10

The trunk and spinal column

Objectives

- To identify and differentiate the different types of vertebrae in the spinal column.
- To label on a skeletal chart the types of vertebrae and their important features.
- To draw and label on a skeletal chart some of the muscles of the trunk and the spinal column.
- To demonstrate and palpate with a fellow student the movements of the spine and trunk and list their respective planes of motion and axes of rotation.
- To palpate on a human subject some of the muscles of the trunk and spinal column.
- To list and organize the muscles that produce the primary movements of the trunk and spinal column and their antagonists.

The trunk and thorax present problems in kinesiology that are not found in the study of other parts of the body. First is the complexity of the vertebral column. It consists of 24 intricate and complex articulating vertebrae. These vertebrae contain the spinal column, with its 31 pairs of spinal nerves. Unquestionably it is the most complex part of the human body other than the brain and the central nervous system.

The anterior portion of the trunk contains the abdominal muscles, which are somewhat different from other muscles in that some sections are linked by fascia and tendinous bands and thus do not attach from bone to bone. In addition, there are many small intrinsic muscles acting on the head, vertebral column, and thorax that assist in spinal stabilization or respiration, depending on their location. These muscles are generally too deep to palpate and consequently will not be given the full attention that the larger superficial muscles will receive in this chapter.

Bones

Vertebral column

The intricate and complex bony structure of the vertebral column consists of 24 articulating vertebrae and 9 that are fused together (Fig. 10.1). The column is further divided into the 7 cervical (neck) vertebrae, 12 thoracic (chest) vertebrae, and 5 lumbar (lower back) vertebrae. The sacrum (posterior pelvic girdle) and the coccyx (tail bone) consist of 5 and 4 fused vertebrae, respectively. The first two cervical vertebrae are unique in that their shapes allow for extensive rotary movements of the head to the sides, as well as forward and backward. The spine has three normal curves within its movable vertebrae. The thoracic spine curve is concave anteriorly and convex posteriorly, while the cervical and lumbar curves are concave posteriorly and convex anteriorly. The normal curves of the spine enable it to absorb blows and shocks.

The bones in each region of the spine have slightly different sizes and shapes to allow for various functions (Fig. 10.2). The vertebrae increase in size from the cervical region to the lumbar region primarily because they have to support more weight in the lower back than in the neck. The first two cervical vertebrae are known as the atlas and axis, respectively. The vertebrae C2 through L5 have similar architecture: each has a bony block anteriorly, known as the body, a vertebral foramen centrally for the spinal cord to pass through, a transverse process projecting out laterally to each side, and a spinous process projecting posteriorly that is easily palpable.

Undesirable deviations from the normal curvatures occur due to a number of factors. Increased posterior concavity of the lumbar and cervical curves is known as *lordosis*, while increased anterior concavity of the normal thoracic curve is known as *kyphosis*. The lumbar spine may have a reduction of its normal lordotic curve, resulting in a flat-back appearance referred to as *lumbar kyphosis*. *Scoliosis* refers to lateral curvatures or sideward deviations of the spine.

Thorax

The skeletal foundation of the thorax is formed by 12 pairs of ribs (Fig. 10.3). Seven pairs are true ribs in that they attach directly to the sternum. Five pairs are considered false ribs. Of these, three pairs attach indirectly to the sternum and two pairs are floating ribs in that their ends are free. The manubrium, the body of the sternum, and the xiphoid process are the other bones of the thorax. All of the ribs are attached posteriorly to the thoracic vertebrae.

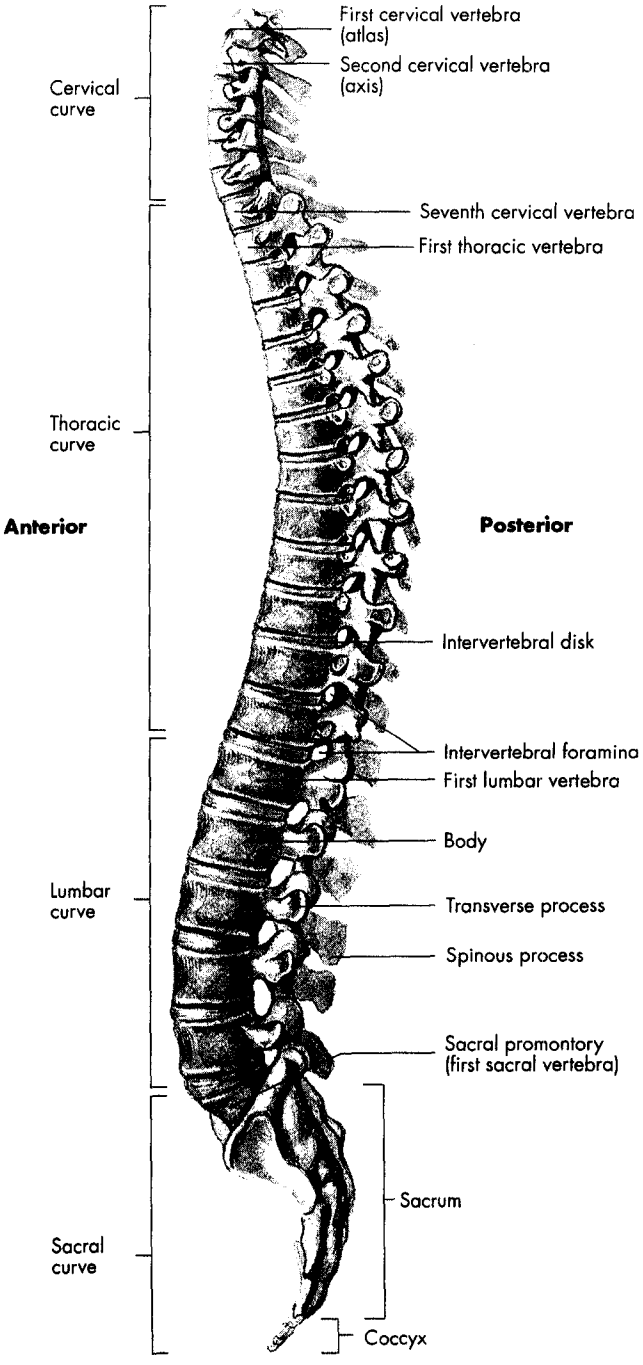
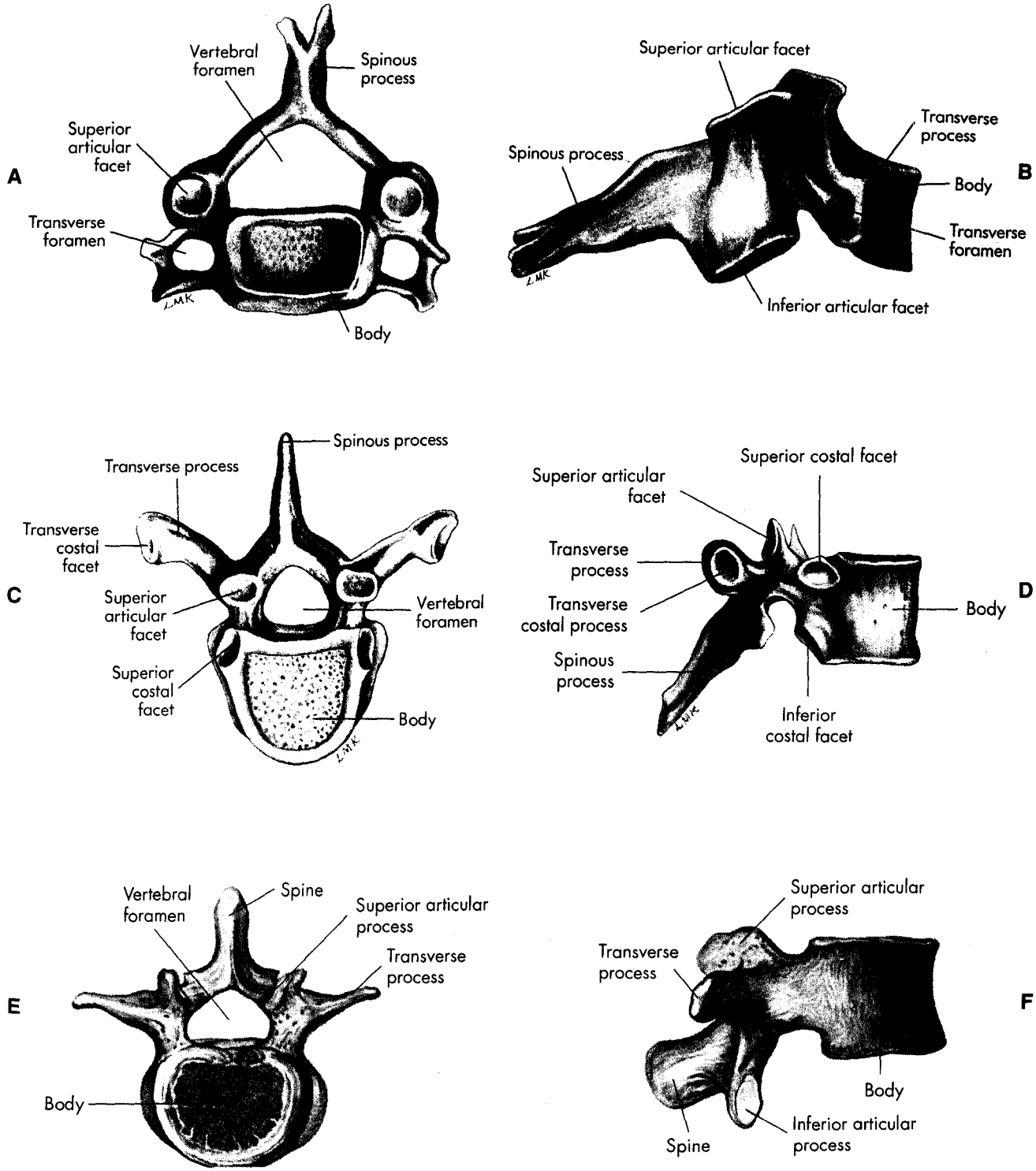


FIG. 10.1 • Vertebral column.

From Seeley, et al: *Anatomy & Physiology*, ed 3, St. Louis, 1995, Mosby.

FIG. 10.2 • Vertebral column. **A**, Typical cervical vertebra viewed from above; **B**, typical cervical vertebra viewed from the side; **C**, typical thoracic vertebra viewed from above; **D**, typical thoracic vertebra viewed from the side; **E**, third lumbar vertebra viewed from above; **F**, third lumbar vertebra viewed from the side.

From Anthony CP, Kolthoff NJ: *Textbook of anatomy and physiology*, ed 9, St. Louis, 1975, Mosby.



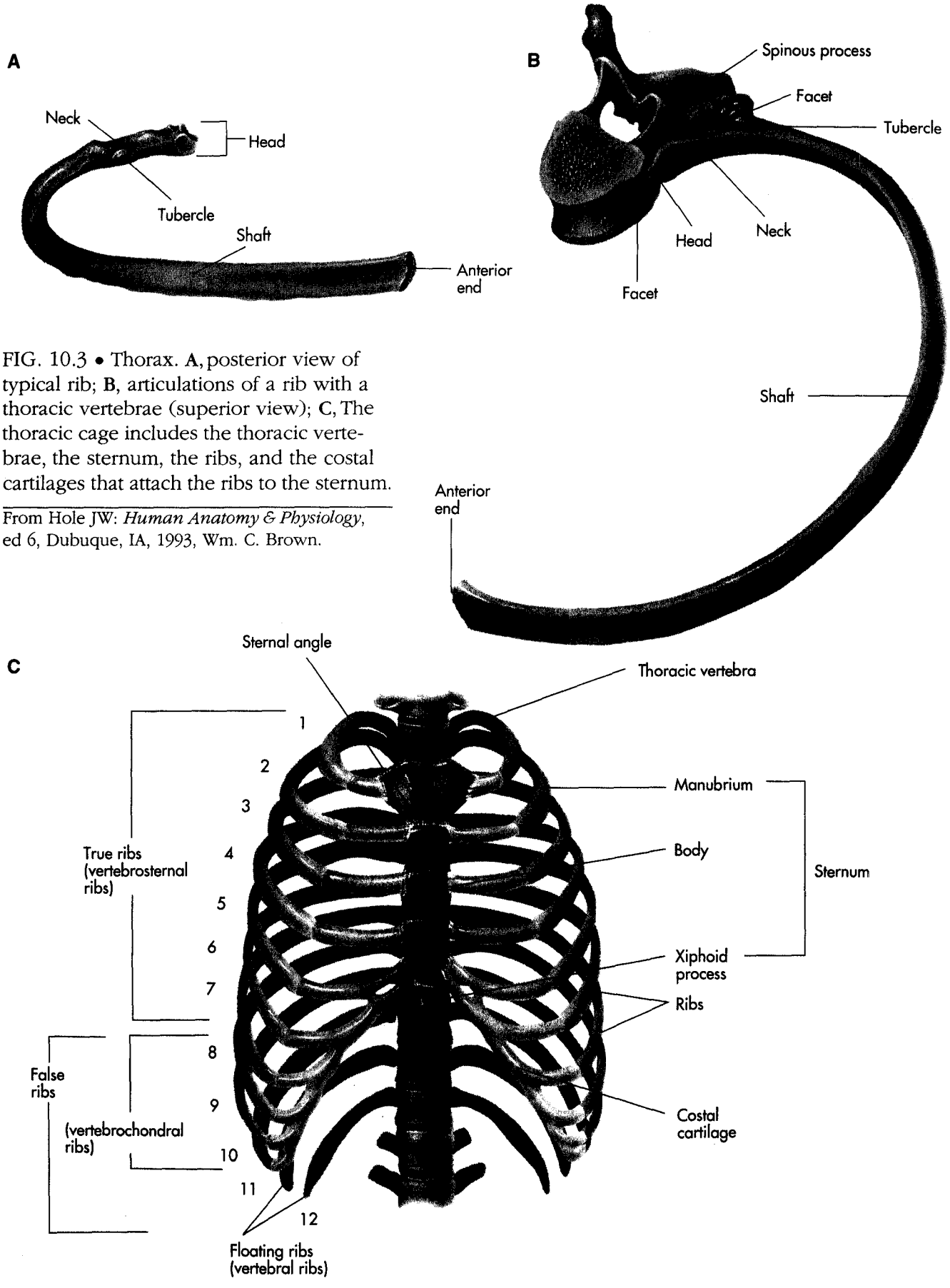


FIG. 10.3 • Thorax. **A**, posterior view of typical rib; **B**, articulations of a rib with a thoracic vertebrae (superior view); **C**, The thoracic cage includes the thoracic vertebrae, the sternum, the ribs, and the costal cartilages that attach the ribs to the sternum.

From Hole JW: *Human Anatomy & Physiology*, ed 6, Dubuque, IA, 1993, Wm. C. Brown.

The first joint in the axial skeleton is the atlantooccipital joint, formed by the occipital condyles of the skull sitting on the articular fossa of the first vertebra, which allows flexion and extension. The atlas (C1) in turn sits on the axis (C2) to form the atlantoaxial joint (Fig. 10.4, *A*). Except for the atlantoaxial joint, there is not a great deal of movement possible between any two vertebrae. However, the cumulative effect of combining the movement from several adjacent vertebrae allows for substantial movements within a given area. Most of the rotation within the cervical region occurs in the atlantoaxial joint, which is classified as a trochoid or pivot-type joint. The remainder of the vertebral articulations are classified as arthrodial or gliding-type joints because of their limited gliding movements.

Gliding movement occurs between the superior and inferior articular processes that form the facets joints of the vertebrae as depicted in Figs. 10.2 and 10.4, *B*. Located in between and adhering to the articular cartilage of the vertebral bodies are the intervertebral disks (Fig. 10.4, *C*). These disks are composed of an outer rim of dense fibrocartilage known as the annulus fibrosus and a central gelatinous, pulpy substance known as the nucleus pulposus. This arrangement of compressed elastic material allows compression in all directions along with torsion. With age, injury, or improper use of the spine, the intervertebral disks become less resilient, resulting in a weakened annulus fibrosus. Substantial weakening combined with compression can result in the nucleus protruding through the annulus, which is known as a herniated nucleus pulposus. Commonly referred to as a herniated or "slipped" disk, this protrusion puts pressure on the spinal nerve root, causing a variety of symptoms including radiating pain, tingling, numbness, and weakness in the lower extremity (Fig. 10.5).

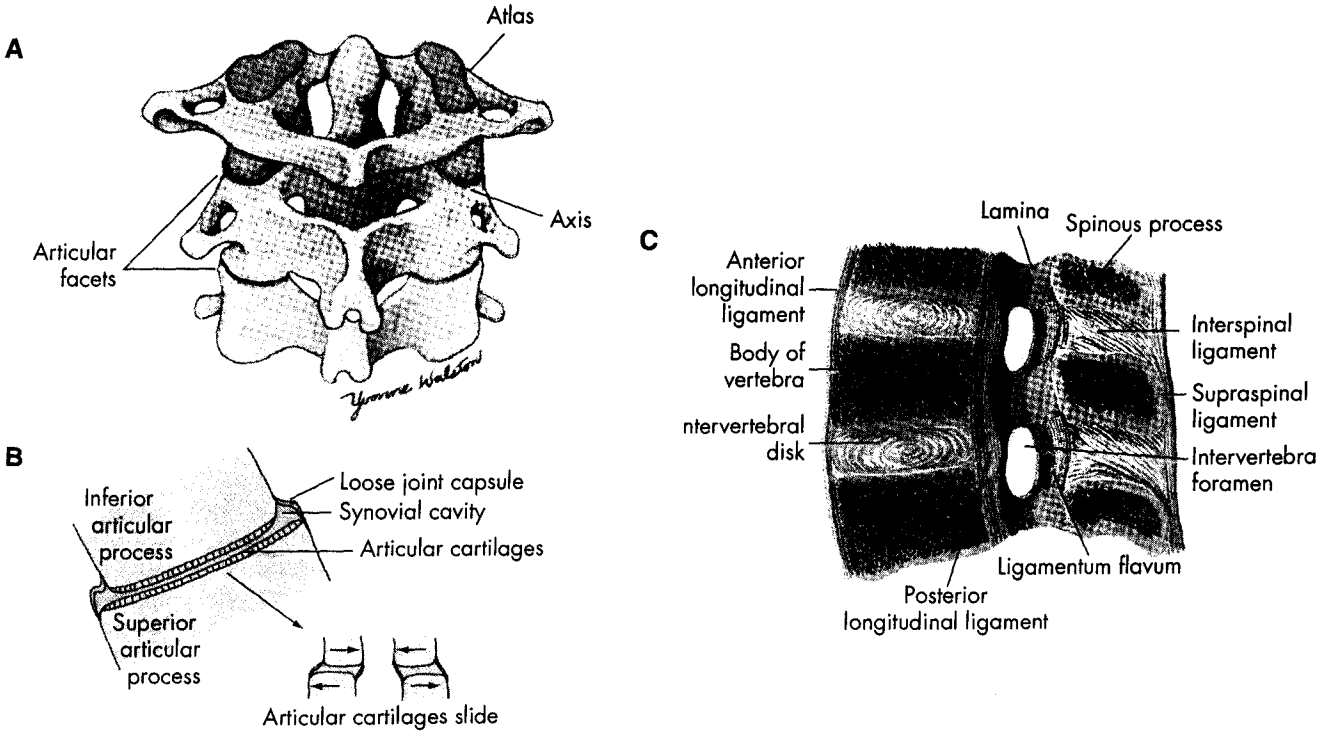


FIG. 10.4 • Articular facets of vertebrae. **A**, The facets of superior and inferior articular processes articulate between adjacent cervical vertebrae. **B**, Articular cartilages slide back and forth on each other, and the loose articular capsule allows this motion. **C**, Ligaments limit motion between vertebrae, shown in sagittal section through three lumbar vertebrae.

From Lindsay DT: *Functional human anatomy*, St. Louis, 1996, Mosby.

Most of the spinal column movement occurs in the cervical and lumbar regions. There is, of course, some thoracic movement, but it is slight in comparison to that of the neck and low back. In discussing movements of the head, it must be remembered that this movement occurs between the cranium and the first cervical vertebra, as well as within the other cervical vertebrae. With the understanding that these motions usually occur together, for simplification purposes this text refers to all movements of the head and neck as cervical movements. Similarly, in discussing trunk movements, lumbar motion terminology is used to describe the combined motion that occurs in both the thoracic and lumbar regions. A closer investigation of specific motion between any two vertebrae is beyond the scope of this text.

The cervical region can flex 45 degrees and extend 45 degrees. The cervical area laterally flexes 45 degrees and can rotate approximately 60 degrees. The lumbar spine, accounting for most of the trunk movement, flexes approximately 80 degrees and extends 20 to 30 degrees. Lumbar lateral flexion to each side is usually within 35 degrees, and approximately 45 degrees of rotation occurs to the left and right.

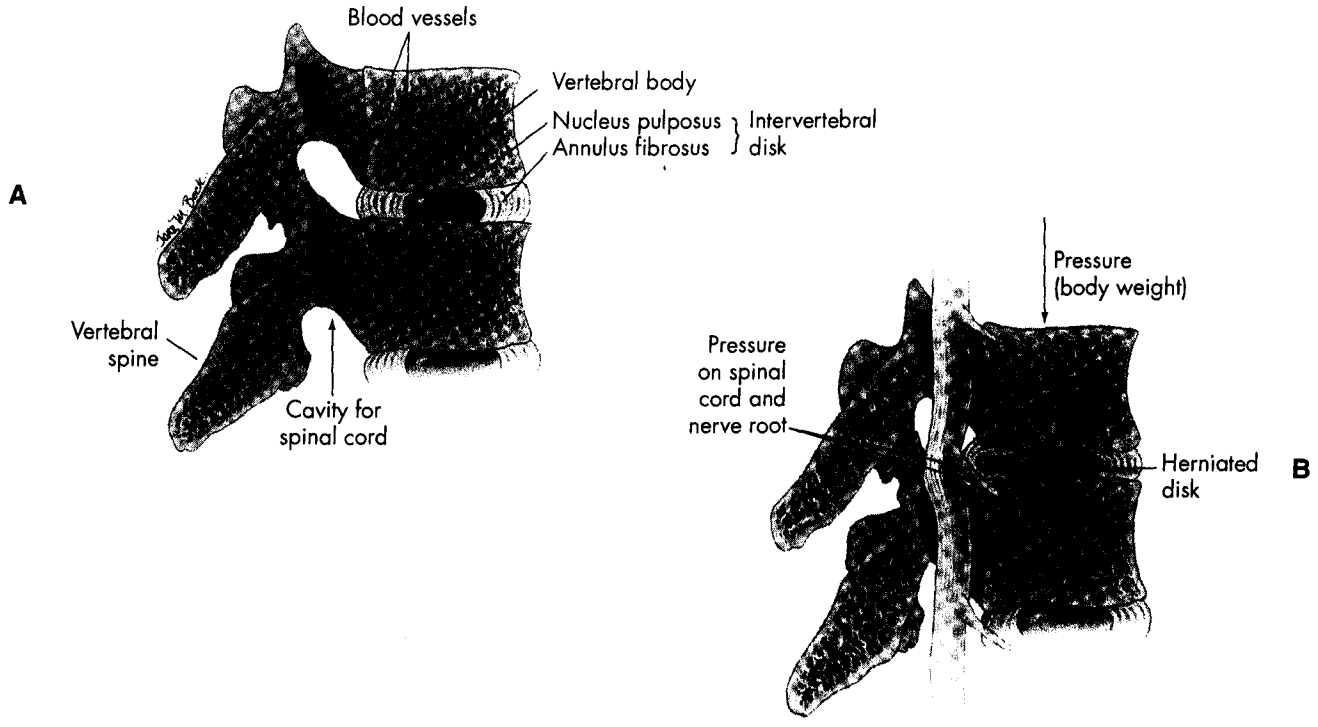


FIG. 10.5 • Sagittal section of vertebrae showing (A) normal disks and (B) herniated disks.

From Thibodeau GA, Patton KT: *Anatomy & physiology*, ed 9, St. Louis, 1993, Mosby.

Movements FIG. 10.6

Spinal movements are often preceded by the name given to the region of movement. For example, flexion of the trunk at the lumbar spine is known as lumbar flexion, and extension of the neck is often referred to as cervical extension. Additionally, as was discussed in Chapter 7, the pelvic girdle rotates as a unit due to movement occurring in the hip joints and the lumbar spine. Refer to Table 7.1.

Spinal flexion: anterior movement of the spine; in the cervical region the head moves toward the chest; in the lumbar region the thorax moves toward the pelvis.

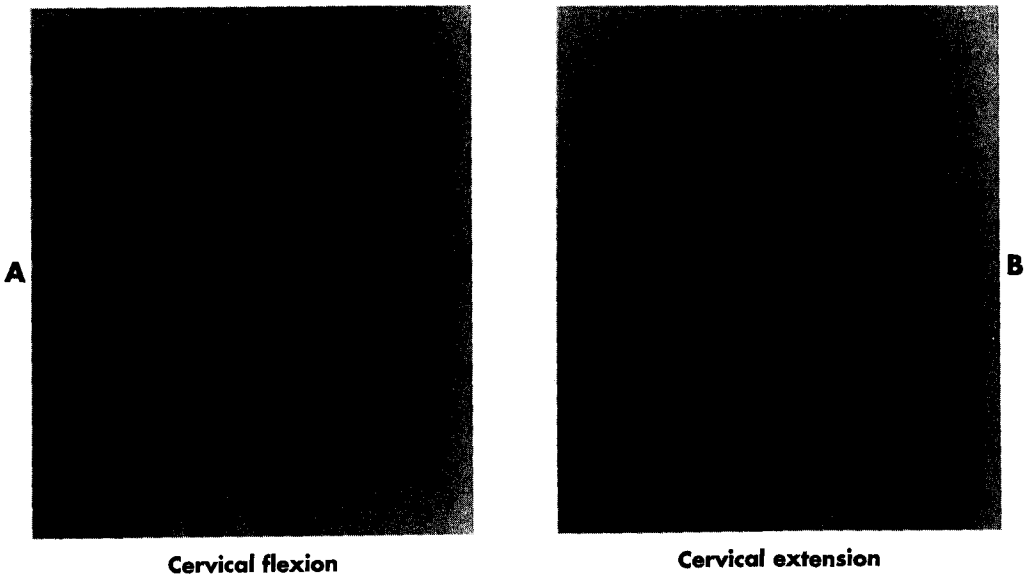
Spinal extension: return from flexion; posterior movement of the spine; in the cervical spine, the head moves away from the chest; in the lumbar spine the thorax moves away from the pelvis.

Lateral flexion (left or right): sometimes referred to as side bending; the head moves laterally toward the shoulder and the thorax moves laterally toward the pelvis.

Spinal rotation (left or right): rotary movement of the spine in the horizontal plane; the chin rotates from neutral toward the shoulder and the thorax rotates to one side.

Reduction: return movement from lateral flexion to neutral.

FIG. 10.6 • Movements of the spine.



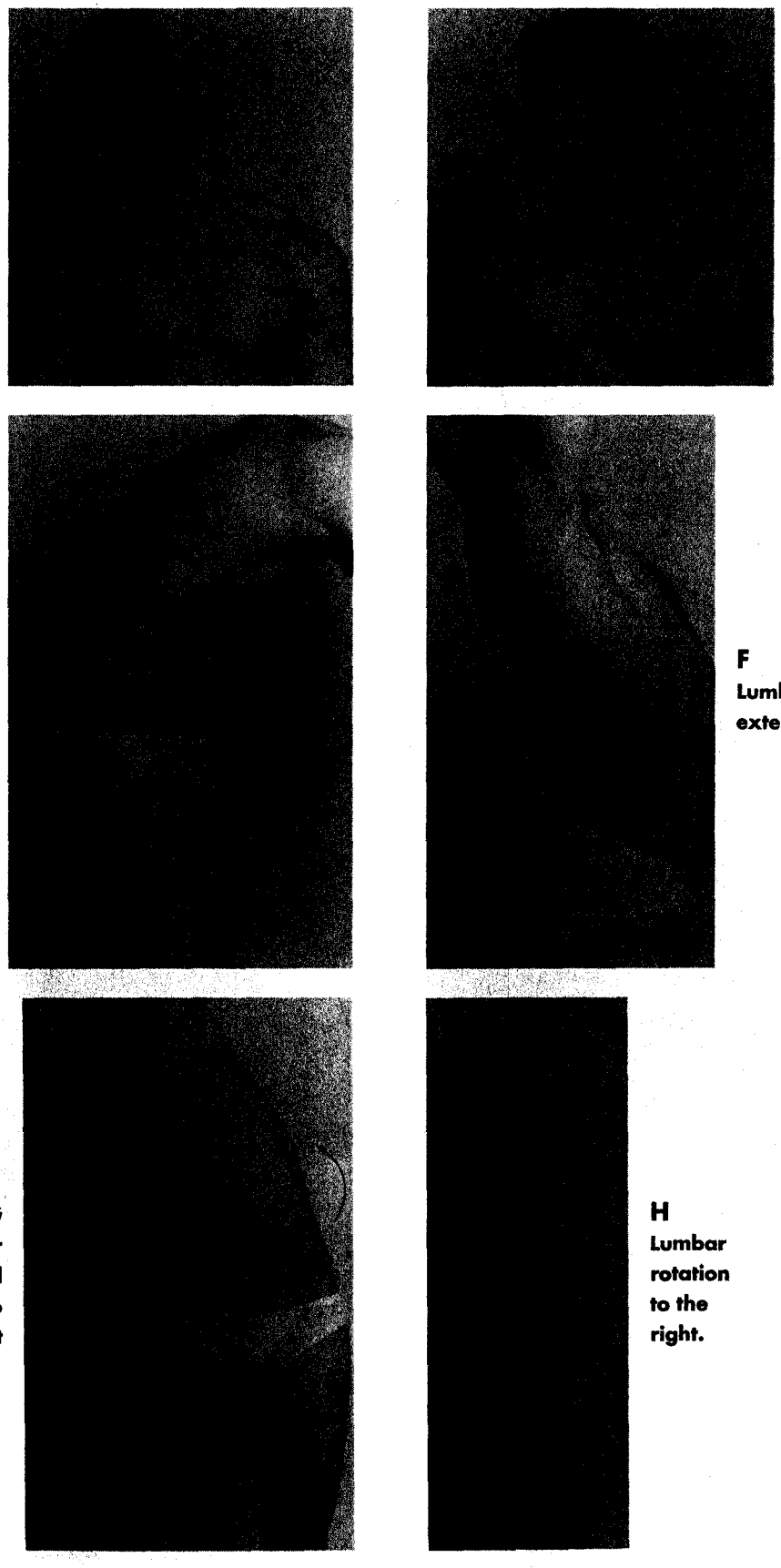


FIG. 10.6 continued • Movements of the spine.

Trunk and spinal column muscles

A few large muscles and many small muscles are found in this area. The largest muscle is the erector spinae (sacrospinalis), which extends on each side of the spinal column from the pelvic region to the cranium. It is divided into three muscles: the spinalis, the longissimus, and the iliocostalis. From the medial to the lateral side it has attachments in the lumbar, thoracic, and cervical regions. Thus the erector spinae group is actually made up of nine muscles. Additionally, the sternocleidomastoid and splenius muscles are large muscles involved in cervical and head movements. Large abdominal muscles involved in lumbar movements include the rectus abdominis, external oblique abdominal, internal oblique abdominal, and quadratus lumborum.

Numerous small muscles are found in the spinal column region. Many of them originate on one vertebra and insert on the next vertebra. They are important in the functioning of the spine, but knowledge of these muscles is of limited value to most people who use this text. Consequently, discussion will concentrate on the larger muscles primarily involved in trunk and spinal column movements and will only briefly address the smaller muscles.

To better understand the muscles of the trunk and spinal column, they may be grouped according to both location and function. It should be noted that some muscles have multiple segments. As a result, one segment of a particular muscle may be located and perform movement in one region while another segment of the same muscle may be located in another region to perform movements in that region. Many of the muscles of the trunk and spinal column function in moving the spine as well as in aiding respiration. All of the muscles of the thorax are primarily involved in respiration. The abdominal wall muscles are different from other muscles that have been studied. They do not go from bone to bone but attach into an aponeurosis (fascia) around the rectus abdominis area. They are the external oblique abdominal, internal oblique abdominal, and transversus abdominis.

Muscles that move the head

Anterior

- Rectus capitis anterior
- Longus capitis

Posterior

- Longissimus capitis
- Obliquus capitis superior
- Obliquus capitis inferior
- Rectus capitis posterior—major and minor
- Trapezius, superior fibers
- Splenius capitis
- Semispinalis capitis

Lateral

- Rectus capitis lateralis
- Sternocleidomastoid

Muscles of the vertebral column

Superficial

- Erector spinae (sacrospinalis)
  - Spinaliss—cervicis, thoracis
  - Longissimus—capitis, cervicis, thoracis
  - Iliocostalisa—cervicis, thoracis, lumborum
- Splenius cervicis

Deep

- Longus colli—superior oblique, inferior oblique, vertical
- Interspinales—entire spinal column
- Intertransversales—entire spinal column
- Multifidus—entire spinal column
- Psoas minor
- Rotatores—entire spinal column
- Semispinalis—cervicis, thoracis

Muscles of the thorax

- Diaphragm
- Intercostalis—external, internal
- Levator costarum
- Subcostales
- Scalenus—anterior, medius, posterior
- Serratus posterior—superior, inferior
- Transversus thoracis

Muscles of the abdominal wall

- Rectus abdominis
- External oblique abdominal (obliquus externus abdominis)
- Internal oblique abdominal (obliquus internus abdominis)
- Transverse abdominis (transversus abdominis)
- Quadratus lumborum

Muscles that move the head

All muscles featured here originate on the cervical vertebrae and insert on the occipital bone of the skull, as implied by their capitis name (Figs. 10.7 and 10.8). Three muscles make up the anterior vertebral muscles—the longus capitis, the rectus capitis anterior, and the rectus capitis lateralis. All are flexors of the head and upper cervical spine. The rectus capitis lateralis laterally flexes the head in addition to assisting the rectus capitis anterior in stabilizing the atlantooccipital joint.

The rectus capitis posterior major and minor, obliquus capitis superior and inferior, and semispinalis capitis are located posteriorly. All are extensors of the head except the obliquus capitis inferior, which rotates the atlas. The obliquus capitis superior assists the rectus capitis lateralis in lateral flexion of the head. In addition to extension, the rectus capitis posterior major is responsible for rotation of the head to the ipsilateral side. It is assisted by the semispinalis capitis, which rotates the head to the contralateral side. The splenius capitis and the sternocleidomastoid are much larger and more powerful in moving the head and cervical spine and will be covered in detail on the following pages. The remaining muscles that act on the cervical spine are addressed with the muscles of the vertebral column.

FIG. 10.7 • Anterior muscles of the neck

Modified from Lindsay DT: *Functional human anatomy*, St. Louis, 1996, Mosby.

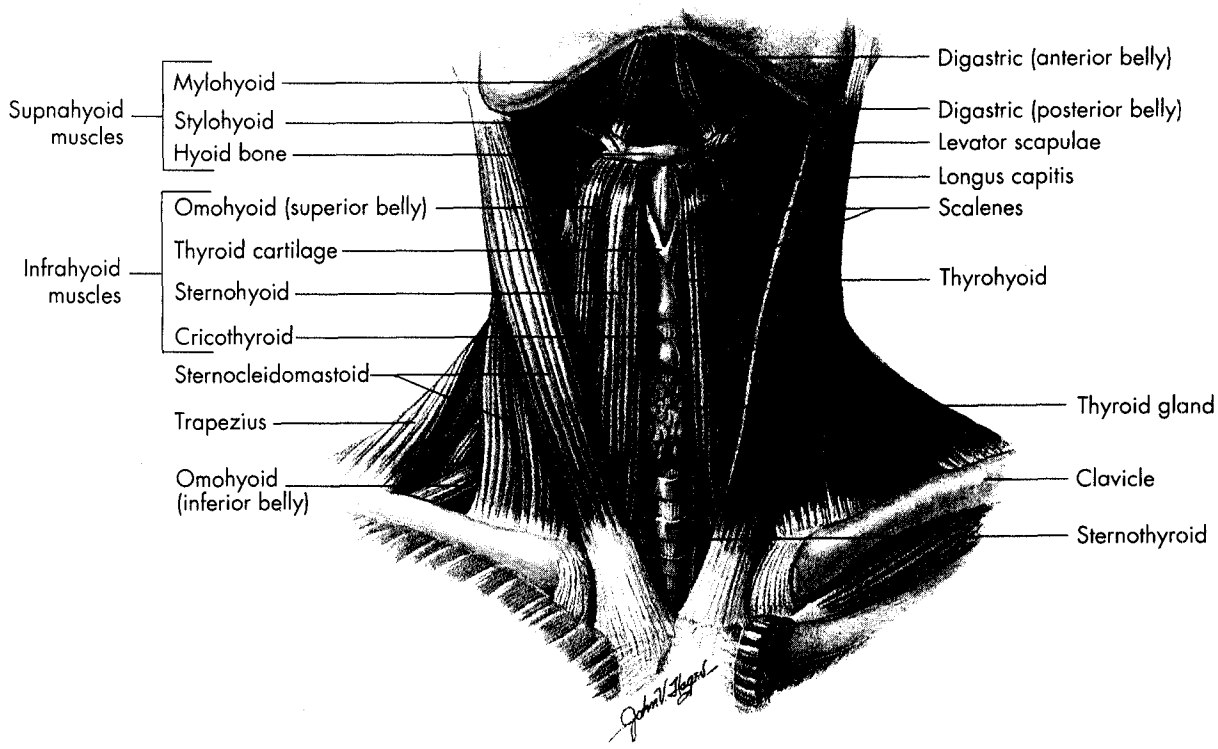


FIG. 10.8 • Deep muscles of the posterior neck and upper back regions.

Modified from Van De Graaff KM: *Human anatomy*, ed 4, Dubuque, IA, 1995, Wm. C. Brown.

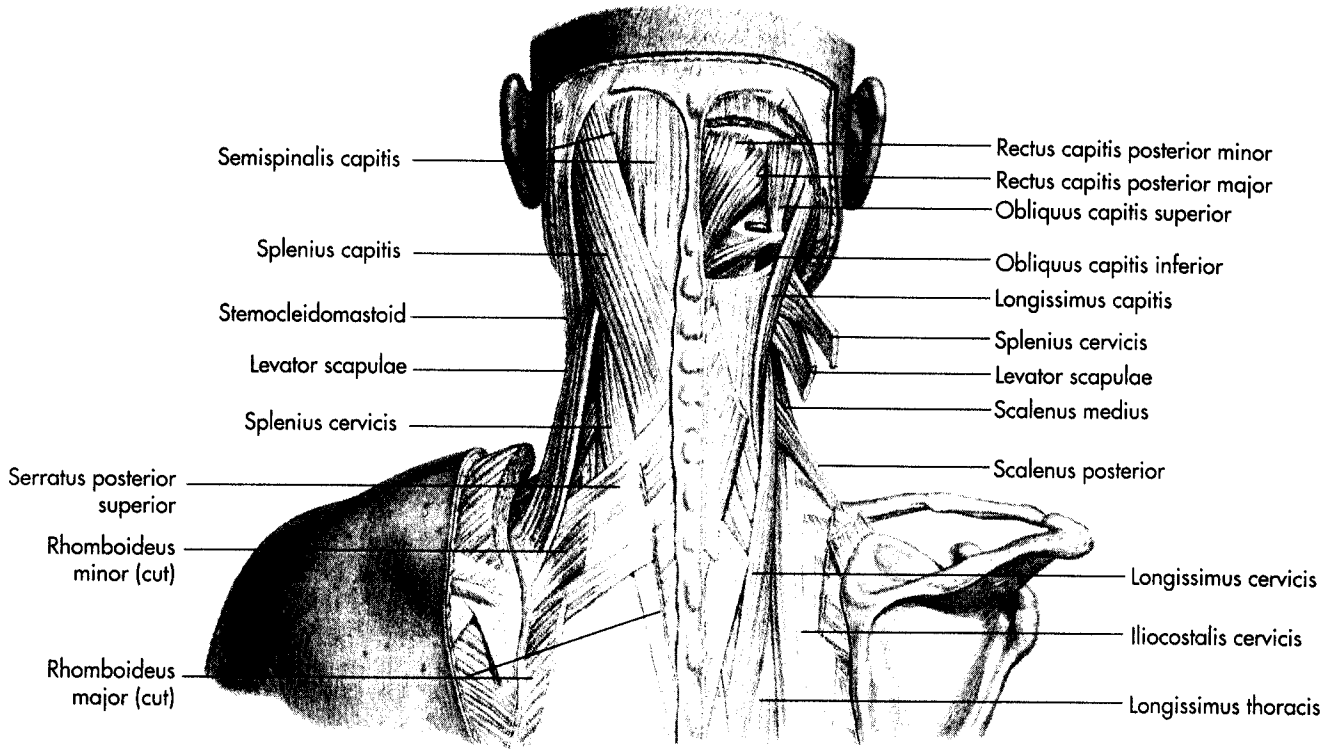


TABLE 10.1 • Muscles that move the head.

MUSCLE	ORIGIN	INSERTION	ACTION	INNERVATION
Rectus capitis anterior	Anterior surface of lateral mass of atlas	Basilar part of occipital bone anterior to foramen magnum	Flexion of head and stabilization of atlantooccipital joint	C1-3
Rectus capitis lateralis	Superior surface of transverse processes of atlas	Jugular process of occipital bone	Lateral flexion of head and stabilization of atlantooccipital joint	C1-3
Rectus capitis posterior (major)	Spinous process of axis	Lateral portion of inferior nuchal line of occipital bone	Extension & rotation of head to ipsilateral side	Posterior rami of C1
Rectus capitis posterior (minor)	Spinous process of atlas	Medial portion of inferior nuchal line of occipital bone	Extension of head	Posterior rami of C1
Longus capitis	Transverse processes of C3-6	Basilar part of occipital bone	Flexes head and cervical spine	C1-3
Obliquus capitis superior	Transverse process of atlas	Occipital bone between inferior & superior nuchal line	Extension & lateral flexion of head	Posterior rami of C1
Obliquus capitis inferior	Spinous process of axis	Transverse process of atlas	Rotation of atlas	Posterior rami of C1
Semispinalis capitis	Transverse processes of C4-T7	Occipital bone, between superior & inferior nuchal lines	Extension and contralateral rotation of head	Posterior primary divisions of spinal nerves

Splenius muscles (cervicis, capitis)

FIG. 10.9

(sple'ni-us) (ser'vi-sis) (kap'i-tis)

Origin

Splenius cervicis: spinous processes of the third through the sixth thoracic vertebrae.

Splenius capitis: lower half of the ligamentum nuchae and the spinous processes of the seventh cervical and the upper three or four thoracic vertebrae.

Insertion

Splenius cervicis: transverse processes of the first three cervical vertebrae.

Splenius capitis: mastoid process and occipital bone.

Action

Both sides: extension of the head and neck.

Right side: rotation and lateral flexion to the right.

Left side: rotation and lateral flexion to the left.

Palpation

Cannot be palpated.

Innervation

Posterior lateral branches of cervical nerves four through eight (C4-8).

Application, strengthening, and flexibility

Any movement of the head and neck into extension, particularly extension and rotation, would bring the splenius muscle strongly into play, together with the erector spinae and the upper trapezius muscles. Tone in the splenius muscle tends to hold the head and neck in proper posture position.

A good exercise for the splenius muscle is to lace the fingers behind the head with the muscle in flexion and then to slowly contract the posterior head and neck muscles to move the head and neck into full extension. This exercise may also be performed by using a towel or a partner for resistance.

The entire splenius may be stretched with maximal flexion of the head and cervical spine. The right side can be stretched through combined movements of left rotation, left lateral flexion, and flexion. The same movements to the right side apply stretch to the left side.

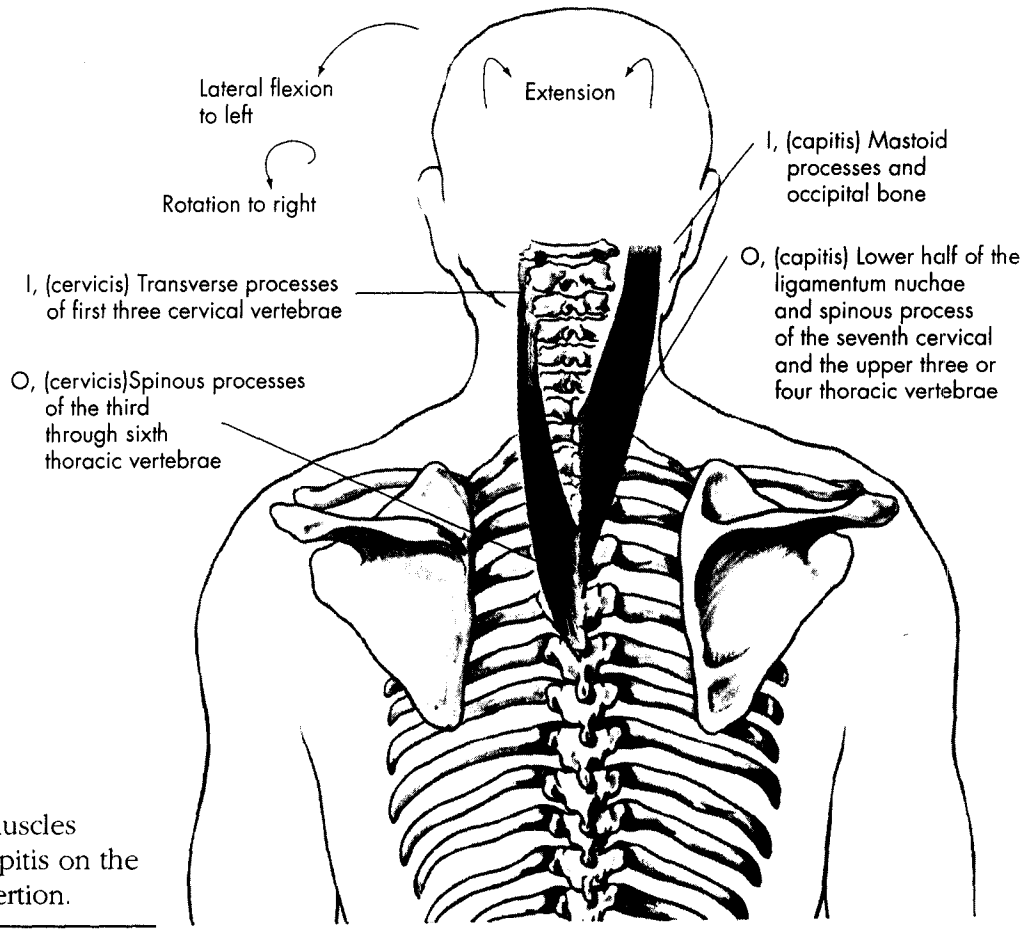


FIG. 10.9 • Splenius muscles (cervicis on the left, capitis on the right). *O*, Origin; *I*, insertion.

Sternocleidomastoid muscle FIG. 10.10

(ster'no-kli-do-mas-toyd)

Origin

Manubrium of the sternum.
Medial clavicle.

Insertion

Mastoid process.

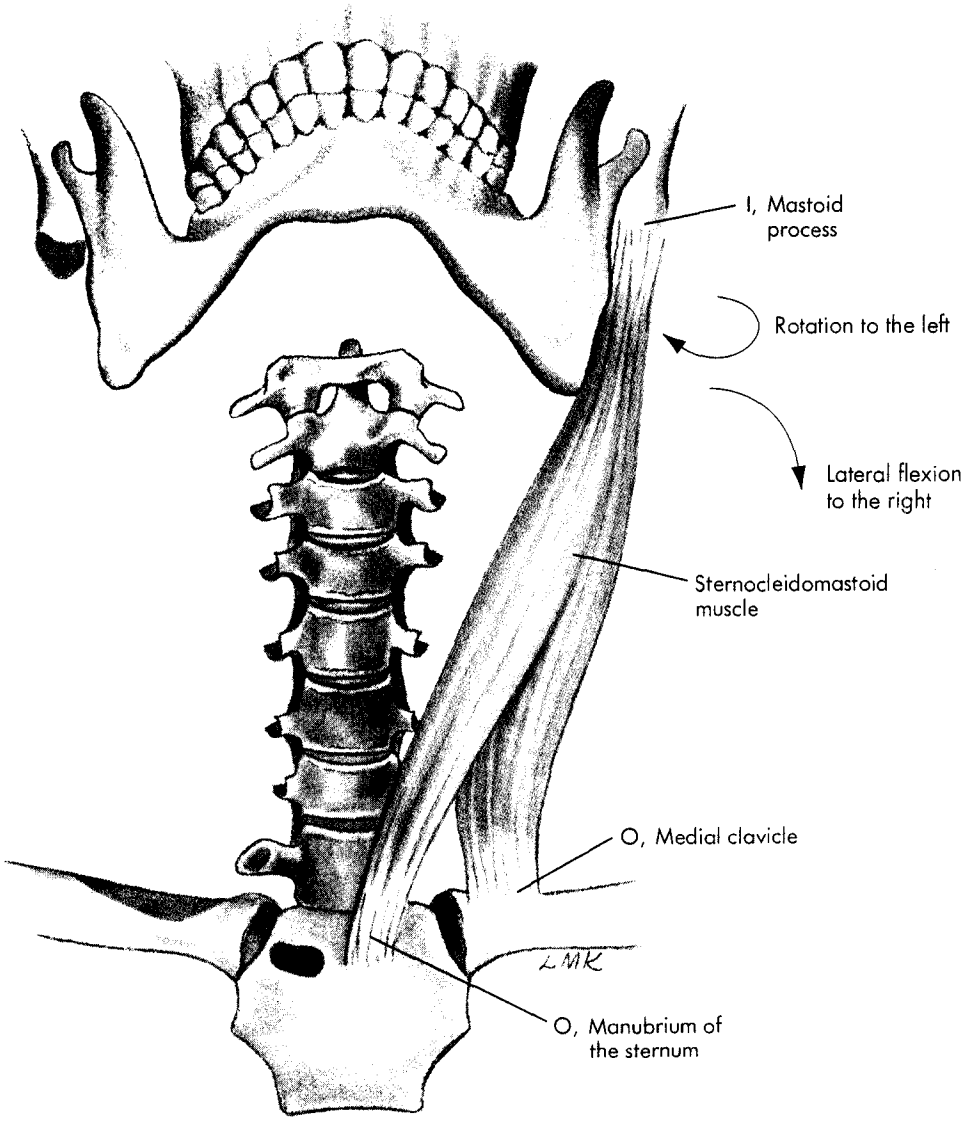
Action

Both sides: flexion of the head and neck.
Right side: rotation to the left and lateral flexion to the right.
Left side: rotation to the right and lateral flexion to the left.

Palpation

Anterolateral neck, diagonally between the origin and insertion.

FIG. 10.10 • Sternocleidomastoid muscle, anterior view. *O*, Origin; *I*, insertion.



Innervation

Spinal accessory nerve (Cr11, C2-3).

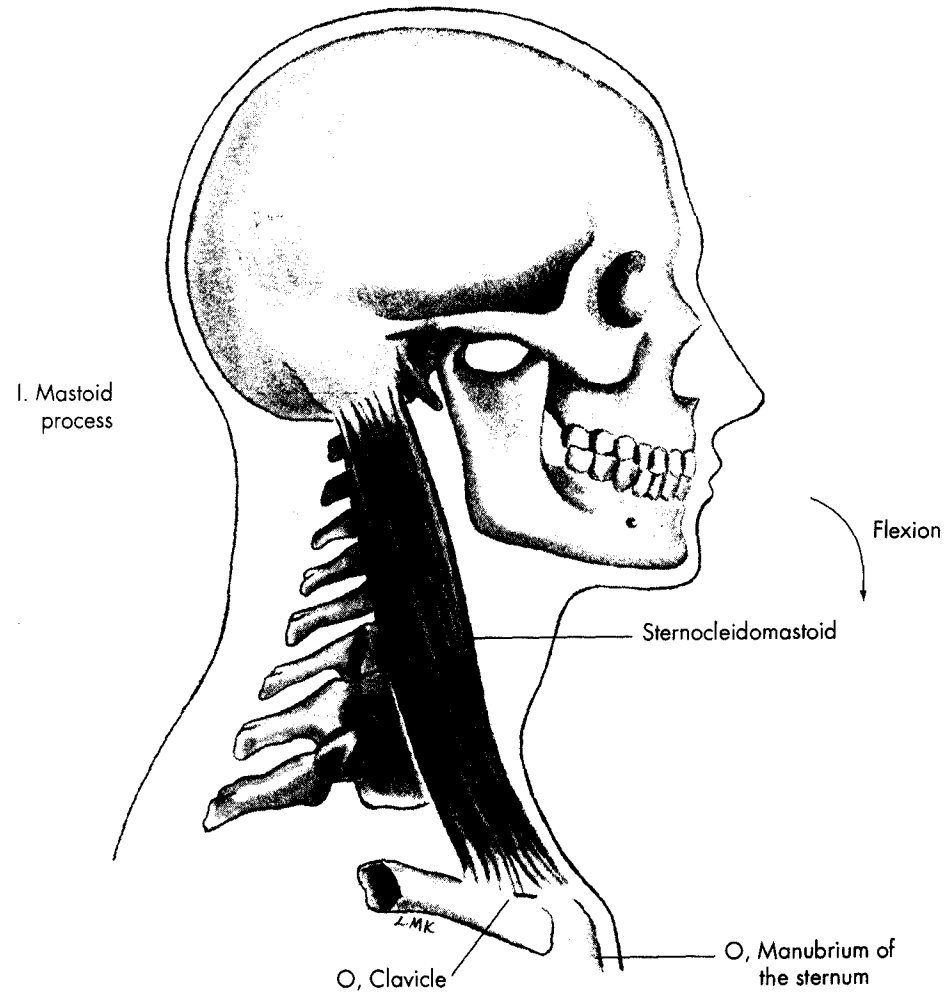
Application, strengthening, and flexibility

The sternocleidomastoid is primarily responsible for flexion and rotation of the head and neck. One side of this muscle may be easily visualized and palpated when rotating the head to the opposite side.

The sternocleidomastoid is easily worked for strength development by placing the hands on the forehead to apply force posteriorly while using these muscles to pull the head forward into flexion. The hand may also be used on one side of the jaw to apply rotary force in the opposite direction while the sternocleidomastoid is contracting concentrically to rotate the head in the direction of the hand.

Cervical hyperextension provides some bilateral stretching of the sternocleidomastoid. Each side may be stretched individually. The right side is stretched by moving into left lateral flexion and right cervical rotation combined with extension. The opposite movements in extension stretch the left side.

FIG. 10.10 continued • Sternocleidomastoid muscle, lateral view.



Muscles of the vertebral column

In the cervical area the longus colli muscles are located anteriorly and flex the cervical and upper thoracic vertebrae. Posteriorly, the erector spinae group, the transversospinalis group, the interspinal-intertransverse group, and the splenius all run vertically parallel to the spinal column (Fig. 10.11). This location enables them to extend the spine as well as assist in rotation and lateral flexion. The splenius and erector spinae group are addressed in detail elsewhere in this chapter. The transversospinalis group consists of the semispinalis, multifidus, and rotatores muscles. These muscles all originate on the transverse processes of their respective vertebrae and generally run posteriorly to attach to the spinous processes on the vertebrae just above their vertebrae of origin. All are extensors of the spine and contract to rotate their respective vertebrae to the contralateral side. The interspinal-intertransverse group lies deep to the rotatores and consists of the interspinales and the intertransversarii muscles. As a group, they laterally flex and extend but do not rotate the vertebrae. The interspinales are extensors that connect from the spinous process of one vertebra to the spinous process of the adjacent vertebra. The intertransversarii muscles flex the vertebral column laterally by connecting to the transverse processes of adjacent vertebrae.

TABLE 10.2 • Muscles of the vertebral column.

MUSCLE	ORIGIN	INSERTION	ACTION	INNERVATION
Longus colli (superior oblique)	Transverse processes of C3-5	Anterior arch of atlas	Flexion of cervical spine	C2-7
Longus colli (inferior oblique)	Bodies of T1-3	Transverse processes of C5-6	Flexion of cervical spine	C2-7
Longus colli (vertical)	Bodies of C5-7 & T1-3	Anterior surface of bodies of C2-4	Flexion of cervical spine	C2-7
Interspinalis	Spinous process of each vertebra	Spinous process of next vertebra	Extension of spinal column	Posterior primary ramus of spinal nerves
Intertransversarii	Tubercles of transverse processes of each vertebra	Tubercles of transverse processes of next vertebra	Lateral flexion of spinal column	Anterior primary ramus of spinal nerves
Multifidus	Sacrum, iliac spine, transverse processes of lumbar, thoracic, and lower four cervical vertebrae	Spinous processes of 2nd, 3rd, or 4th vertebra above origin	Extension & contralateral rotation of spinal column	Posterior primary ramus of spinal nerves
Rotatores	Transverse process of each vertebra	Base of spinous process of next vertebra above	Extension & contralateral rotation of spinal column	Posterior primary ramus of spinal nerves
Semispinalis cervicis	Transverse processes of T1-5 or 6	Spinous processes from C2-C5	Extension & contralateral rotation of vertebral column	All divisions, posterior primary ramus of spinal nerves
Semispinalis thoracis	Transverse processes of T6-10	Spinous processes of C6-7 & T1-4	Extension & contralateral rotation of vertebral column	Posterior primary ramus of spinal nerves

FIG. 10.11 • Deep back muscles. On the right the erector spinae group of muscles is demonstrated. On the left these muscles have been removed to reveal the deeper back muscles.

Modified from Seeley RR, Stephens TD, Tate P: *Anatomy & physiology*, ed 3, St. Louis, 1995, Mosby-Year Book.

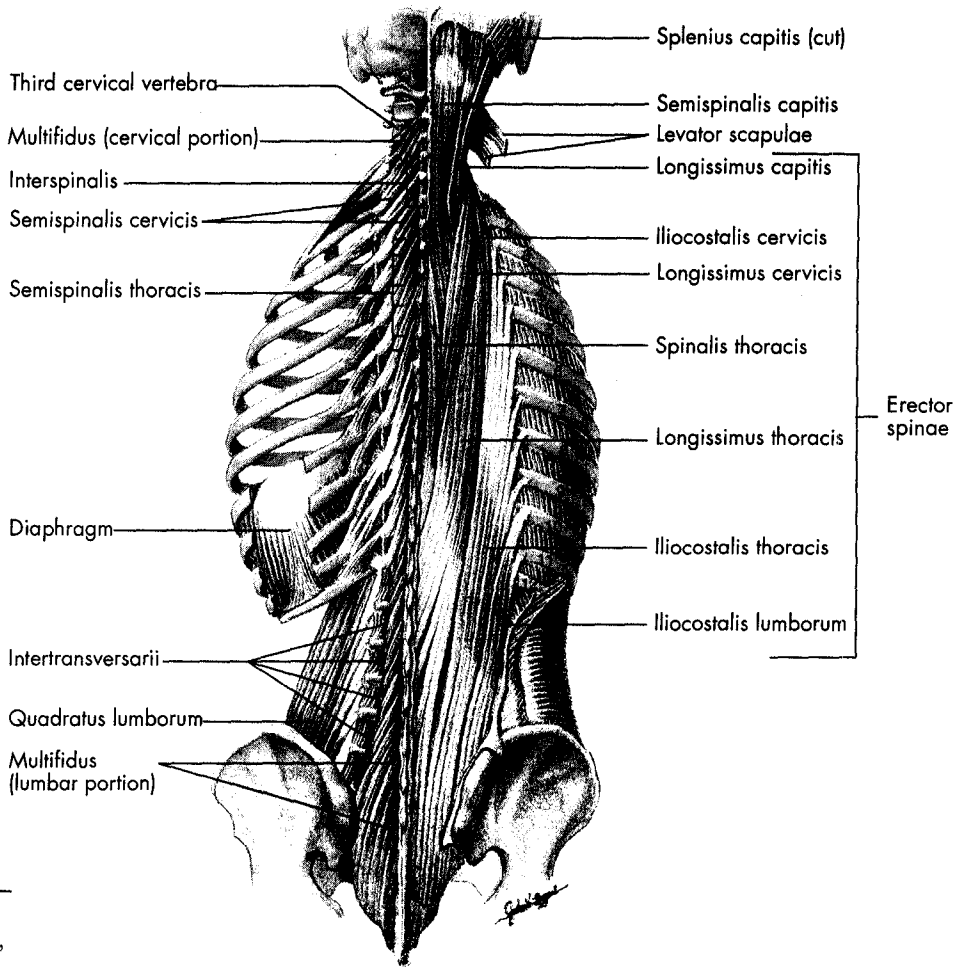
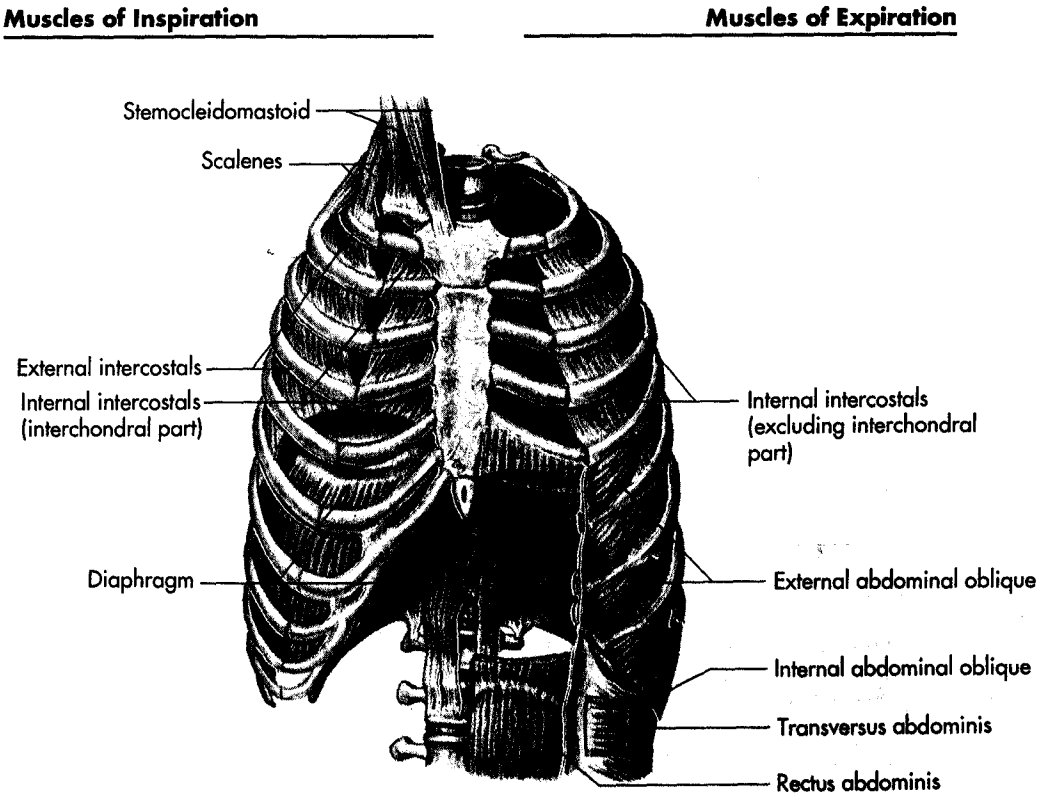


FIG. 10.12 • Muscles of respiration.

Modified from Van De Graaff KM: *Human anatomy*, ed 4, Dubuque, Ia, 1995, Wm. C. Brown.



Muscles of the thorax

The thoracic muscles are involved almost entirely in respiration (Fig. 10.12). During quiet rest the diaphragm is responsible for breathing movements. As it contracts and flattens, the thoracic volume is increased and air is inspired to equalize the pressure. When larger amounts of air are needed, such as during exercise, the other thoracic muscles take on a more significant role in inspiration. The scalene muscles elevate the first two ribs to increase the thoracic volume. Further expansion of the chest is accomplished by the external intercostals. Additional muscles of inspiration are the levator costarum and the serratus posterior. Forced expiration occurs with contraction of the internal intercostals, transversus thoracis, and subcostales.

TABLE 10.3 • Muscles of the thorax.

MUSCLE	ORIGIN	INSERTION	ACTION	INNERVATION
Diaphragm	Circumference of thoracic inlet from xiphoid process, costal cartilages 6-12, & lumbar vertebrae	Central tendon of diaphragm	Depresses and draws central tendon forward in inhalation, reduces pressure in thoracic cavity, & increases pressure in abdominal cavity	Phrenic nerve (C3-5)
Internal intercostals	Longitudinal ridge on inner surface of ribs & costal cartilages	Superior border of next rib below	Elevates costal cartilages of ribs 1-4 during inhalation, depresses all ribs in exhalation	Intercostal branches of T1-11
External intercostals	Inferior border of ribs	Superior border of next rib below	Elevates ribs	Intercostal branches of T1-11
Levator costarum	Ends of transverse processes of C7, T2-12	Outer surface of angle of next rib below origin	Elevates ribs, lateral flexion of thoracic spine	Intercostal nerves
Subcostales	Inner surface of each rib near its angle	Medially on the inner surface of 2nd or 3rd rib below	Draws the ventral part of the ribs downward, decreasing the volume of the thoracic cavity	Intercostal nerves
Scalenus anterior	Transverse processes of C3-6	Inner border and upper surface of 1 st rib	Elevates 1 st rib, flexion, lateral flexion, & contralateral rotation of cervical spine	Ventral rami of C5-6, sometimes C4
Scalenus medius	Transverse processes of C2-7	Superior surface of 1 st rib	Elevates 1 st rib, flexion, lateral flexion, & contralateral rotation of cervical spine	Ventral rami of C3-8
Scalenus posterior	Transverse processes of C5-7	Outer surface of 2nd rib	Elevates 2nd rib, flexion, lateral flexion, & slight contralateral rotation of cervical spine	Ventral rami of C6-8
Serratus posterior (superior)	Ligamentum nuchae, spinous processes of C7, T1 & T2 or T3	Superior borders lateral to angles of ribs 2-5	Elevates upper ribs	Branches from anterior primary rami of T1-4
Serratus posterior (inferior)	Spinous processes of T10-12 & L1-3	Inferior borders lateral to angles of ribs 9-12	Counteracts inward pull of diaphragm by drawing last four ribs outward & downward	Branches from anterior primary rami of T9-12
Transversus thoracis	Inner surface of sternum & xiphoid process, sternal ends of costal cartilages of ribs 3-6	Inner surfaces & inferior borders of costal cartilages 3-6	Depresses ribs	Intercostal branches of T3-6

Erector spinae muscles* (sacrospinalis) FIG. 10.13

(e-rek'tor spi'ne) (sa'kro-spi-na'lis)

Iliocostalis

(il'i-o-kos-ta'lis): lateral layer

Longissimus

(lon-jis'i-mus): middle layer

Spinalis

(spi-na'lis): medial layer

Origin

Iliocostalis: Thoracolumbar aponeurosis from sacrum, posterior ribs.

Longissimus: Thoracolumbar aponeurosis from sacrum, lumbar and thoracic transverse processes.

Spinalis: ligamentum nuchae, cervical and thoracic spinous processes.

Insertion

Iliocostalis: posterior ribs, cervical transverse processes.

Longissimus: cervical and thoracic transverse processes, mastoid process.

Spinalis: cervical and thoracic spinous processes, occipital bone.

Action

Extension and lateral flexion of the spine.

Palpation

Lower lumbar region on either side of the spine.

*This muscle group includes the iliocostalis, the longissimus dorsi, the spinalis dorsi, and divisions of these muscles in the lumbar, thoracic, and cervical sections of the spinal column.

Innervation

Posterior branches of the spinal nerves.

Application, strengthening, and flexibility

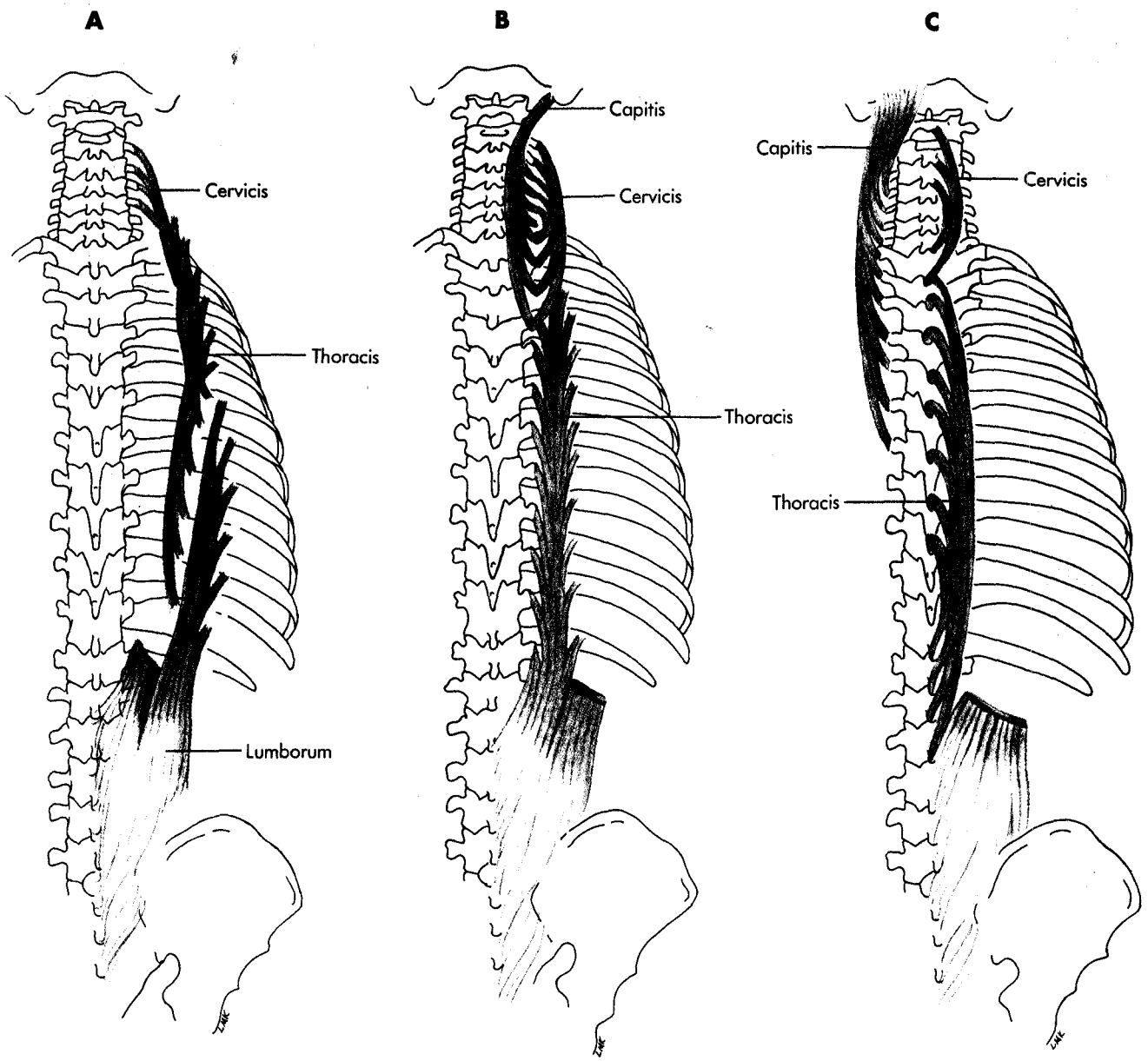
The erector spinae muscle functions best when the pelvis is held up in front, thus pulling it down slightly in back. This lowers the origin of the erector spinae and makes it more effective in keeping the spine straight. As the spine is held straight, the ribs are raised, thus fixing the chest high and consequently making the abdominal muscles more effective in holding the pelvis up in front and flattening the abdominal wall.

An exercise known as the "dead lift," employing a barbell, uses the erector spinae in extending the spine. In this exercise the subject bends over, keeping the arms and legs straight, picks up the barbell, and returns to a standing position. In performing this type of exercise, it is very important to always use correct technique to avoid back injuries. Voluntary static contraction of the erector spinae in the standing position would provide a mild exercise and improve body posture.

The erector spinae and its various divisions may be strengthened through numerous forms of back extension exercises. These are usually done in a prone or face-down position in which the spine is already in some state of flexion. The subject then uses these muscles to move part or all of the spine toward extension against gravity. A weight may be held in the hands behind the head to increase resistance.

Maximal hyperflexion of the entire spine stretches the erector spinae muscle group. Stretch may be isolated to specific segments through specific movements. Maximal flexion of the head and cervical spine stretches the capitis and cervical segments. Flexion combined with lateral flexion to one side accentuates the stretch on the contralateral side. Thoracic and lumbar flexion places the stretch primarily on the thoracis and lumborum segments.

FIG. 10.13 • Erector spinae (sacrospinalis) muscle. A, Iliocostalis; B, longissimus; C, spinalis.



Muscles of the abdominal wall

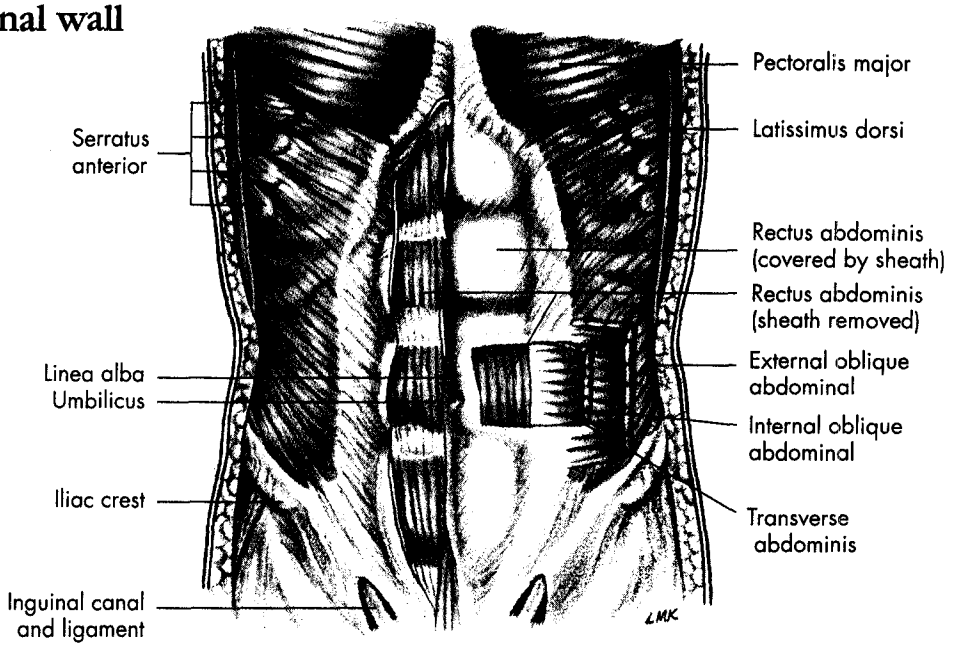


FIG. 10.14 • Muscles of the abdomen. External oblique and rectus abdominis. The fibrous sheath around the rectus has been removed on the right side to show the muscle within.

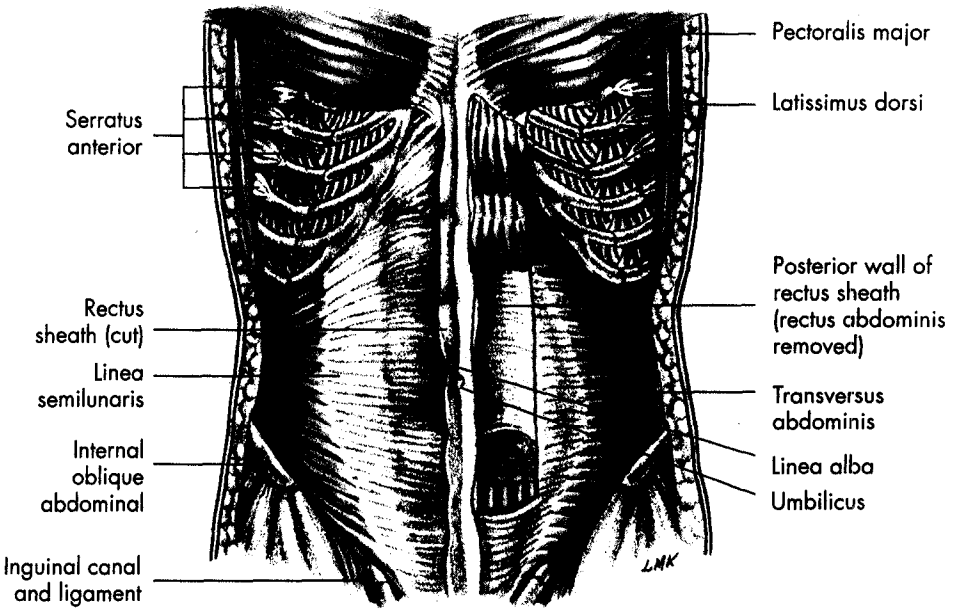


FIG. 10.15 • Muscles of the abdomen. The external oblique has been removed on the right to reveal the internal oblique. The external and internal obliques have been removed on the left to reveal the transversus abdominis. The rectus abdominis has been cut to reveal the posterior rectus sheath.

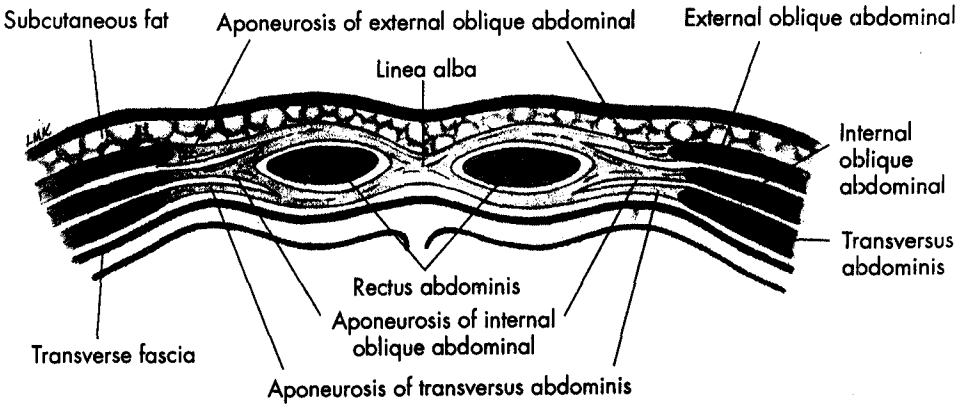


FIG. 10.16 • Abdominal wall. The unique arrangement of the four abdominal muscles with their fascial attachment in and around rectus abdominis muscle is shown. With no bones for attachments, these muscles can be adequately maintained through exercise.

Rectus abdominis muscle FIG. 10.17

(rek'tus ab-dom'i-nis)

Origin

Crest of the pubis.

Insertion

Cartilage of the fifth, sixth, and seventh ribs and the xiphoid process.

Action

Both sides: lumbar flexion.
Right side: lateral flexion to the right.
Left side: lateral flexion to the left.

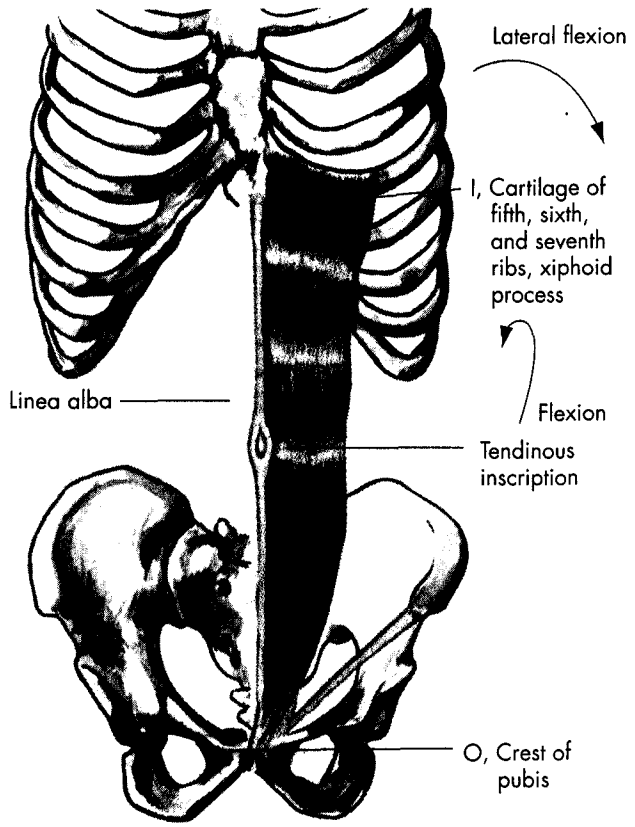
Palpation

Anteromedial surface of the abdomen, between the rib cage and the pubic bone.

Innervation

Intercostal nerves (T7-12).

FIG. 10.17 • Rectus abdominis muscle. *O*, Origin; *I*, insertion.



Application, strengthening, and flexibility

The rectus abdominis muscle controls the tilt of the pelvis and the consequent curvature of the lower spine. By rotating the pelvis posteriorly, it flattens the lower back, making the erector spinae muscle more effective as an extensor of the spine and the hip flexors (the iliopsoas muscle, particularly) more effective in raising the legs.

In a relatively lean person with well developed abdominals, three distinct sets of lines or depressions may be noted. Each represents an area of tendinous connective tissue connecting or supporting the abdominal arrangement of muscles in lieu of bony attachments. Running vertically from the xiphoid process through the umbilicus to the pubis is the *linea alba*. It divides each rectus abdominis and serves as its medial border. Lateral to each rectus abdominis is the *linea semilunaris*, a crescent or moon-shaped line running vertically. This line represents the aponeurosis connecting the lateral border of the rectus abdominis and the medial border of the external and internal abdominal obliques. The *tendinous inscriptions* are horizontal indentations that transect the rectus abdominis at three or more locations, giving the muscle its segmented appearance. Refer to Fig. 10.16.

There are several exercises for the abdominal muscles, such as leg raises, bent-knee sit-ups, crunches, and isometric contractions. Bent-knee sit-ups with the arms folded across the chest are considered by many to be a safe and efficient exercise. Crunches are also considered to be very effective for isolating the work to the abdominals. Both of these exercises shorten the iliopsoas muscle and other hip flexors, thus reducing their ability to generate force. Twisting to the left and right brings the oblique muscles into more active contraction.

The rectus abdominis is stretched by simultaneously hyperextending both the lumbar and thoracic spine. Extending the hips assists in this process by accentuating the anterior rotation of the pelvis to hyperextend the lumbar spine.

External oblique abdominal muscle

FIG. 10.18

(ek-stur'nel o-bleek' ab-dom'i-nel)

Origin

Borders of the lower eight ribs at the side of the chest, dovetailing with the serratus anterior muscle.*

Insertion

Anterior half of the crest of the ilium, the inguinal ligament, the crest of the pubis, and the fascia of the rectus abdominis muscle at the lower front.

Action

Both sides: lumbar flexion.

Right side: lumbar lateral flexion to the right and rotation to the left.

Left side: lumbar lateral flexion to the left and rotation to the right.

*Sometimes the origin and insertion are reversed in anatomy books. This is the result of different interpretations of which bony structure is the more movable. The insertion is considered the most movable part of a muscle.

Palpation

Lateral side of the abdomen, either left or right.

Innervation

Intercostal nerves (T8-12), iliohypogastric nerve (T12, L1), and ilioinguinal nerve (L1).

Application, strengthening, and flexibility

Working on each side of the abdomen, the external oblique abdominal muscles aid in rotating the trunk when working independently of each other. Working together, they aid the rectus abdominis muscle in its described action. The left external oblique abdominal muscle contracts strongly during sit-ups when the trunk rotates to the right, as in touching the left elbow to the right knee. Rotating to the left brings the right external oblique into action.

Each side of the external oblique must be stretched individually. The right side is stretched by moving into extreme left lateral flexion combined with extension or by extreme lumbar rotation to the right combined with extension. The opposite movements in extension stretch the left side.

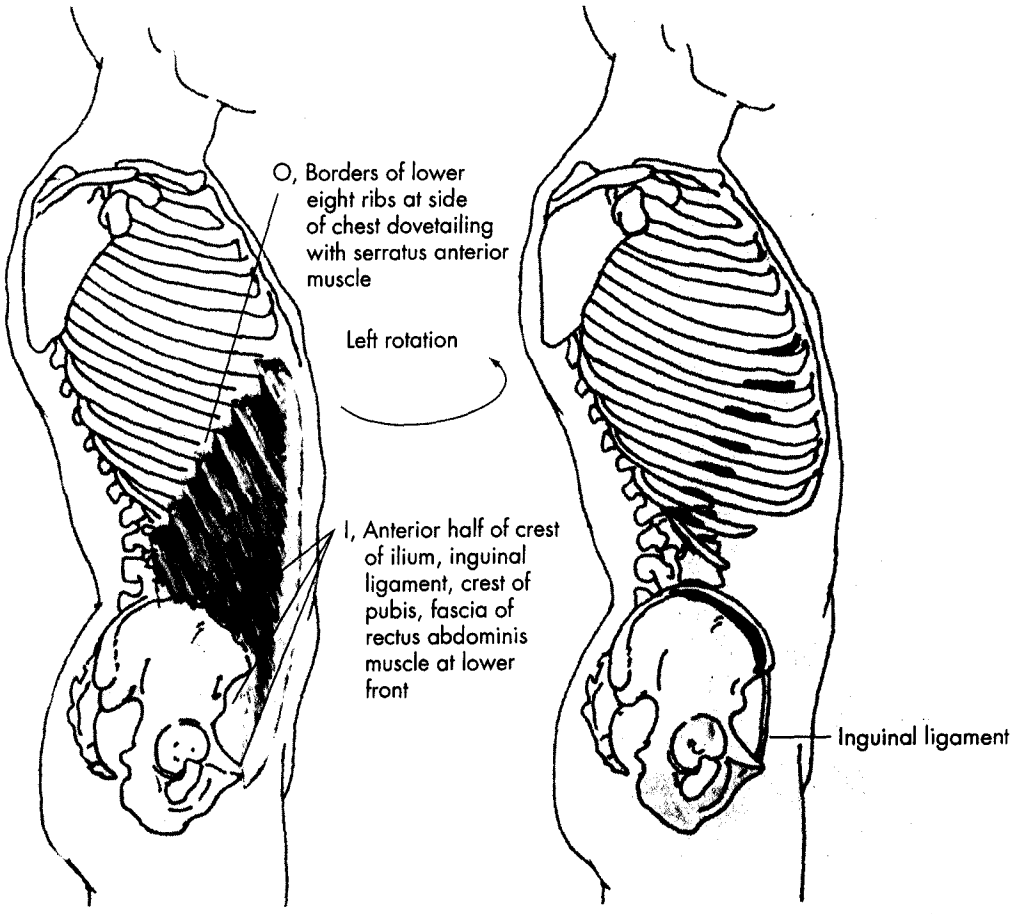


FIG. 10.18 • External oblique abdominal muscle. *O*, Origin; *I*, insertion.

Internal oblique abdominal muscle

FIG. 10.19

(in-ter'nel o-bleek ab-dom'i-nel)

Origin

Upper half of the inguinal ligament, anterior two-thirds of the crest of the ilium, and the lumbar fascia.

Insertion

Costal cartilages of the eighth, ninth, and tenth ribs and the linea alba.

Action

Both sides: lumbar flexion.

Right side: lumbar lateral flexion and rotation to the right.

Left side: lumbar lateral flexion and rotation to the left.

Palpation

Palpated on the lateral side of the abdomen when the external oblique is relaxed.

Innervation

Intercostal nerves (T8-12), iliohypogastric nerve (T12, L1), and ilioinguinal nerve (L1).

Application, strengthening, and flexibility

The internal oblique abdominal muscles run diagonally in the direction opposite to that of the external obliques. The left internal oblique rotates to the left, and the right internal oblique rotates to the right.

In touching the left elbow to the right knee in sit-ups, the left external oblique and the right internal oblique abdominal muscles rotate at the same time, assisting the rectus abdominis muscle in flexing the trunk to make the completion of the movement possible. In rotary movements, the internal oblique and the external oblique on opposite sides from each other always work together.

Like the external oblique, each side of the internal oblique must be stretched individually. The right side is stretched by moving into extreme left lateral flexion and extreme left lumbar rotation combined with extension. The same movements to the right combined with extension stretch the left side.

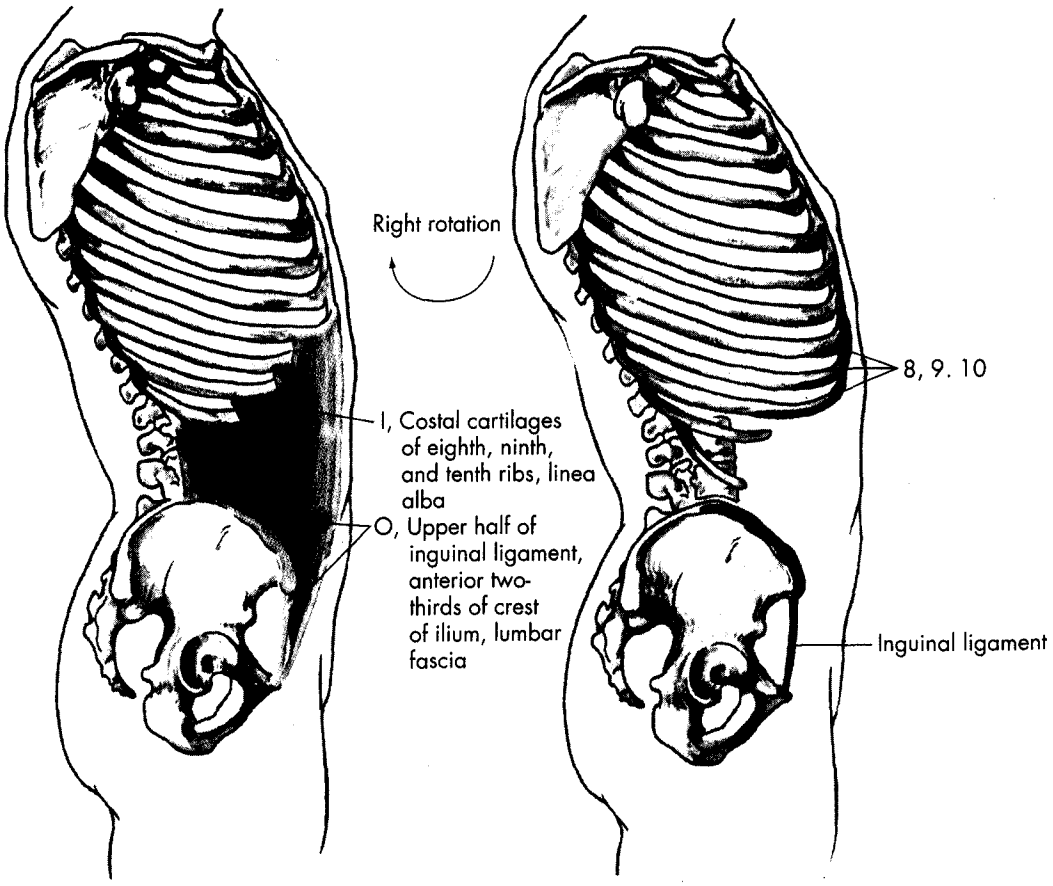


FIG. 10.19 • Intern oblique abdominal muscle. *O*, Origin; *I*, insertion.

Transversus abdominis muscle

FIGS. 10-20

(trans-vurs'us ab-dom'i-nis)

Origin

Outer third of the inguinal ligament.
Inner rim of the iliac crest.
Inner surface of the cartilage of the lower six ribs.
Lumbar fascia.

Insertion

Crest of the pubis and the iliopectineal line.
Abdominal aponeurosis to the linea alba.

Action

Forced expiration by pulling the abdominal wall inward.

FIG. 10.20 • Transversus abdominis muscle. *O*, Origin; *I*, insertion.

Palpation

Cannot be palpated.

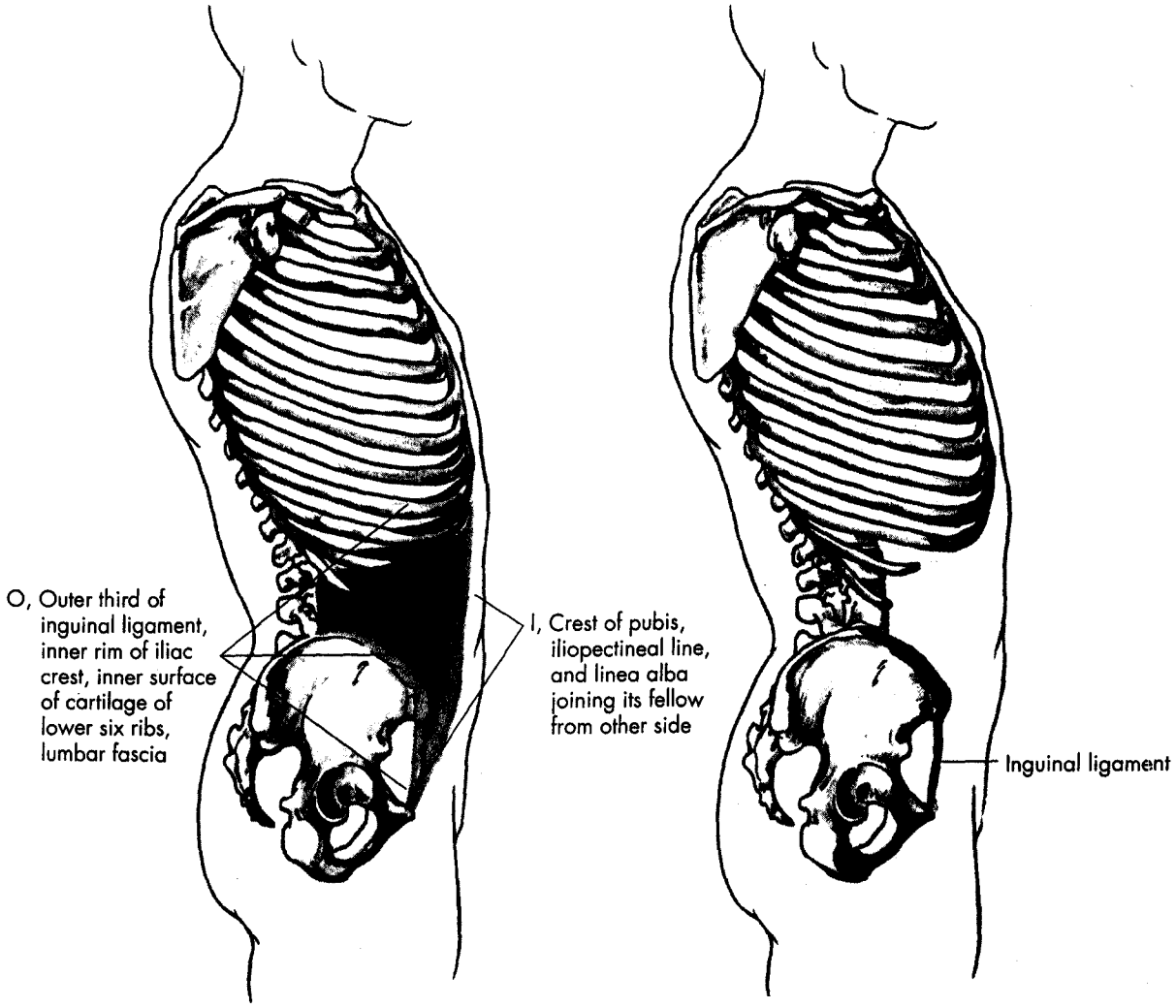
Innervation

Intercostal nerves (T7-12), iliohypogastric nerve (T12, L1), and ilioinguinal nerve (L1).

Application, strengthening, and flexibility

The transversus abdominis is the chief muscle of forced expiration and is effective, together with the rectus abdominis, the external oblique abdominal, and the internal oblique abdominal muscles, in helping to hold the abdomen flat. This abdominal flattening and forced expulsion of the abdominal contents is the only action of this muscle.

The transversus abdominis muscle is exercised effectively by attempting to draw the abdominal contents back toward the spine. This may be done isometrically in the supine position or while standing. A maximal inspiration held in the abdomen applies stretch.



Quadratus lumborum muscle FIG. 10.21

(kwad-ra'tus lum-bo'rum)

Origin

Posterior inner lip of the iliac crest.

Insertion

Approximately one-half the length of the lower border of the twelfth rib and the transverse process of the upper four lumbar vertebrae.

Action

Lateral flexion to the side on which it is located. Stabilizes the pelvis and lumbar spine.

Palpation

For all practical purposes, it is impossible to palpate except on an extremely thin individual.

Innervation

Branches of T12, L1 nerves.

Application, strengthening, and flexibility

The quadratus lumborum is important in lumbar lateral flexion and in elevating the pelvis on the same side in the standing position. Trunk rotation and lateral flexion movements against resistance are good exercises for development of this muscle. The position of the body relative to gravity may be changed to increase resistance on this and other trunk and abdominal muscles. Left lumbar lateral flexion stretches the right quadratus lumborum and vice versa.

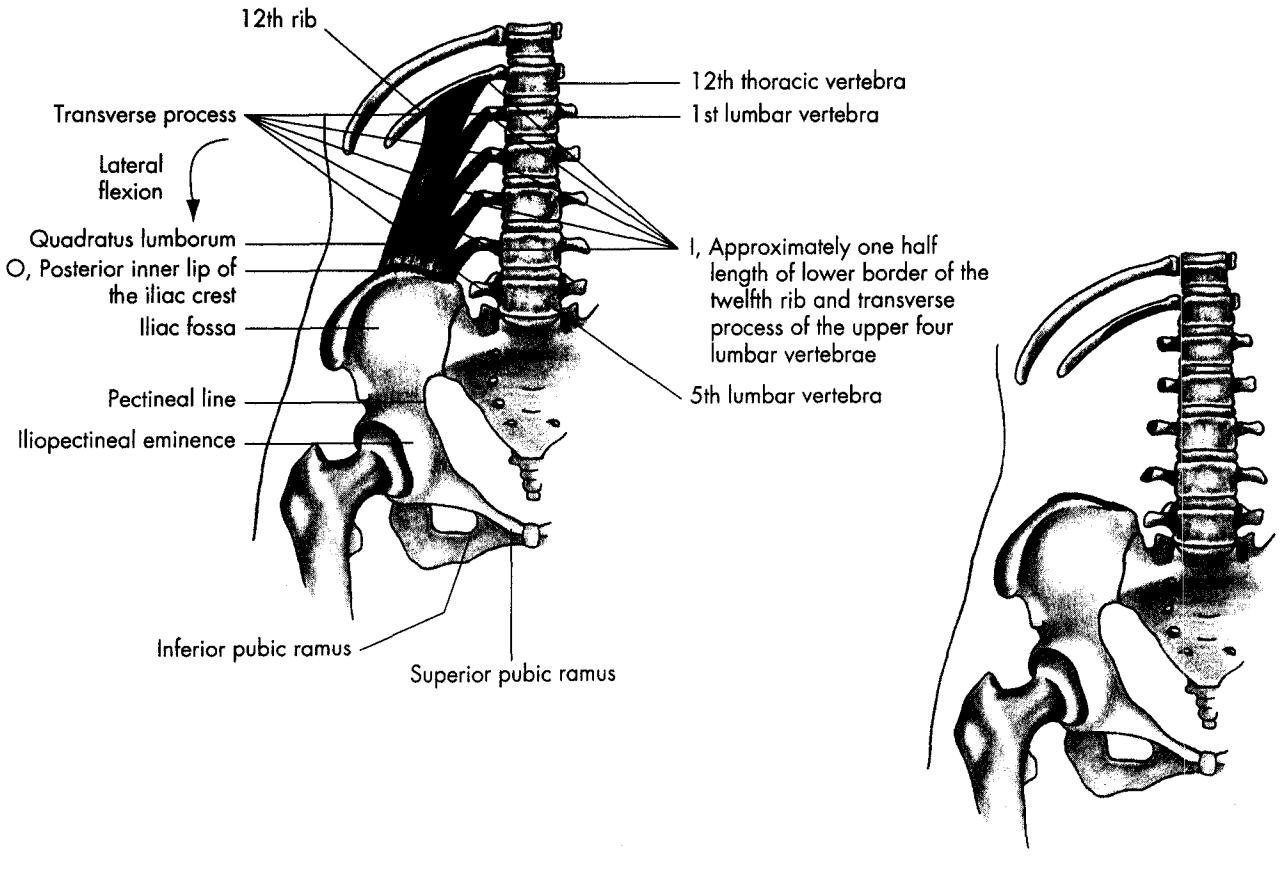


FIG. 10.21 • Quadratus lumborum muscle. *O*, Origin; *I*, insertion.

Modified from Anthony CP, Kolthoff NJ: *Textbook of anatomy and physiology*, ed 9, St. Louis, 1975, Mosby.

Worksheet exercises

As an aid to learning, for in-class or out-of-class assignments, or for testing, tear-out worksheets are found at the end of the text (pp. 258 and 259).

Anterior skeletal worksheet (no. 1)

Draw and label the following muscles on the skeletal chart:

a. Rectus abdominis
b. External oblique abdominal
c. Internal oblique abdominal

Posterior skeletal worksheet (no. 2)

Draw and label the following muscles on the skeletal chart:

a. Erector spinae
b. Quadratus lumborum
c. Splenius—cervicis and capitis

Laboratory and review exercises

1. Locate the following parts of the spine on a human skeleton and on a human subject:
   a. Cervical vertebrae
   b. Thoracic vertebrae
   c. Lumbar vertebrae
   d. Spinous processes
   e. Transverse processes
   f. Sacrum
   g. Manubrium
   h. Xiphoid process
   i. Sternum
   j. Rib cage (various ribs)
2. How and where can the following muscles be palpated on a human subject?
   a. Rectus abdominis
   b. External oblique abdominal
   c. Internal oblique abdominal
   d. Erector spinae
   e. Sternocleidomastoid
3. List the planes in which each of the following movements occurs. List the respective axis of rotation for each movement in each plane.
   a. Cervical flexion
   b. Cervical extension
   c. Cervical rotation
   d. Cervical lateral flexion
   e. Lumbar flexion
   f. Lumbar extension
   g. Lumbar rotation
   h. Lumbar lateral flexion
4. Contrast crunches with bent-knee sit-ups and with straight-leg sit-ups. Does having a partner to hold the feet make a difference in the ability to do the bent-knee and straight-leg sit-ups? If so, why?
5. Have a laboratory partner stand and assume a position exhibiting good posture. What motions in each region of the spine does gravity attempt to produce? Which muscles are responsible for counteracting these motions against the pull of gravity?
6. Compare and contrast the spinal curves of a laboratory partner sitting erect versus sitting slouched in a chair. Which muscles are responsible for maintaining good sitting posture?
7. Which exercise is better for the development of the abdominal muscles—leg-lifts or sit-ups? Defend your answer.
8. Why is good abdominal muscular development so important? Why is this area so frequently neglected?
9. Why are weak abdominal muscles frequently blamed for lower back pain?
10. Prepare an oral or written report on abdominal or back injuries found in the literature.
11. Fill in the movements and muscle actions of the cervical and lumbar spine on the chart on the next page. List the muscles primarily responsible for each movement.
12. Fill in the antagonistic muscle action chart by listing the muscle(s) or parts of muscles that are antagonistic in their actions to the muscles in the left column.

Muscle analysis chart • Lumbar and cervical spine

Cervical spine	
Flexion	Extension
Lateral flexion right	Rotation right
Lateral flexion left	Rotation left
Lumbar spine	
Flexion	Extension
Lateral flexion right	Rotation right
Lateral flexion left	Rotation left

Antagonistic muscle action chart • Cervical and lumbar spine

Agonist	Antagonist
Splenius capitis	
Splenius cervicis	
Sternocleidomastoid	
Erector spinae	
Rectus abdominis	
External oblique abdominal	
Internal oblique abdominal	
Quadratus lumborum	

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