distal rows of the transverse tarsal joint is inversion–eversion of the sole of the foot. This action enables you to adjust to uneven ground when walking or running. As in the hand, there are joints between the tarsal bones, metatarsals, and phalanges. They are strengthened by plantar ligaments that aid in maintaining the arch of the foot (weakened ligaments result in "flat foot," although you may be born with flat feet that cause you no discomfort).

Muscles of the Human Body

Muscles allow the skeleton to move. Most muscles are attached from one bone to another with a joint in between. The attachment closer to the centre of the body is the muscle's **origin** (also known as its *proximal attachment*). The attachment away from the centre of the body is the muscle's **insertion** (also known as its *distal attachment*). The origin of the muscle is usually attached to more stationary parts, whereas the insertion is attached to more mobile structures of the skeleton. Remember, muscles can only act on the joints they cross.

There are over 600 muscles present in the human body. It would be impossible to describe here all the muscles, so keep in mind that a short section in this chapter cannot do justice to the vast number and functions of these muscles. Only the major superficial muscles will be identified (Figures 2.24 and 2.25) as they relate to the bony regions discussed in the previous section.

Muscles of the Face

Facial muscles enable you to change expression and display your emotions outwardly; but most importantly, they allow you to close your eyes and your mouth (Figure 2.21). Closing the eyelids, as in blinking, acts to move tears across the cornea of the eye, keeping it moistened. When the eyeball is not kept moist, it will dry out and ulcerate, leading to discomfort and irritation, even blindness. People with paralysis of facial muscles will put artificial tears in their eyes to prevent this.

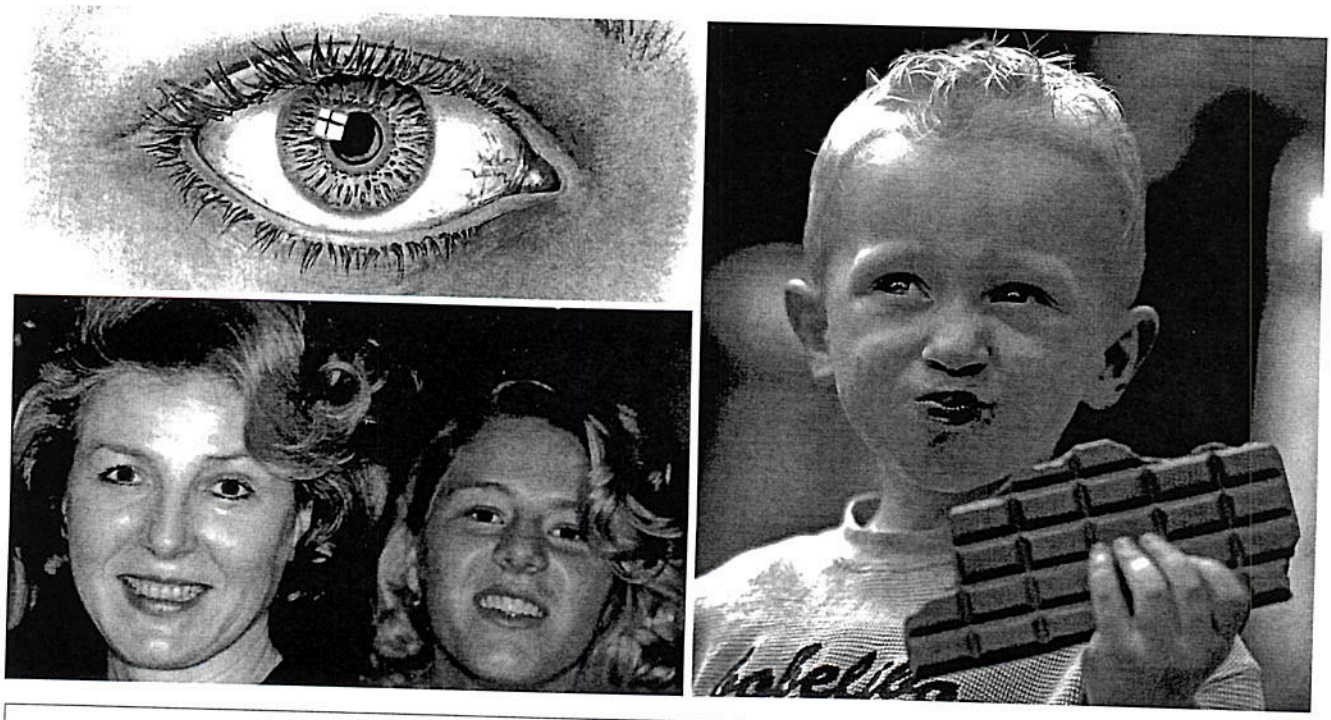


Figure 2.21 Facial muscles are essential for a variety of tasks, from smiling and blinking to chewing and speaking.

Facial muscles are also essential for opening and closing the mouth, thereby keeping food in the mouth and allowing you to move it between the teeth during chewing, to say nothing of forming words in speaking.

Muscles of the Neck and Back

The head sits on the first cervical vertebra (C1) called the atlas. To maintain this position there are muscles posterior, lateral, and anterior to the neck or cervical region that allow you to hold up your head, and also permit a wide range of movement. Try turning your own head while keeping your shoulders in a fixed position. The most important anterior pair of neck muscles are the **sternocleidomastoids** (Figure 2.22). Acting together, they are the muscles that allow you to flex your head towards your chest. Without them you cannot get up from a supine position (lying down). Individually, each sternocleidomastoid muscle tilts the face up and towards the opposite side.

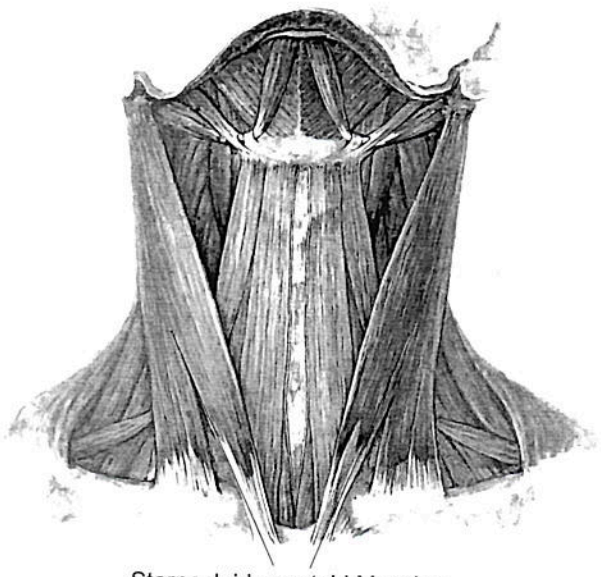


Figure 2.22 Anterior neck with sternocleidomastoid muscles.

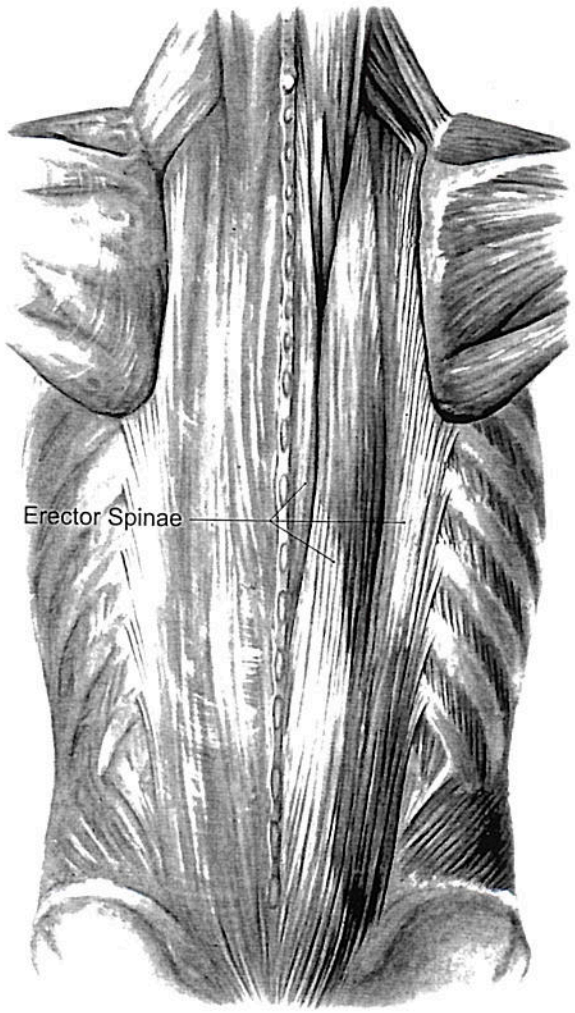


Figure 2.23 Deep posterior back muscles.

Posteriorly, there is a large muscle mass reaching in segments from the sacrum inferiorly, and to the skull superiorly, called the **erector spinae muscles** (Figure 2.23). They do what their name suggests – maintain your erect position. They are sometimes called the **anti-gravity muscles.** When someone faints, these muscles no longer function and the body falls face forward to the ground. Just imagine what it would be like if we were unable to keep our bodies upright – this ability to stand erect and walk on two feet is one feature that sets us apart from most other species.

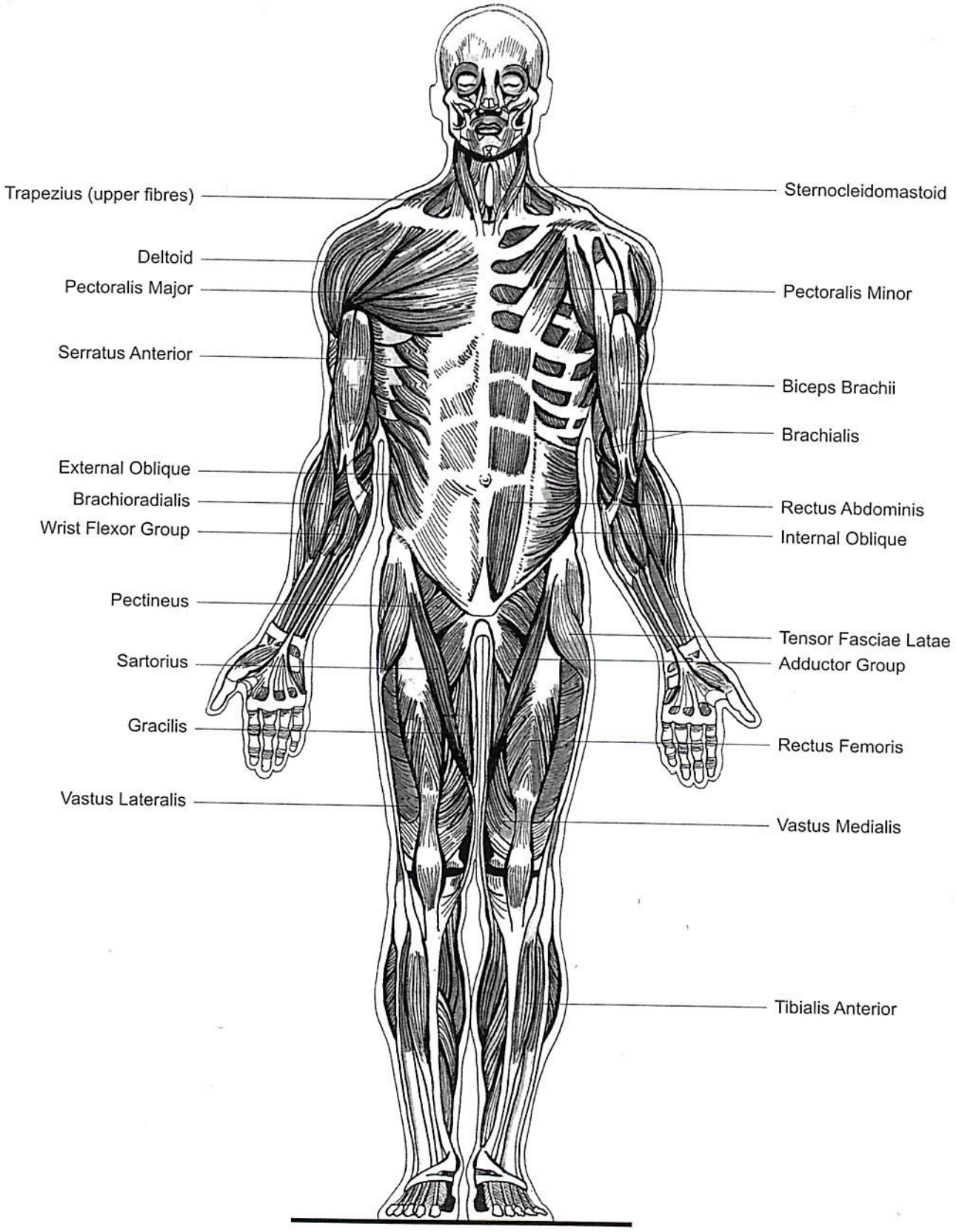


Figure 2.24 Anterior muscles of the human body.

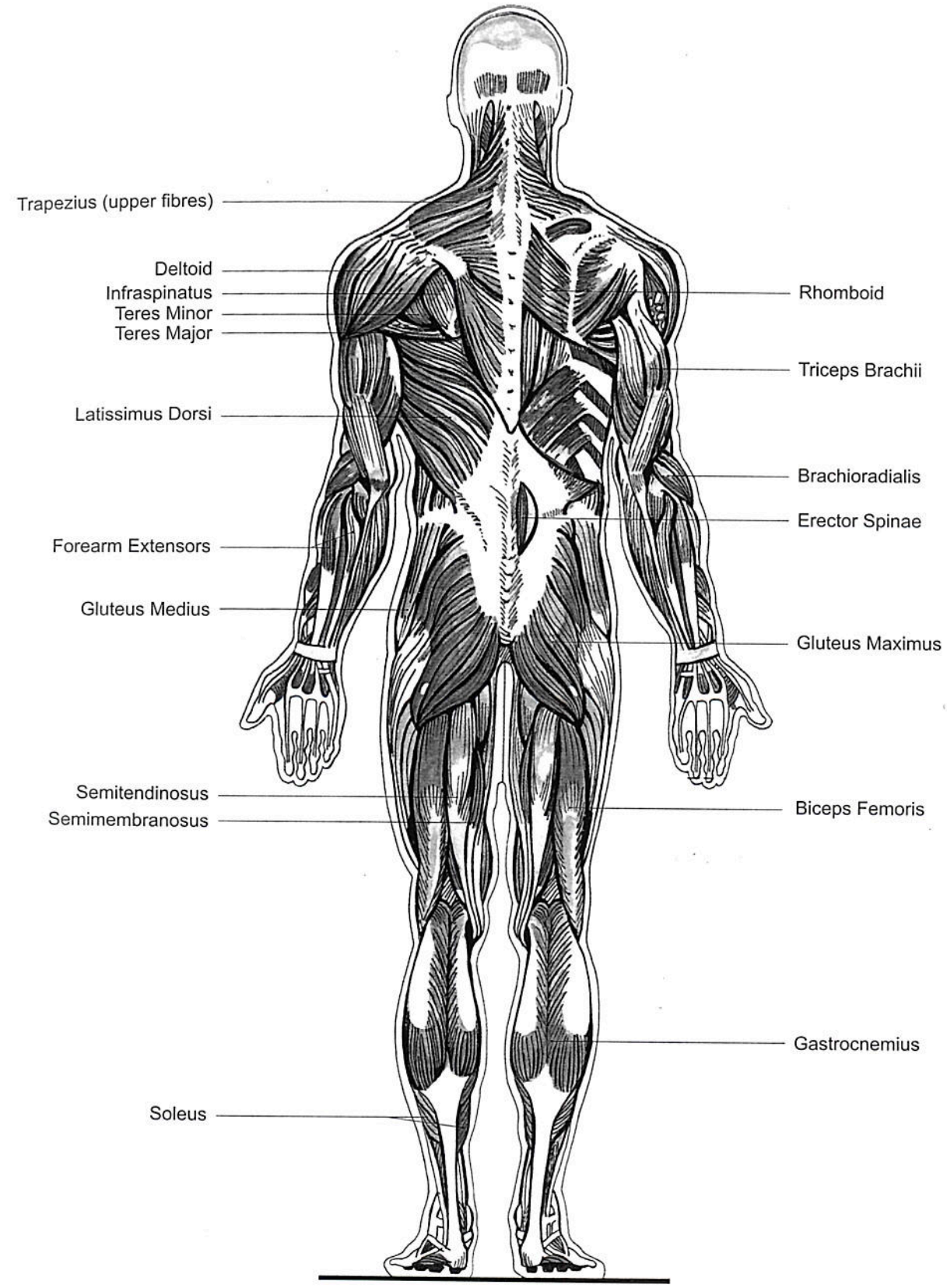


Figure 2.25 Posterior muscles of the human body.

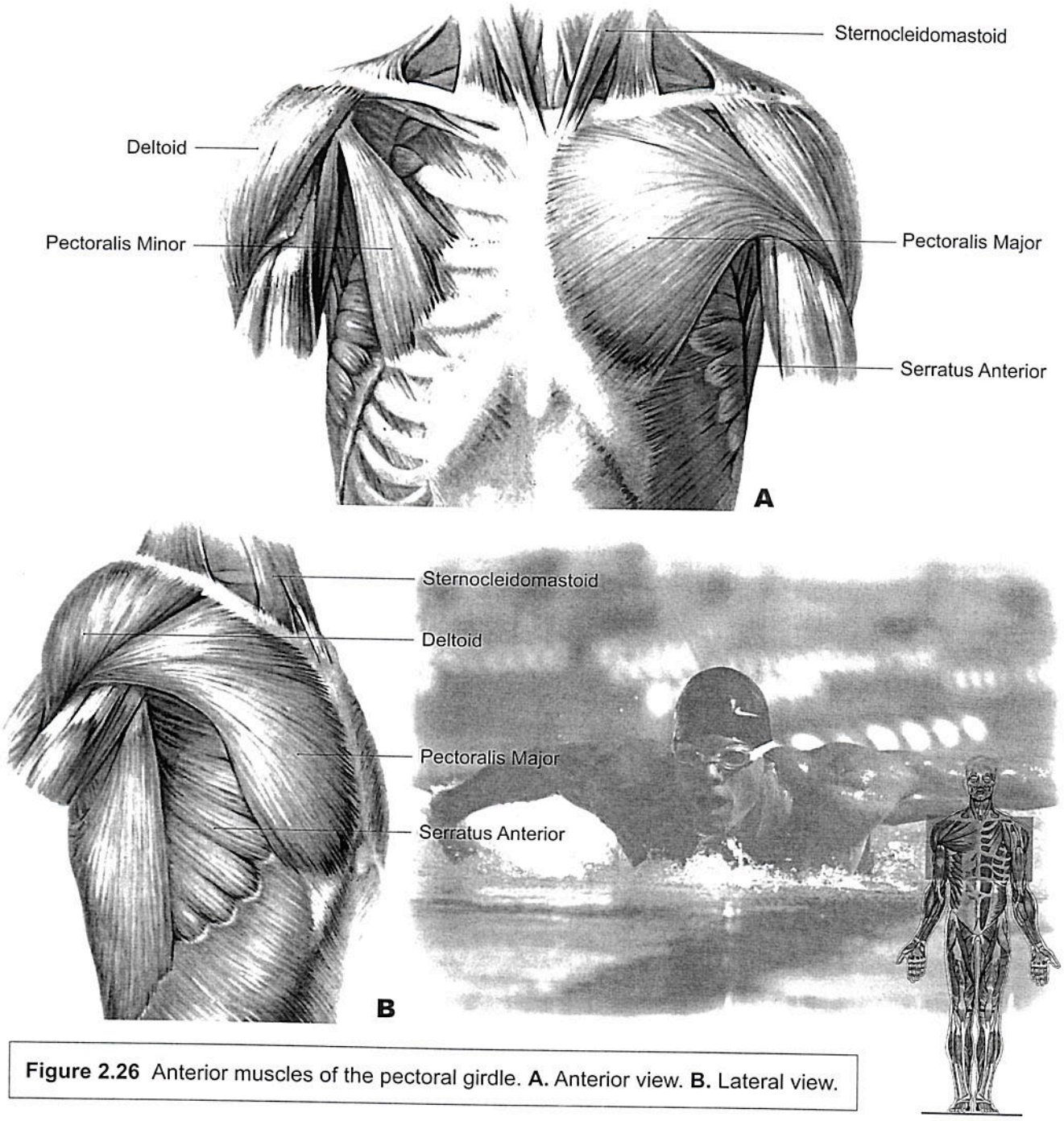


Figure 2.26 Anterior muscles of the pectoral girdle. **A.** Anterior view. **B.** Lateral view.

Muscles Connecting the Humerus and Scapula to the Axial Skeleton

Anterior and Posterior Groups

Muscles acting to hold the pectoral girdle to the chest wall can be divided into anterior and posterior groups as follows.

Anterior Group **Pectoralis major** has two heads. The clavicular head (attached to the clavicle) flexes and medially rotates the shoulder joint; the sternal head (attached to the sternum) extends the shoulder joint from a flexed position and medially rotates the shoulder joint. **Pectoralis minor** depresses and stabilizes the scapula. **Serratus anterior** steadies and holds the scapula forward (protracts it) against the chest wall (Figure

2.26). This frees the upper limb for actions such as rope climbing. These muscles as a group would also be required to perform the butterfly stroke in swimming.

Posterior Group **Trapezius** has three groups of fibres reflecting their relative positions. The *upper fibres* elevate the scapula, *middle fibres* retract the scapula, and *lower fibres* depress the scapula. **Latissimus dorsi** medially rotates, adducts, and extends the humerus, and **teres major** medially rotates the humerus (Figure 2.27).

Scapula–Humeral Region

The following muscles from the scapula to the humerus act across the shoulder joint. Their primary role is to stabilize the shoulder joint to allow full use of the upper limb.

Anterior Group **Subscapularis** adducts and medially rotates the upper limb. (Figure 2.27 C).

Superior and Posterior Group **Supraspinatus** initiates abduction of the upper limb at the shoulder joint. **Infraspinatus** and **teres minor** adduct and

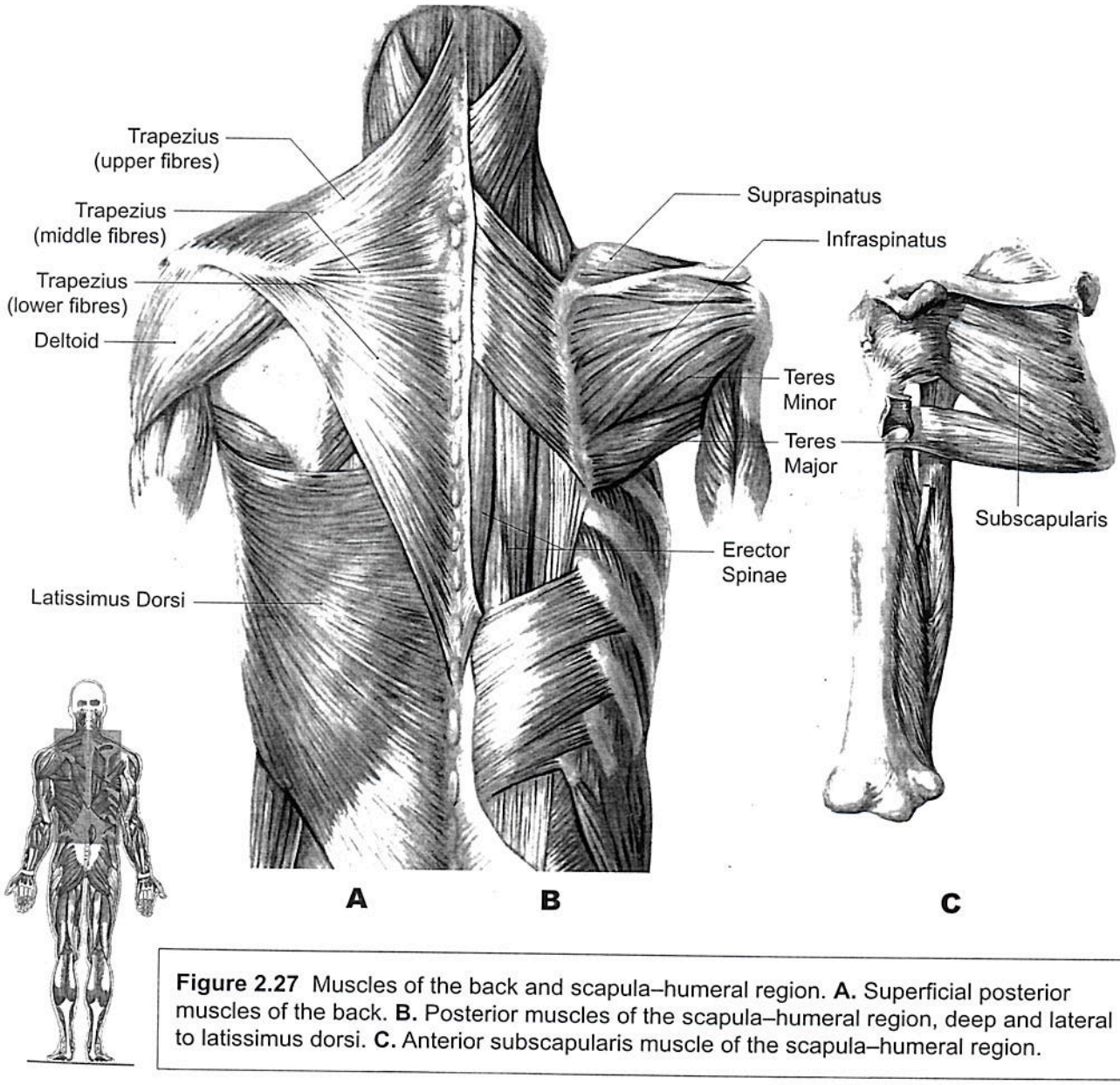


Figure 2.27 Muscles of the back and scapula–humeral region. **A.** Superficial posterior muscles of the back. **B.** Posterior muscles of the scapula–humeral region, deep and lateral to latissimus dorsi. **C.** Anterior subscapularis muscle of the scapula–humeral region.

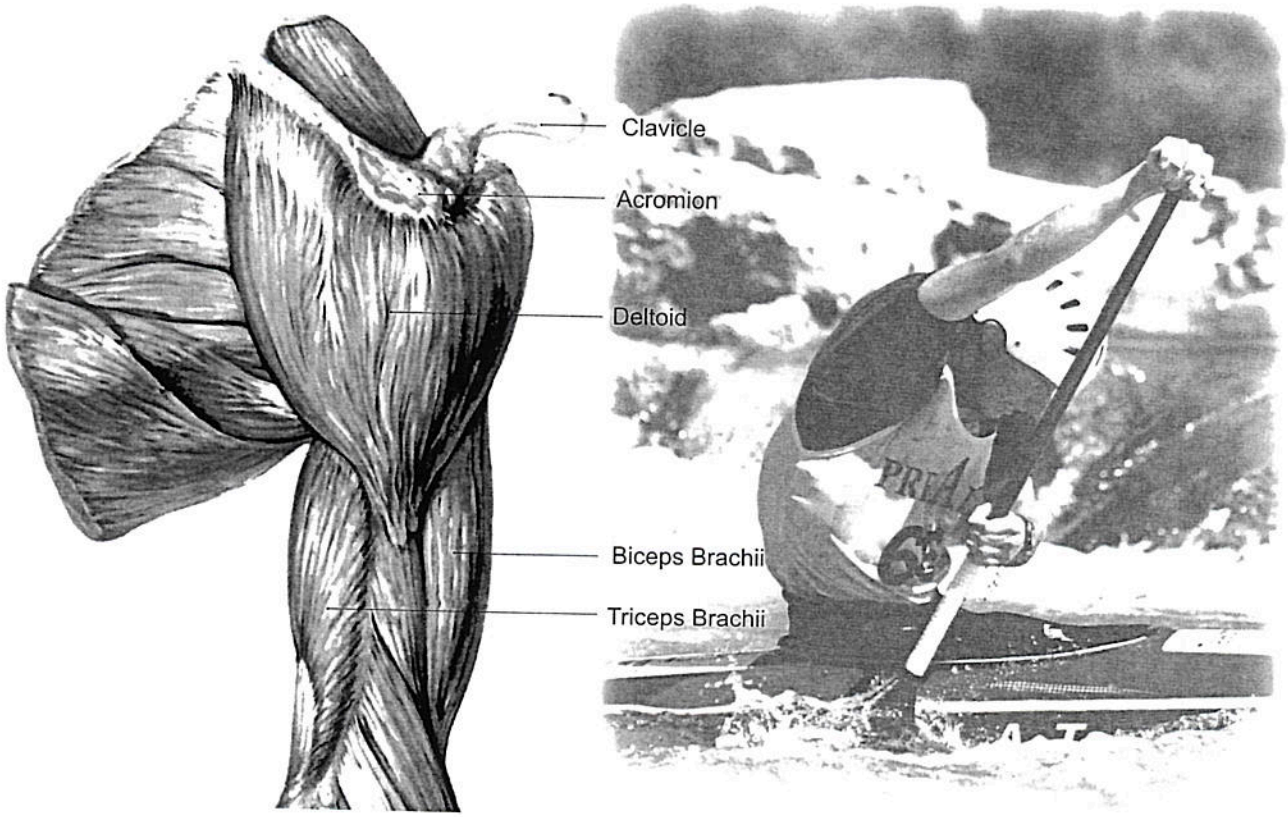


Figure 2.28 The lateral muscles of the scapula–humeral region.

laterally rotate the upper limb at the shoulder joint. These muscles, combined with subscapularis, are the **SSIT** (rotator cuff) muscles of the shoulder (Figure 2.27 B).

Lateral Group **Deltoid** has three functional groups of fibres. The *anterior fibres* flex and medially rotate the upper limb, the *middle fibres* abduct the upper limb, and the *posterior fibres* extend and laterally rotate the upper limb. All actions occur at the shoulder joint (Figure 2.28). The deltoid muscles are used extensively in paddling sports such as kayaking and canoeing.

Muscles of the Arm

Muscles of the limbs are primarily flexors or extensors. In the upper limb, the flexors are on the anterior surface of the arm, forearm, and hand, and the extensors are on the posterior surface. Some muscles from the scapula to the forearm span the arm to reach the radius and ulna of the forearm.

The muscles with proximal attachments to the humerus are divided by a strong fascial sheet of connective tissue into anterior and posterior compartments.

Anterior Compartment A muscle with two heads, both attached proximally to the scapula, the **biceps brachii** spans the arm to reach the radial tubercle of the radius. It is a powerful flexor of the elbow joint and supinator of the forearm (Figure 2.29 A). **Brachialis** is attached proximally to the anterior surface of the humerus and attaches distally to the coronoid process of the ulna. An important and powerful flexor of the elbow joint, it works along with the biceps brachii. To isolate brachialis in exercise, flex and pronate the forearm and perform repeated elbow curls.

Posterior Compartment Triceps brachii has three heads. The medial and lateral heads are attached to the humerus. They join with the long head from the scapula to attach distally to the olecranon process of the ulna. It is *the* powerful extensor of the elbow (Figure 2.29 B).

Muscles of the Forearm

The distal end of the humerus widens into lateral and medial epicondyles which provide attachments for muscle groups that act on the forearm and wrist.

The forearm muscles act on the elbow, wrist, and digits (fingers and thumb). Muscles attached to the medial epicondyle of the humerus are the **flexor–pronator** group (Figure 2.29 A) while those attached to the lateral epicondyle of the humerus are the **extensor–supinator** group (Figure 2.29 B).

One muscle attached above the lateral epicondyle of the humerus is the **brachioradialis** muscle. It is on the extensor side of the humerus but, because it is positioned anterior to the elbow joint, it acts as an elbow flexor, especially when the forearm is partially pronated. You use this muscle when you shake hands with someone.

Muscles of the Hand

These muscles are divided into groups. The **thenar (palm) group** acts on the thumb and its metacarpal to abduct, flex, and oppose the thumb tip to the four remaining digits. The

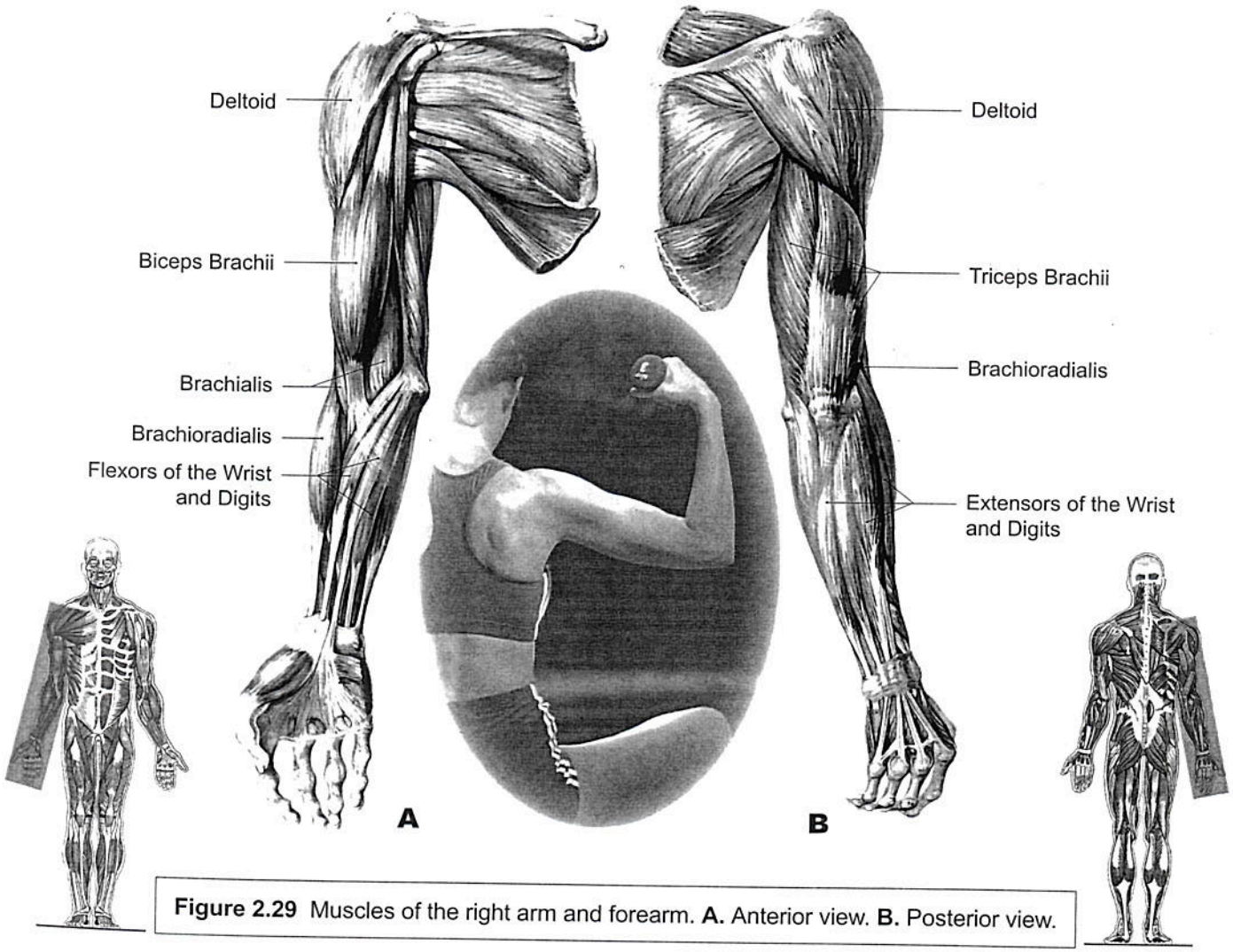


Figure 2.29 Muscles of the right arm and forearm. **A.** Anterior view. **B.** Posterior view.

hypothenar (little palm) group acts on the little finger and its metacarpal. Together the thenar and hypothenar muscles permit you to cup your hand as in holding a baseball. Between these two groups lie the **interossei** (between bones) and the **lumbrical** (earthworm) **muscles** that are referred to collectively as the **intrinsic** (within) muscles of the hand. Together they flex, extend, abduct, and adduct the fingers, positioning the digits for fine movements.

Muscles of the Pelvic Girdle

From the bony pelvis, muscles are attached that permit a wide range of movement in the lower limb; but here, stability and transfer of weight for walking are the prime focus, not the fine discriminatory movements that are necessary with the hands and fingers. Some of the muscles acting at the hip joint come from the abdomen; others come from the sacrum and external surface of the hip bone (os coxae).

Because the hip joint is a ball and socket joint, flexion–extension, abduction–adduction, medial and lateral rotation, as well as circumduction can all occur here. Try it yourself. Notice, however, that the movement here is more limited than at the shoulder joint.

Anterior Group **Psoas major** (from the abdomen) and **iliacus** (from the iliac fossa of the pelvis) unite to form the **iliopsoas** muscle that crosses the anterior aspect of the joint and is the primary flexor of the hip, allowing you to bring your thighs up to your chest or your chest to your knees (Figure 2.30).

Posterior and Lateral Group Large gluteal muscles cover the hip posteriorly. Put your hand on your hip and extend the joint. Feel the large muscle mass as it contracts. These are the three **gluteals**. The largest and most superficial posterior muscle, **gluteus maximus**, is the principal power extensor of the hip. **Gluteus medius** and **minimus** lie deep and lateral to maximus and in that order,

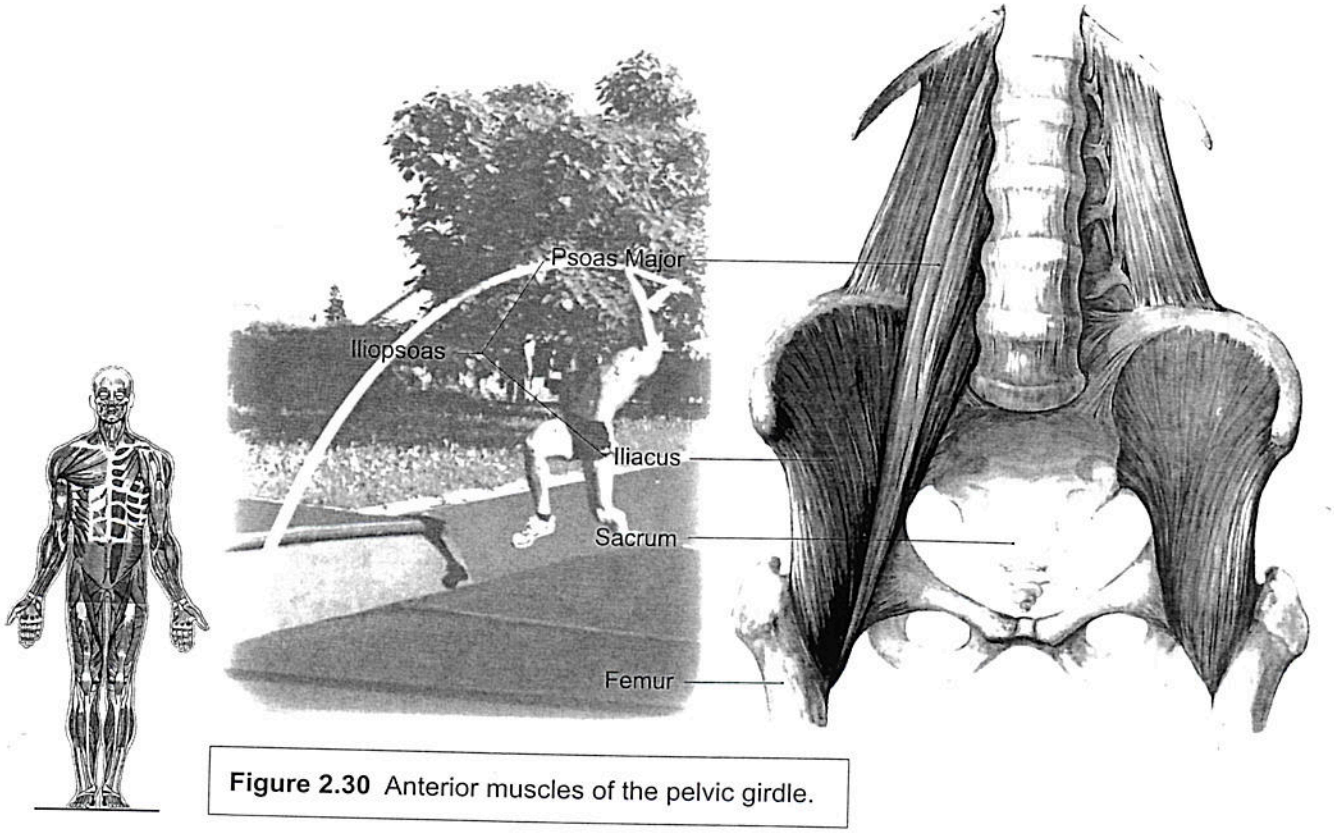


Figure 2.30 Anterior muscles of the pelvic girdle.

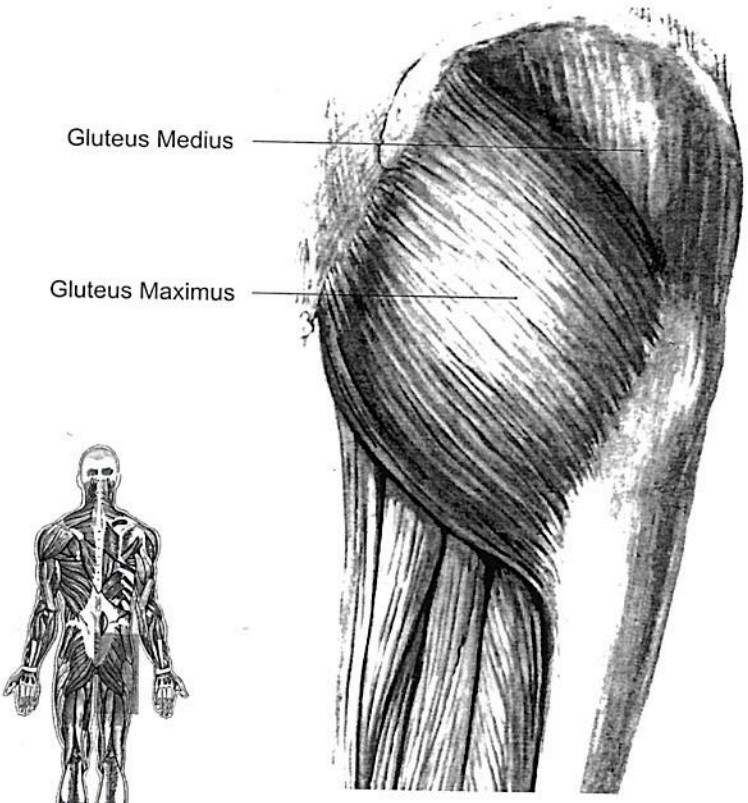


Figure 2.31 Posterior muscles of the pelvic girdle.

and have a very important role – they abduct the hip (Figure 2.31). This is a very important movement in normal gait, or walking (a skill that is required for so many physical activities). Deep to gluteus maximus are six little muscles that all perform the same job: they laterally (externally) rotate the hip.

Muscles of the Thigh

The thigh is divided very conveniently into three compartments: medial, anterior, and posterior. Like the arm, most of the muscles acting in these compartments are attached proximally to the pelvic girdle. Some will attach distally to the femur, others will span the entire length of the femur and attach to the bones of the leg.

Anterior Compartment The anterior group is the extensor group, also known as the **quads** or **quadriceps**. They are the **rectus** (*rectus* = straight) **femoris**, **vastus lateralis**, **vastus intermedius**, and **vastus medialis** (Figure 2.32 A). The principal role of the quads is to extend the knee. To kick a soccer ball the knee must come into full extension for maximum distance, utilizing these leg extensors. The **sartorius** muscle lies anterior to the quads and acts to abduct and flex the thigh at the hip, and to flex the knee. You use this muscle to dance the limbo or to sit cross-legged on the floor.

Medial Compartment This group of medial muscles has one primary action – that is, to adduct the thigh towards the midline. This action prevents your leg from swinging too wide laterally as you walk. It is also the group of muscles you would use to stay on a horse. As their action implies, they are the adductor muscles comprised of **pectineus**, **adductor longus**, **adductor brevis**, and **adductor magnus**, as well as **gracilis** (Figure 2.32 B).

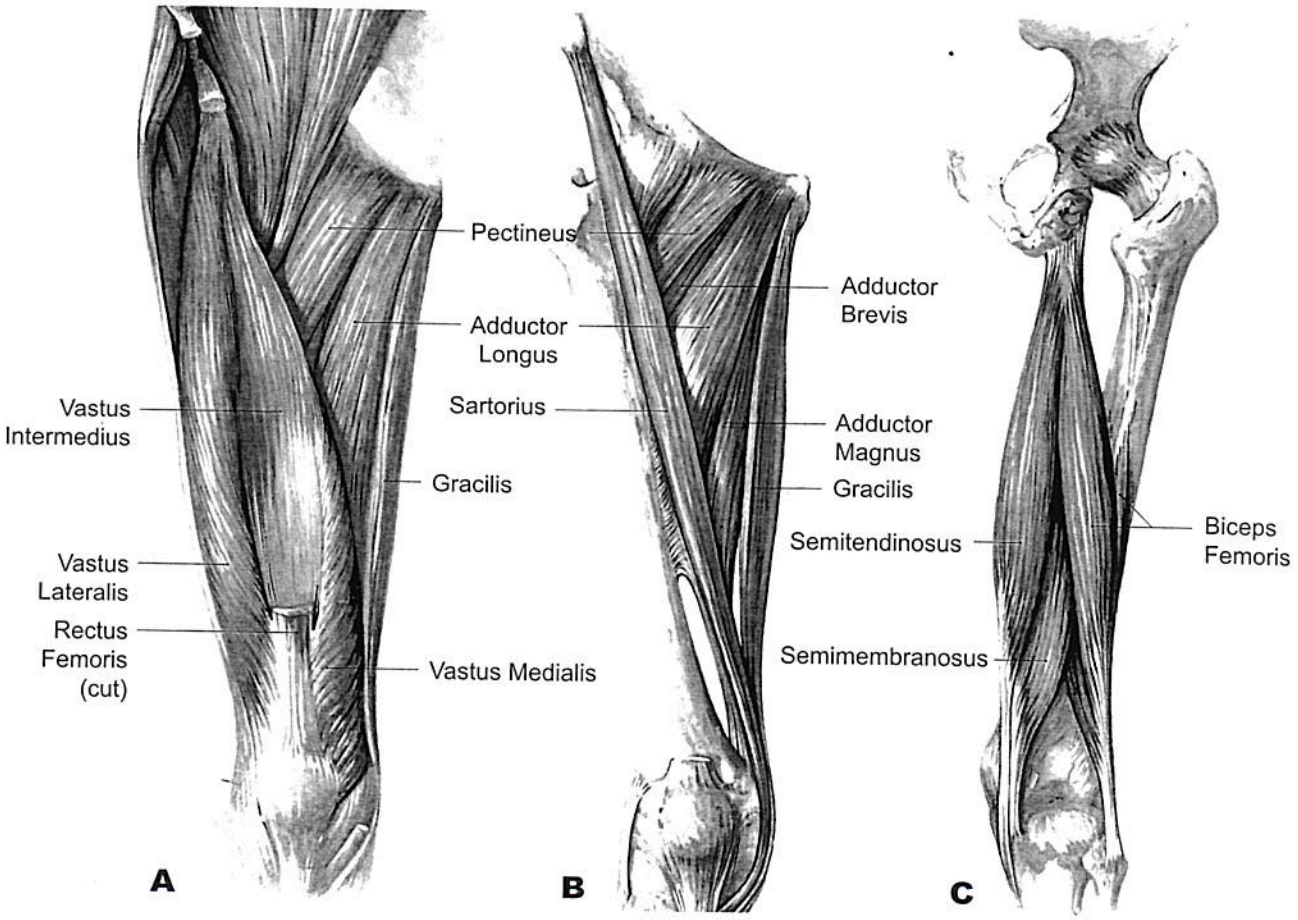


Figure 2.32 Muscles of the right thigh. **A.** Anterior compartment. **B.** Medial compartment. **C.** Posterior compartment.

Posterior Compartment The posterior group includes the muscles you know as the **hamstrings**. You may have thought the hamstrings were one muscle, but the group is actually made up of the **biceps femoris**, **semitendinosus**, and **semimembranosus** (Figure 2.32 C). Their role is to flex the knee and extend the hip with gluteus maximus. They are attached proximally to the ischial tuberosity (the bony part you sit on that gets sore when you sit on a hard chair for too long a time). Distally, the muscles cross posterior to the knee joint with the biceps femoris attaching to the head of the fibula and the semitendinosus and semimembranosus attaching to the tibia.

Muscles of the Leg

The joints of the leg are arranged in the opposite conformation to the arm. The extensors are on the anterior surface and the flexors are located posteriorly. Let's look at the compartments.

Nature is very kind to those studying anatomy. Again, as in the thigh, the leg muscles are grouped into compartments, but here into anterior, lateral, and posterior compartments.

Anterior and Lateral Compartments

Anterior Compartment These muscles do not cross the knee joint, but arise from the anterolateral surface of the tibia, the interosseous membrane

between the tibia and the fibula, and from the anterior surface of the fibula. Their tendons cross anterior to the ankle joint and go to the medial side of the foot, and to the distal phalanges of the digits. They are primarily dorsiflexors of the ankle and extensors of the toes. The major anterior compartment muscle is **tibialis anterior** (Figure 2.33 A), which also functions to invert the sole of the foot. Loss of the nerve supply to these muscles results in foot drop.

Lateral Compartment There are two muscles in the lateral compartment, the **peroneus longus** and **peroneus brevis** (Figure 2.33 A). Both muscles attach to the lateral surface of the fibula and pass behind the lateral malleolus to enter the foot. Because they cross behind the ankle joint they are plantar flexors of the ankle and the evertors of the sole of the foot. For example, loss of the nerve supply to these muscles would mean you would have difficulty adapting your foot to uneven ground surfaces when running.

Posterior Compartment

Superficial Group The large muscles of the calf are formed by the **gastrocnemius** and **soleus** muscles (Figure 2.33 B). Gastrocnemius has two proximal heads attached to the medial and lateral epicondyles of the distal femur. They come together to form a large muscle belly that attaches to the back of the calcaneus (large bone of the heel) in common with the tendon of soleus as the calcaneal tendon (**Achilles tendon**). These three are the principal plantar flexors of the ankle. Often, the medial head of gastrocnemius can be partially torn away from its attachment to the

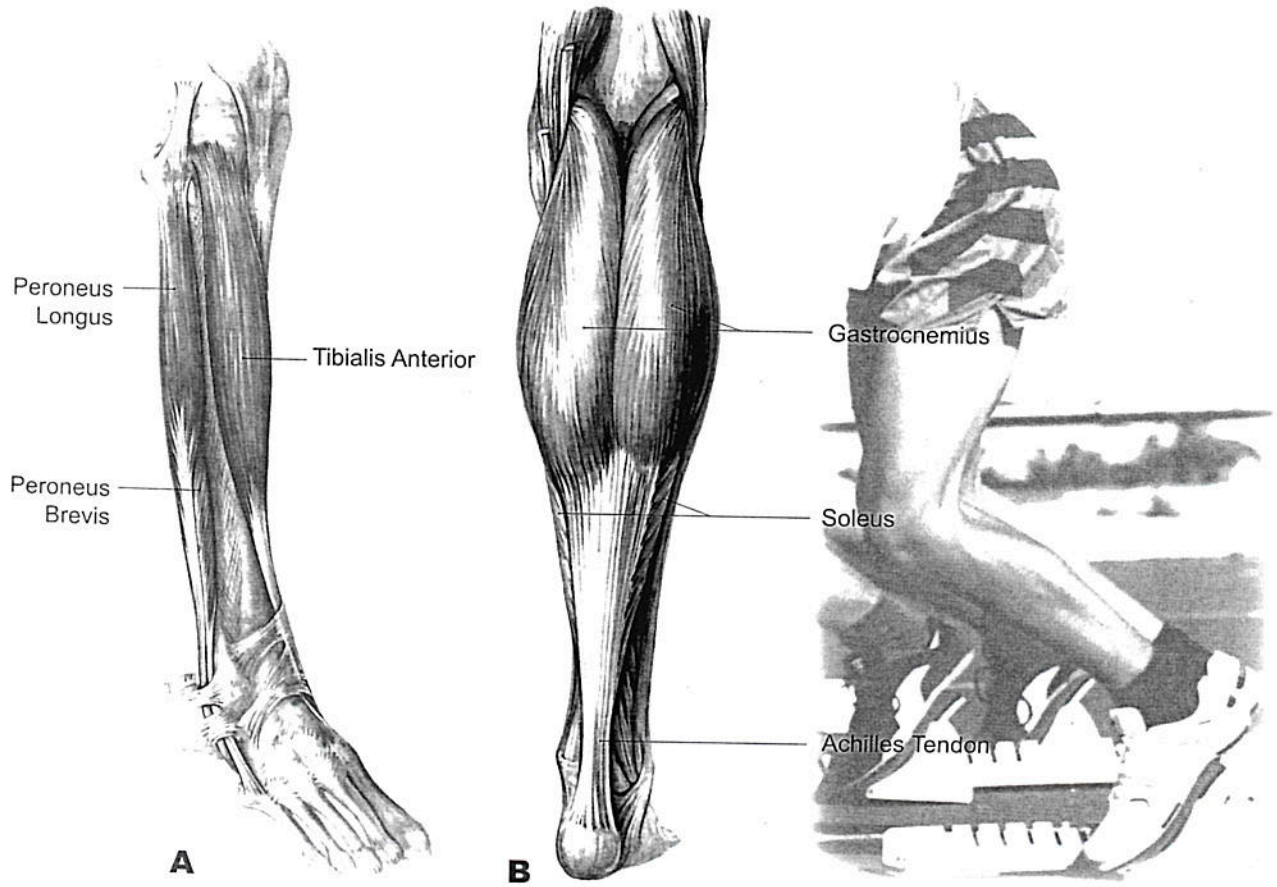


Figure 2.33 Muscles of the right leg. **A.** Anterolateral compartment. **B.** Posterior compartment.

femur (e.g., during a game of squash when you are making very sudden starts, stops, and turns); it can be very painful, but the fibres will naturally reattach during the healing process.

Deep Group The deep muscles are the ones that assist in plantar flexion of the ankle, but their primary role is flexion of the toes. These tendons enter the foot by passing behind the medial malleolus of the tibia.

Muscles of the Foot

There are four layers of intrinsic foot muscles. Together with the bones and ligaments, they are arranged to permit the foot to support the body on uneven ground. As a group, they permit flexion, extension, abduction, and adduction of the digits. The great toe (digit 1) is the primary lever in the "push-off" in walking, running, and jumping.

Muscles of the Abdomen

The anterior abdominal wall is a plywood-like trilaminar muscular wall. The triple layer is formed by, from superficial to deep, the **external oblique**, **internal oblique**, and **transversus abdominis** muscles (Figures 2.34 and 2.35). They reach

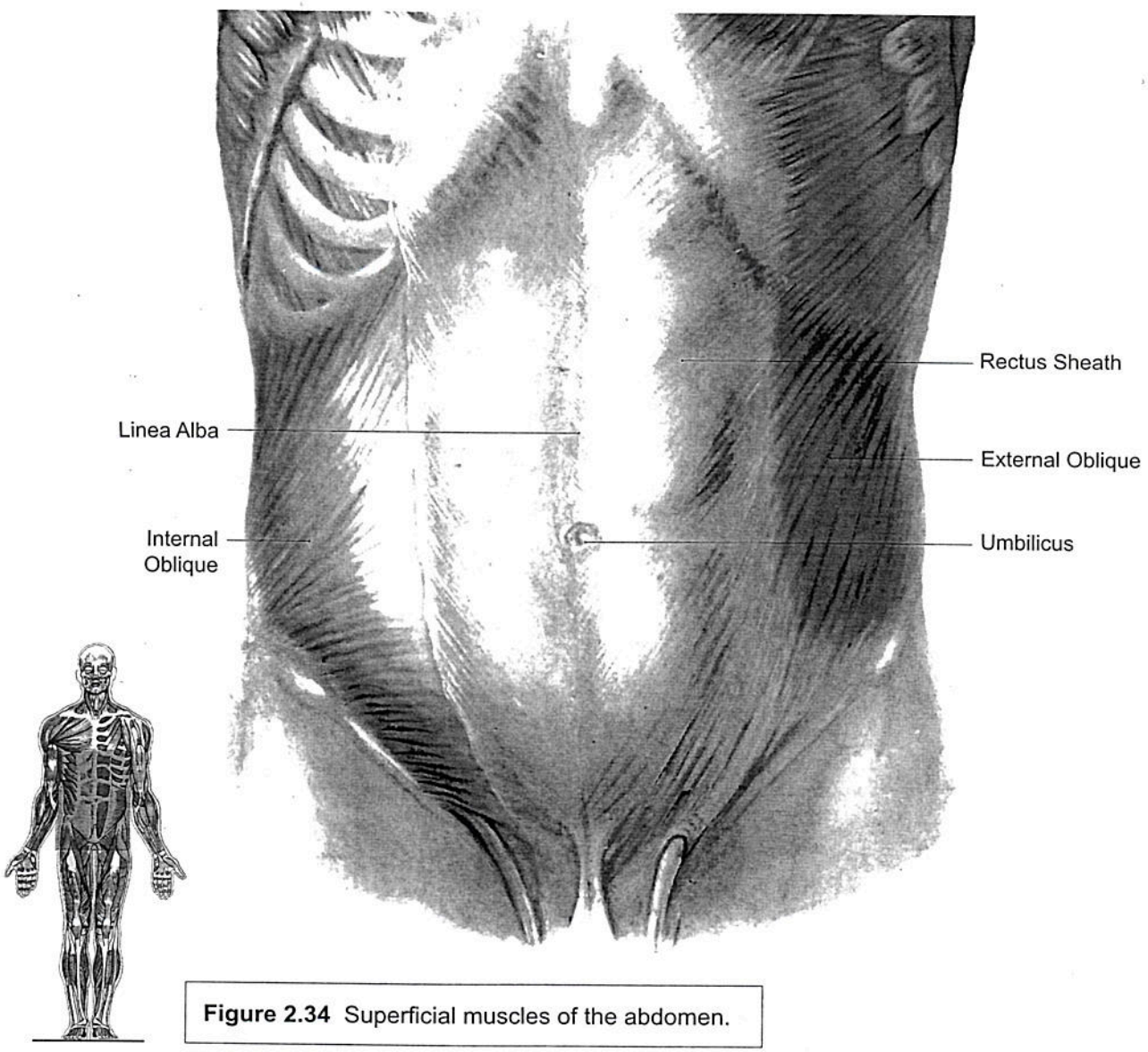
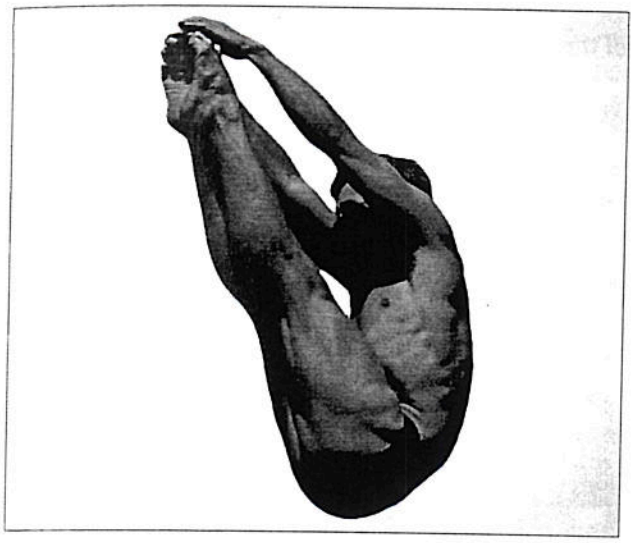


Figure 2.34 Superficial muscles of the abdomen.



from the vertebral column, ribs, and hip bone posteriorly, to meet in the midline anteriorly at the **linea alba**. As the right and left muscle groups approach each other, they envelop paired midline muscles, the **rectus abdomini** (Figure 2.35). The obliques are important in lateral bending and in rotation of the trunk (e.g., in throwing the javelin). They also permit extension of the abdomen during forced inspiration, and allow the development of a pregnant uterus. They contract during forced expiration and help to expel fecal contents from the rectum. The rectus abdominis, the muscle used in sit-ups, is a powerful flexor of the anterior abdominal wall. Strengthening of the

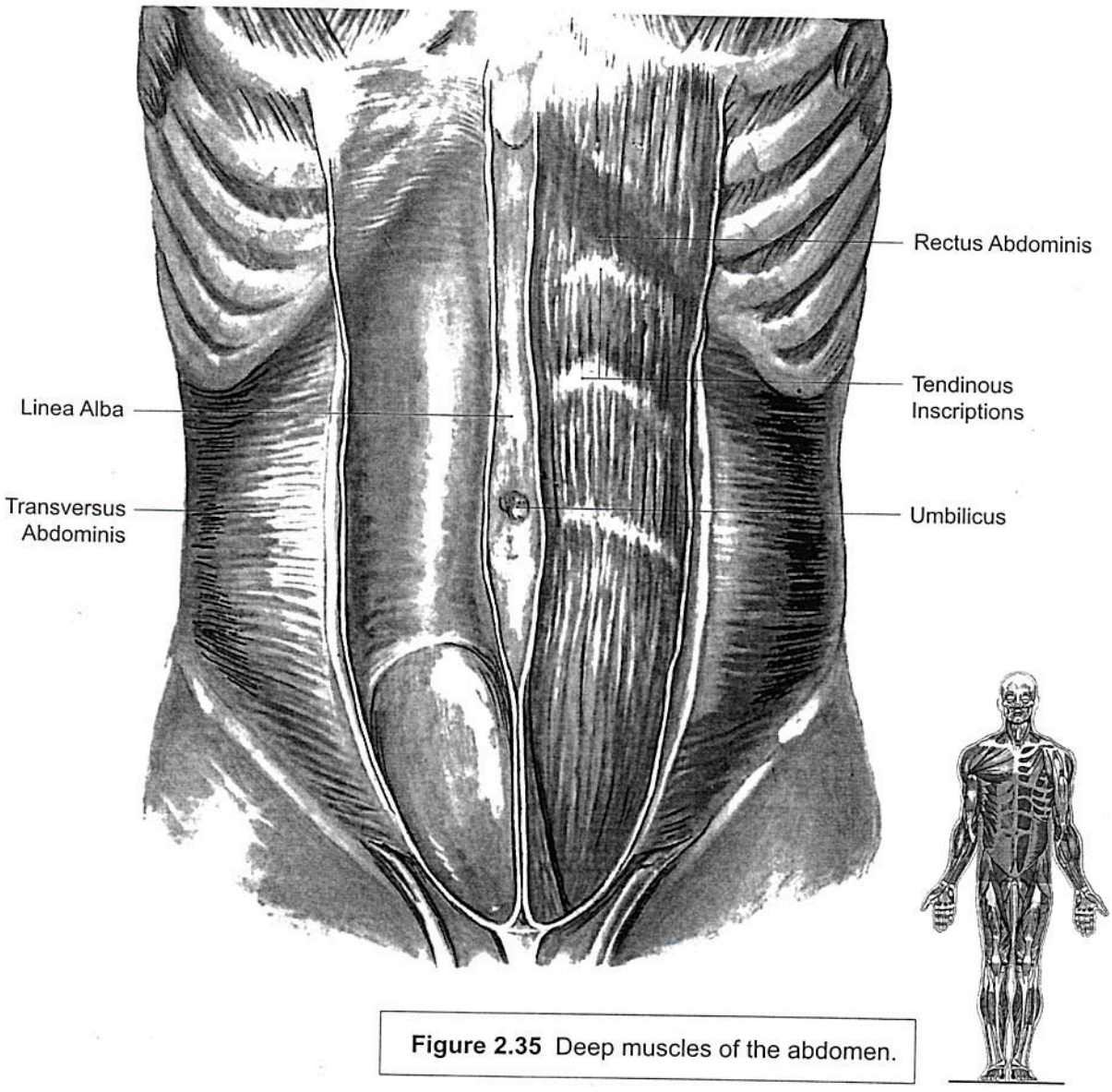


Figure 2.35 Deep muscles of the abdomen.

Table 2.2 Summary of major muscles and movements of the upper limb.

Joint	Action	Muscles	Sport or Activity
Shoulder	Flexion	*Pectoralis major, clavicular head *Deltoid, anterior fibres *Biceps brachii	Cross-country and downhill skiing, pull-through in freestyle swimming
	Extension	*Latissimus dorsi Teres major *Deltoid, posterior fibres Pectoralis major, sternal head	Iron cross formation in gymnastics, freestyle stroke, racquet positioning in tennis
	Abduction	*Deltoid Supraspinatus	Position in take-off in diving
	Adduction	*Pectoralis major Latissimus dorsi	Dance positions, cross-court shot in tennis
	Medial rotation	*Pectoralis major *Deltoid, anterior fibres Latissimus dorsi	Crossing one's arms, butterfly stroke in swimming, arm positioning in ballet
	Lateral rotation	*Deltoid, posterior fibres Teres minor Infraspinatus	Back stroke in swimming, lawn bowling, curling
Elbow	Flexion	Brachialis *Biceps brachii Brachioradialis	Weightlifting, shaking hands, positioning forearm to write, boxing
	Extension	*Triceps Anconeus	Pull stroke in paddling, backhand in tennis, painting a wall
Radioulnar	Pronation	Pronator teres	Volleyball spike, tennis serve, football pass
	Supination	*Biceps brachii Supinator	Fencing, volleyball serve, lawn bowling
Radiocarpal	Flexion–Extension	Forearm flexors and extensors	Baseball pitch, throwing a javelin
	Abduction–Adduction	Forearm flexors and extensors	Positioning wrist to maneuver a basketball or baseball
Metacarpo-phalangeal	Flexion–Extension	Forearm flexors and extensors	Position of wrist for throwing baseball, basketball, darts, javelin
	Abduction–Adduction	Forearm flexors and extensors Intrinsic hand muscles	Grasping a basketball or javelin, releasing a baseball or dart
Inter-phalangeal	Flexion–Extension	Intrinsic hand muscles Forearm flexors	Grasping an object, i.e., baseball, darts; releasing an object

* indicates prime movers

As you read the sports and activities listed in the table, try to imagine how the movements would be performed.

Table 2.3 Summary of major muscles and movements of the lower limb.

Joint	Action	Muscles	Sport or Activity
Hip	Flexion	*Iliopsoas Sartorius Pectineus Rectus femoris	Sprinting, climbing, gymnastics, diving
	Extension	*Gluteus maximus Semitendinosus Semimembranosus Biceps femoris Adductor magnus	Rising from a squat in weightlifting, running uphill, gymnastics
	Abduction	*Gluteus medius Gluteus minimus Tensor fasciae latae	Figure skating, gymnastics, hurdles
	Adduction	Adductor magnus Adductor longus Adductor brevis Gracilis	Equestrian events, cross-country skiing
	Lateral rotation	Obturator externus Obturator internus Piriformis Quadratus femoris	Figure skating, gymnastics, soccer
	Medial rotation	Tensor fasciae latae Gluteus medius Gluteus minimus	Gymnastics, ballet, diving
Knee	Extension	*Quadriceps femoris Tensor fasciae latae	Place kick in football, diving, gymnastics
	Flexion	*Biceps femoris *Semimembranosus *Semitendinosus Gastrocnemius Sartorius Gracilis Popliteus	Running, hurdles, rowing
Ankle	Dorsiflexion	*Tibialis anterior Extensor hallucis longus Extensor digitorum longus Peroneus tertius	Heel-toe walking, skiing
	Plantar flexion	*Gastrocnemius *Soleus Tibialis posterior Flexor hallucis longus	Push-off in sprinting, going "en pointe" in dance, gymnastics, diving
Transverse Tarsal	Inversion	*Tibialis anterior Tibialis posterior	Maintaining stability when walking on uneven ground
	Eversion	Peroneus longus Peroneus brevis	Maintaining stability when walking on uneven ground

* indicates prime movers

anterior abdominal wall is a very important part of back therapy, whereby the anterior wall muscles act to support the back.

Summary

Human anatomy deals with the structures that make up the human body, and how these various structures are related to one another. Having knowledge about the structures of the human body and their associated functions, the major bones, joints, and muscles that allow us to move, and an understanding of anatomical description and analysis, is important to realizing your full potential as an individual.

The bones, joints, and muscles that make up the musculoskeletal system allow numerous movements to occur, with varying degrees of motion capabilities, strength, and flexibility. Bones provide the structural framework necessary for support, muscles supply the power, and the joints supply the mechanism that allows human movement to occur.

While the human body is highly organized, intricate, and complex, it is structured precisely to respond to the demands of the world around us with astounding efficiency. Our ability to move and perform an almost limitless number of skills can be enhanced with knowledge of anatomy; and because structure determines function, knowing our structure can go a long way in improving the functions of those structures for performance in our everyday lives.

Key Words

Abduction
Adduction
Anatomical position
Anterior (ventral)
Appendicular skeleton
Axial skeleton
Ball and socket joint
Circumduction
Condyloid (knuckle) joint
Deep
Distal
Dorsiflexion
Epidural haemorrhage
Eversion
Extension
Flat bone
Flexion
Frontal (coronal) plane
Hinge (ginglymus) joint
Human anatomy
Inferior
Insertion
Inversion
Irregular bone
Lateral
Lateral (external) rotation
Long bone
Medial
Medial (internal) rotation
Median (midsagittal) plane
Origin
Pivot joint
Plane (gliding) joint
Plantar flexion
Posterior (dorsal)
Pronation
Prone
Proximal
Saddle joint
Sagittal plane
Sesamoid bone
Short bone
Superficial
Superior
Supination
Supine
Synovial joint
Transverse (horizontal) plane

Discussion Questions

1. Describe the anatomical position and discuss its relationship to the directional terms of the body.
2. What are the four major planes that bisect the body? Provide an example of a movement that occurs in each plane.
3. Define three types of movement and give an example of each for a specific joint in the human body.
4. List the six major types of synovial joints. Which synovial joints allow the greatest amount of movement? The least?

5. Outline the components and roles of the axial and appendicular skeletons.

6. List the five regions of the vertebral column from the most superior to the most inferior. In what region are the atlas and axis located?

7. What type of joint is the knee? What structures present at the knee provide additional support to this joint?

8. What muscles are primarily responsible for maintaining an upright posture?

9. The posterior group of leg muscles is commonly called the hamstrings. What three muscles combine to form the hamstrings? What role do they play?

10. List the four major muscles comprising the abdomen. Which layer is most superficial? Most deep? What actions do these muscles allow you to do?