing), precision handling (a change in position of a handled object that requires exact control of finger and thumb positions, as in winding a watch or threading a needle), and pinch (compression between the thumb and index finger or between the thumb and first two fingers).

Movements of the thumb are very important in the precise activities of the hand, and they are defined in different planes from comparable movements of other digits because the thumb is positioned at a right angle to the other digits. The five principal movements of the thumb are illustrated in Figure 13.11e and include *flexion* (movement of the thumb medially across the palm), *extension* (movement of the thumb laterally away from the palm), *abduction* (movement of the thumb in an anteroposterior plane away from the palm), *adduction* (movement of the thumb in an anteroposterior plane toward the palm), and *opposition* (movement of the thumb across the palm so that the tip of the thumb meets the tip of a finger). Opposition is the single most distinctive digital movement that gives humans and other primates the ability to grasp and manipulate objects precisely.

CONTINUES

Surface Features of the Hand

The ***hand,*** or *manus,* is the region from the wrist to the termination of the upper limb; it has several conspicuous surface features (Figure 13.12).

- **Knuckles.** Commonly refers to the dorsal aspect of the heads of metacarpals 2–5 (or II–V), but also includes the dorsal aspects of the metacarpophalangeal and interphalangeal joints.
- **Dorsal venous network of the hand (dorsal venous arch).** Superficial veins on the dorsum of the hand that drain blood into the cephalic vein. It can be displayed by compressing the blood vessels at the wrist for a few moments as the hand is opened and closed.
- **Tendon of extensor digiti minimi muscle.** This can be seen on the dorsum of the hand in line with the phalanx of the little finger.
- **Tendons of extensor digitorum muscle.** These can be seen on the dorsum of the hand in line with the phalanges of the ring, middle, and index fingers.

Relating Muscles to movements

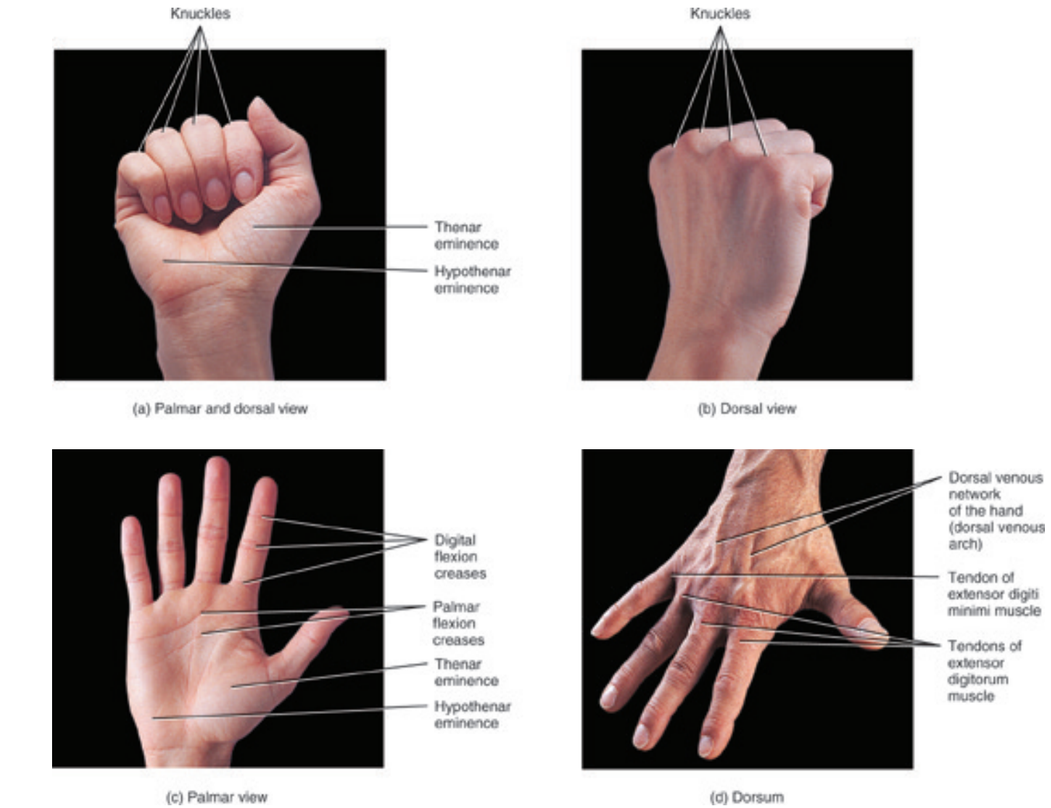
Arrange the muscles in the exhibit according to the following actions on the thumb at the carpometacarpal and metacarpophalangeal joints: (1) abduction, (2) addiction, (3) flexion, and (4) opposition; and the following actions on the fingers at the metacarpophalangeal and interphalageal joints: (1) abduction (2) adduction, (3) flexion, and (4) extension. The same muscle may be mentioned more than once.

CHECKPOINT

How do the actions of the extrinsic and intrinsic muscles of the hand differ?

Figure 13.12 Surface anatomy of the hand.

Several tendons on the dorsum of the hand can be identified by their alignment with the phalanges of the digits.



? What muscles form the hypothenar eminence?

FPO

STUDY OUTLINE

Muscles that move the pectoral girdle (Exhibit 13.1)

1. Muscles that move the pectoral girdle stabilize the scapula so it can function as a stable point of origin for most of the muscles that move the humerus.
2. Anterior thoracic muscles that move the pectoral girdle are the subclavius, pectoralis minor, and serratus anterior.
3. Posterior thoracic muscles that move the pectoral girdle are the trapezius, levator scapulae, rhomboid major, and rhomboid minor.
4. The serratus anterior is an antagonist of the rhomboids and is responsible for abduction of the scapula.
5. The trapezius is the most superficial muscle of the back with three sets of fibers (superior, middle, and inferior) that enable this muscle to cause multiple actions.

Muscles that move the humerus (Exhibit 13.2)

1. Muscles that move the humerus originate for the most part on the scapula; the remaining muscles originate on the axial skeleton.
2. The two axial muscles that move the humerus, the pectoralis major and the latissimus dorsi, form the anterior and posterior axillary folds, respectively, and a twist in each muscle near the insertion increases the contraction strength.
3. The prominence of the shoulder is formed by the deltoid muscle, a frequent site of intramuscular injection.
4. The rotator (musculotendinous) cuff muscles, which include the supraspinatus, infraspinatus, teres minor, and subscapularis, strengthen and stabilize the shoulder joint.

Muscles that move the radius and ulna (Exhibit 13.3)

1. Muscles that move the radius and ulna are involved in flexion and extension at the elbow joint and are organized into flexor and extensor compartments.
2. The biceps brachii muscle spans both the shoulder and elbow joints with two heads of origin (long and short), both from the scapula, and an insertion on the radius and bicipital aponeurosis.
3. The triceps brachii, the only muscle belly located in the posterior compartment of the arm, is an antagonist to the biceps brachii.
4. The axilla is a pyramid-shaped area at the junction of the arm and chest that contains blood vessels and nerves that pass between the neck and upper limbs.

Muscles that move the wrist, hand, and digits (Exhibit 13.4)

1. Muscles that move the wrist, hand, and digits are many and varied; those muscles that act on the digits are called extrinsic muscles of the hand.
2. Based on location and function, the muscles of the forearm are divided into two groups: (1) anterior (flexor) compartment muscles and (2) posterior (extensor) compartment muscles.
3. The superficial anterior muscles of the forearm have a common origin on the medial epicondyle of the humerus, insert on the carpals, metacarpals, and phalanges, and function as flexors.
4. The superficial posterior muscles of the forearm have a common origin on the lateral epicondyle of the humerus, insert on the metacarpals and phalanges, and function as extensors.
5. Carpal tunnel syndrome is caused by compression of the median nerve within the narrow passageway formed anteriorly by the flexor retinaculum and posteriorly by carpal bones.
6. Several muscles of the forearm are more easily identifiable by their tendons.

Intrinsic muscles of the hand (Exhibit 13.5)

1. The intrinsic muscles of the hand are important in skilled activities and provide humans with the ability to grasp and manipulate objects precisely.
2. The thenar muscles act on the thumb and form the lateral aspect of the palm (thenar eminence).
3. The hypothenar muscles act on the little finger and form the medial aspect of the palm (hypothenar eminence).
4. The hand contains the extensor tendons on the dorsum, and the thenar and hypothenar eminences on the palm.
5. The intermediate (midpalmar) muscles act on the digits and include the lumbricals, palmar interossei, and dorsal interossei.

SELF-QUIZ QUESTIONS

1. Impingement syndrome, common among athletes, is usually caused by the frequent pinching of
   a. coracobrachialis **b.** deltoid
   c. subscapularis **d.** supraspinatus.
2. Pronator quadratus originates on the _____ and inserts on the _____.
   a. radius; radius **b.** radius; ulna
   c. ulna; ulna **d.** ulna; radius
3. Which of the following muscles is NOT innervated by the median nerve?
   a. flexor carpi radialis **b.** flexor digitorum superficialis
   c. flexor carpi ulnaris **d.** palmaris longus
4. Which muscle is commonly called the "swimmer's muscle"?
   a. deltoid **b.** latissimus dorsi
   c. pectoralis major **d.** supraspinatus
5. Which of the following muscles does not adduct the scapula?
   a. rhomboid major **b.** rhomboid minor
   c. serratus anterior **d.** trapezius
6. The anterior fibers of the deltoid _____ and _____ rotate the arm at the shoulder.
   a. extend; laterally **b.** extend; medially
   c. flex; laterally **d.** flex; medially
7. The muscle that originates on the medial epicondyle of the humerus and inserts on second and third metacarpals is the
   a. flexor carpi radialis
   b. flexor digitorum superficialis
   c. flexor carpi ulnaris
   d. palmaris longus.

8. The origin of the levator scapulae is
   a. C1–C4 **b.** C4–C8
   c. T1–T4 **d.** superior vertebral border of the scapula.
9. Which muscle is NOT innervated, at least partially, by the musculocutaneous nerve?
   a. brachialis **b.** biceps brachii
   c. brachioradialis **d.** coracobrachialis
10. Which of the following is not an innervation of the trapezius?
   a. accessory (cranial nerve XI)
   b. C2
   c. C3
   d. C4
11. The innervation of the triceps brachii is the _____ nerve.
   a. median **b.** radial
   c. musculocutaneous **d.** two of the above
12. Which muscle is NOT part of the rotator cuff?
   a. infraspinatus **b.** subscapularis
   c. teres major **d.** teres minor
13. Which of the following muscles does NOT originate on the scapula?
   a. infraspinatus **b.** subscapularis
   c. pectoralis major **d.** supraspinatus
14. Which of the following muscles inserts on the radial tuberosity and bicipital aponeurosis?
   a. biceps brachii **b.** brachioradialis
   c. brachialis **d.** coracobrachialis
15. The origin of the rhomboid minor is
   a. C7–T1 **b.** T2–T5
   c. C7–T5 **d.** C6–T6
16. Which muscle inserts on the middle of the medial surface of the shaft of the humerus?
   a. coracobrachialis **b.** latissimus dorsi
   c. supraspinatus **d.** teres minor
17. Which muscle usually originates on the third, fourth, and fifth ribs and inserts on the coracoid process?
   a. coracobrachialis **b.** pectoralis minor
   c. serratus anterior **d.** subclavius
18. Carpal tunnel syndrome may be caused by compression of the _____ nerve.
   a. median **b.** radial
   c. musculocutaneous **d.** ulnar
19. The brachialis inserts on the
   a. humerus **b.** radius
   c. ulna **d.** two of the above.
20. The tendon of palmaris longus lies
   a. deep to extensor retinaculum
   b. superficial to extensor retinaculum
   c. deep to flexor retinaculum
   d. superficial to flexor retinaculum.

CRITICAL THINKING QUESTIONS

1. Minor league pitcher José has been throwing a hundred pitches a day in order to perfect his curve ball. Lately he has experienced pain in his pitching arm. The doctor diagnosed a torn rotator cuff. José was confused because he thought his cuffs were only found on shirtsleeves, not inside his shoulder. Explain to José what the doctor means and how the injury could affect his arm movement.

ANSWERS TO FIGURE QUESTIONS

13.1 The main action of the muscles that move the pectoral girdle is to stabilize the scapula to assist in movements of the humerus.
13.2 The acromion of the scapula forms the top of the shoulder.
13.3 T/K
13.4 The subscapularis is the only rotator cuff muscle that inserts on the lesser tubercle located on the anterior humerus.
13.5 With the aid of a stethoscope, respiratory sounds can be heard clearly in the triangle of auscultation.
13.6 The brachialis is the most powerful forearm flexor; the triceps brachii is the most powerful forearm extensor.
13.7 The anterior axillary fold is formed by the pectoralis major muscle; the posterior axillary fold is formed by the latissimus dorsi and the teres major muscles.
13.8 The palmaris longus is the only flexor muscle of the anterior compartment of the forearm that does not pass under the flexor retinaculum.
13.9 The median nerve may become compressed within the carpal tunnel.
13.10 The "anatomical snuffbox" is formed by the tendons of the extensor pollicis brevis and extensor pollicis longus muscles.
13.11 Muscles of the thenar eminence act on the thumb.
13.12 The hypothenar eminence is formed by the abductor digiti minimi and opponens digiti minimi muscles.