THE PRIMARY MUSCLES OF RESPIRATORY FUNCTION

COMPILED AND DEVELOPED BY
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MUSCLES OF INHALATION (INSPIRATORY MUSCLES)

I. Muscles of the Rib Cage/Thorax

**Muscle:** Diaphragm

- **D:** A dome-shaped, musculotendinous sheet which forms a partition between the thoracic and abdominal cavities; composed of a central tendon or aponeurosis forming the summit of the dome and a peripheral outer ring of muscle fibers passing around the inner surface of the body wall.
- **O:** Muscle fibers forming the circular, peripheral portion arise from the upper two or three lumbar vertebrae by way of two musculotendinous crura, the inner surfaces of the xiphoid process of the sternum, and the lower border of the inner surfaces of the six lower ribs and their costal cartilages.
- **I:** Fibers pass vertically upward and turn inward to insert onto the central tendon of the diaphragm.
- **A:** Contraction of the muscle fibers pulls the central tendon downward and forward while slightly raising and outwardly rotating the lower ribs and slightly raising the sternum; the vertical diameter of the thoracic area is increased, intrathoracic pressure is decreased, and the intraabdominal pressure is increased resulting in expansion of the lower abdominal wall (diaphragmatic/abdominal breathing) during inhalation.

**Muscle:** External Intercostals

- **D:** Eleven sheets of short, parallel muscle fibers occupying the spaces between the ribs on both sides of the rib cage; fibers extend from the tubercles of the ribs at the vertebral column posteriorly to a region near the cartilages of the ribs anteriorly; they do not occupy the intercostal spaces at the chondral portion of the ribs.
- **O:** Arise from the lower borders of each of the first eleven ribs.
- **I:** Muscles insert into the upper border of the rib immediately below its origin; anterior fibers course downward and medially; posterior fibers course downward and laterally.
- **A:** With fixation of the upper ribs by the scaleni, contraction results in the lifting of the ribs upward and outward during inspiration. Suspected that contraction also occurs with voluntary expiration and with coughing when the lower ribs are held down by the abdominals and quadratus lumborum. With the internal intercostals, provides rigidity to the thoracic wall, helps control the spaces between the ribs, and influences the coordination of movement and position between the ribs.
### Internal Intercostals - Intercartilaginous Portion

**D:** A set of eleven pairs of short muscle fibers occupying the spaces between the ribs generally lying beneath the external intercostals; the intercartilaginous portion occupies the intercostal spaces immediately lateral to the sternum at the chondral portion of the ribs which is devoid of external intercostal muscle fibers.

**O:** Arise from the costal grooves on the lower borders of the first eleven ribs.

**I:** Insert into the inner aspect of the rib immediately below its origin; intercartilaginous fibers course downward and outward.

**A:** Intercartilaginous portion works in conjunction with the external intercostals to elevate the ribs during inhalation, help control the spaces between the ribs, and coordinate movements and position between the ribs.

### Levator Costarum (Costal Elevators)

**D:** Two sets of twelve fan-shaped muscles on each side of the vertebral column.

**O:** Arise from the transverse processes of the last cervical and first eleven thoracic vertebrae.

**I:** Muscle fibers course obliquely downward and laterally inserting on the superior, posterior surface of the rib below, between the tubercle and the angle. Reportedly, the lower four muscles divide into two parts so that they attach to the rib beneath and to the second rib below its origin.

**A:** No adequate studies of their function exists. Analysis of their anatomical position and attachments suggests that contraction may assist in lifting the ribs and in increasing the thoracic cavity while creating extension, lateral flexion, and slight rotation to the opposite side in the vertebral column.

### Serratus Posterior Superior

**D:** A flat, rhomboid-shaped sheet of muscle fibers lying under the upper half of the scapula, the trapezius, and the rhomboid.

**O:** Lower part of the ligamentum nuchae in the neck and the spinous processes of the seventh cervical and the upper three thoracic vertebrae.

**I:** Fibers run down (inferior-laterally) inserting on the outer surfaces of the upper edges of the second through fifth ribs.

**A:** Little is known about its actual activity. It is postulated that upon contraction, it assists in elevating the upper four ribs, increasing the diameter of the thoracic area, and raising the sternum (supplementary muscle of inhalation).
Anterior View Without
Sternum Present

Posterior View
II. Muscles of the Head and Neck

<table>
<thead>
<tr>
<th>Muscle:</th>
<th>Sternocleidomastoid (Sternomastoid)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D:</td>
<td>Broad, straplike muscle composed of two divisions of origin located on the anterolateral aspects of the neck.</td>
</tr>
<tr>
<td>O:</td>
<td>Sternal head arises from the anterior surface of the manubrium of the sternum coursing upward, backward, and slightly laterally; clavicular head arises from the superior surface of the sternal end of the clavicle coursing vertically upward.</td>
</tr>
<tr>
<td>I:</td>
<td>Sternal and clavicular heads unite to form a single muscle coursing upward and laterally along the side of the neck to insert on the mastoid process of the temporal bone (behind the ear) and the superior nuchal line of the occipital bone.</td>
</tr>
<tr>
<td>A:</td>
<td>Muscles acting together on either side of neck (bilateral contraction) powerfully flexes head and neck; one side flexes head and neck laterally toward the same side while turning face to opposite side (unilateral contraction). If the head is fixed in position, the sternocleidomastoids can increase the anteroposterior diameter of the thorax by elevating the sternum and clavicles to assist during inhalation (supplementary muscle of inhalation).</td>
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<table>
<thead>
<tr>
<th>Muscle:</th>
<th>Scalenus (Scalene) Muscles</th>
</tr>
</thead>
<tbody>
<tr>
<td>D:</td>
<td>Three deep muscle bundles found on the sides of the neck which compose the lateral vertebral muscles coursing from the transverse processes of the cervical vertebrae to the upper two ribs.*</td>
</tr>
<tr>
<td>A:</td>
<td>If ribs are fixed in position, contraction of the scalenes on one side will result in lateral flexion of the cervical spine toward the side contracting. If ribs are fixed in position, bilateral contraction of the scalenes will result in flexion of the cervical spine. If the neck is fixed in position, the scalenes will raise the first and second ribs in forced inspiration and fixate them in quiet inspiration (supplementary muscles of inhalation).</td>
</tr>
</tbody>
</table>

*Scalenus Anterior
O: Arises from the transverse processes of the third through sixth cervical vertebrae as four tendinous slips.
I: Runs vertically downward and slightly laterally to the inner border of the upper surface of the first rib towards the sternal attachment.

*Scalenus Medius (largest and longest scalene muscle)
O: Arises from the transverse processes of the second through seventh cervical vertebrae as five tendinous slips.
I: Runs vertically downward inserting into the upper surface of the first rib as a broad tendon.

*Scalenus Posterior (smallest and deepest scalene muscle)
O: Arises from the posterior tubercles of the fourth through sixth cervical vertebrae.
I: Runs downward and laterally to the outer surface of the second rib.

D = Description, O = Origin, I = Insertion, A = Action
III. Muscles of the Shoulder Girdle, Upper Extremities, and Trunk

The direct or indirect influences of the musculature of the trunk, shoulder girdle, and upper extremities on the respiratory process cannot be disregarded. Musculature which have primary functions in terms of postural control and movement play a role in establishing a foundation throughout the body for efficient and coordinated respiratory function. The following muscles are most often discussed in terms of their potential roles as supplementary or accessory muscles of inhalation.

<table>
<thead>
<tr>
<th>Muscle: Pectoralis Major</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>D:</strong> Large, fan-shaped muscle covering most of the upper part of the chest; forms the anterior wall of the axilla or armpit, discussed in terms of its clavicular and sternal heads.</td>
</tr>
<tr>
<td><strong>O:</strong> Clavicular head from the medial half of the anterior surface of the clavicle. Sternal head from the whole length of the sternum, the costal cartilages of the first six ribs, and the aponeurosis of the external oblique muscle. The fascial sheath which encloses the pectoralis major muscle originates from the clavicle and sternum.</td>
</tr>
<tr>
<td><strong>I:</strong> Thick band of fibers run laterally and slightly downward inserting into the greater tubercle of the humerus near the insertion of the deltoid (clavicular head). Muscle fibers run laterally and upward as they converge and pass behind the clavicular head inserting onto the outer border of the bicipital groove of the humerus (sternal head).</td>
</tr>
<tr>
<td><strong>A:</strong> Prime flexor of the arm and can assist in abduction once the arm has already been horizontally abducted (clavicular head). Prime extensor and adductor of the arm; lowest of the sternocostal fibers help to depress the arm (sternal head). When the sternal and clavicular heads act together, contraction results in horizontal flexion of the arm and assists in its internal rotation. When the humerus is fixed in position, contraction will raise the ribs and sternum so as to assist in the expansion of the upper rib cage at the end of maximum inhalation.</td>
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</tbody>
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<thead>
<tr>
<th>Muscle: Pectoralis Minor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>D:</strong> Small, triangular or fan-shaped muscle lying beneath the pectoralis major and surrounded by a thin fascial sheath called the clavipectoral fascia.</td>
</tr>
<tr>
<td><strong>O:</strong> The anterior surfaces of the third, fourth, and fifth ribs near their costal cartilages.</td>
</tr>
<tr>
<td><strong>I:</strong> Courses laterally and obliquely upward in front of the axilla inserting on the medial border and superior surface of the coracoid process of the scapula.</td>
</tr>
<tr>
<td><strong>A:</strong> Pulls the scapula laterally and anteriorly against the thoracic wall so that the medial border and inferior angle of the scapula lift off the ribs posteriorly (&quot;winged scapula&quot;). Assists in depressing the shoulder girdle. When the scapula is fixed in position with the shoulders raised as in forced or deep inspiration, contraction results in lifting of ribs three through five so as to assist in expansion of the rib cage.</td>
</tr>
</tbody>
</table>
### Subclavius

**D:** Small triangular muscle lying inferior to the clavicle.

**O:** Upper surface of the first rib at its junction with its costal cartilage.

**I:** Runs laterally to insert on the inferior surface of the clavicle near where the clavicle meets the acromion of the scapula.

**A:** Generally pulls the clavicle medially, drawing the shoulder forward and slightly downward.

When the clavicle is raised and fixed in position, contraction may assist in pulling the first rib upward so as to assist in expansion of the upper rib cage. (No data to support its role in respiration.)

### Serratus Anterior (Serratus Magnum)

**D:** Thin, large muscle sheet which lies over the lateral rib cage and intercostal musculature between the ribs and scapula. Although often referred to in respiratory musculature reviews, questionable as to whether it has any active role in respiration.

**O:** Fleshy, muscle fiber digitations on the anterolateral surface of the upper eight to nine ribs which present a saw-toothed appearance.

**I:** Runs backward along the curve of the ribs inserting on the anterior surface of the medial border (superior to inferior angle) of each scapula.

Most heavily inserts on inferior angle of scapula.

**A:** Serves as protractor of the scapula especially at the inferior angle.

Important part in the upward rotation of the lateral angle of the scapula.

Helps to keep the medial border of the scapula close to the thoracic wall as the arm is elevated.

With fixation of the scapula, contraction will result in the lifting of the ribs. (This has not been found in studies of musculature activity during inhalation.)

### Latissimus Dorsi

**D:** Broad, thin, fan-shaped sheet of muscle fibers covering the inferior half of the back.

**O:** Spinous processes of the lower six thoracic and the lumbar vertebrae, the sacrum, the thoracolumbar fascia, the posterior third of the iliac crest, and the outer surface of the inferior three or four ribs.

**I:** Muscle fibers converge into a flat tendon passing across the posterior wall of the axilla and continue forward around the medial humeral surface inserting on the medial lip of the intertubercular groove (crest of the lesser tubercle) of the humerus. Prior to its insertion, it twists around the teres major so that its upper fibers insert into the floor of the intertubercular groove.

**A:** Extends, adducts, and medially rotates the humerus.

Also assists in hyperextending the arm backward and depressing the shoulder girdle.

With fixation of the humerus, contraction of the latissimus dorsi may help elevate the lower ribs in deep inspiration. (Limited data to support this role.)

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*D = Description, O = Origin, I = Insertion, A = Action*
Anterior View
MUSCLES OF ACTIVE EXHALATION (EXPIRATORY MUSCLES)

I. Muscles of the Rib Cage/Thorax

<table>
<thead>
<tr>
<th>Muscle: Internal Intercostals - Interosseous portion</th>
</tr>
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<tbody>
<tr>
<td>D: A set of eleven pairs of short, thin muscles occupying the space between the ribs generally lying beneath the external intercostals; fibers run at almost a 90 degree angle to the fibers of the external intercostals; the interosseous portion occupies the space from the intercartilaginous portion to the angle of the rib posteriorly continuing to the vertebral column as thin aponeuroses called the posterior (internal) intercostal membranes.</td>
</tr>
<tr>
<td>O: Arise from the costal grooves on the lower borders of the first eleven ribs.</td>
</tr>
<tr>
<td>I: Insert into the inner aspect of the rib immediately below its origin; interosseous fibers course downward and outward anteriorly and course downward and inward posteriorly. (The inferior internal intercostals are continuous with the internal obliques of the anterolateral abdominal wall.)</td>
</tr>
<tr>
<td>A: Interosseous portion appears to decrease the intercostal spaces and, in conjunction with the abdominal muscles, depresses the ribs to assist in exhalation. Helps to control the spaces between the ribs and coordinate the movements and position between the ribs in conjunction with the intercartilaginous portion of the internal intercostals and the external intercostals.</td>
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<table>
<thead>
<tr>
<th>Muscle: Subcostals (Innermost Intercostals or Intracostals)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D: Course parallel to the internal intercostals and often hard to distinguish from them; more easily distinguished on the lower aspect of ventral surface of the posterior thoracic wall; thin muscular slips which are highly variable in size and shape.</td>
</tr>
<tr>
<td>O: Arise from lower margin of the inner surface of the ribs at the area of the rib angles.</td>
</tr>
<tr>
<td>I: Run downward and medially, often passing over one or two ribs, to insert onto the internal surface of the ribs below.</td>
</tr>
<tr>
<td>A: Contraction may aid in the depression of the ribs in active expiration. (No direct evidence of this is now available.)</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Muscle: Serratus Posterior Inferior</th>
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</thead>
<tbody>
<tr>
<td>D: Flat, quadrilateral sheet of muscle tissue covering the true muscles of the back which lies between these muscles and those of the upper limb; located at the junction of the lumbar and thoracic regions. The inner half of the muscle appears to be a tendinous sheet which blends with the tendons of the latissimus dorsi and the erector spinae.</td>
</tr>
<tr>
<td>O: Arises from the spinous processes of the last two or three thoracic vertebrae and the first two or three lumbar vertebrae.</td>
</tr>
<tr>
<td>I: Muscle fibers course upward and laterally inserting into the inferior borders of the lower four ribs near their angles.</td>
</tr>
<tr>
<td>A: Contraction results in the depression of the lower ribs which enlarges the thorax and steadies the ribs against the upward pull of the diaphragm in forced expiration. May assist in stabilizing the lower four ribs as the diaphragm exerts strong downward pressure in forced or deep inhalation. (Role in respiration is still unsubstantiated.)</td>
</tr>
</tbody>
</table>

D = Description, O = Origin, I = Insertion, A = Action
Muscle: Transverse Thoracis
D: Thin muscles of the anterior rib cage which are continuous inferiorly with the transversus abdominis muscle.
O: Attached posteriorly to the xiphoid process of the sternum, the inferior part of the body of the sternum, and the adjacent costal cartilages of the ribs.
I: Muscle fibers pass superolaterally to insert on the second to sixth costal cartilages.
A: Probable function is that these muscles depress the ribs to assist in exhalation.
If sternum is actually considered to be fixed in position, contraction of transversus thoracis muscles will pull down on the ribs decreasing the transverse diameter of the thorax.

II. Muscles of the Anterior Abdominal Wall

Muscle: External Obliques (Obliquus Externus)
D: The largest, strongest, and most superficial of the abdominal muscles located in the anterolateral part of the abdominal wall.
O: Arise from the external surfaces and lower borders of ribs five through twelve as fleshy slips.
I: Runs down and medially in broad sheets attaching to the anterior part of the iliac crest, the pubis, and the linea alba. Primarily muscle fibers insert anteriorly into the aponeurosis of the external oblique with its lower edge forming the inguinal ligament.
A: Contraction results in inward movement of the abdominal wall, helping to fix the thorax against the pull of the diaphragm which raises intraabdominal and intrathoracic pressures. When one side of the external obliques acts alone, the lower ribs on that side are pulled forward and downward resulting in flexion, lateral flexion, and rotation to the opposite side. When both sides act together, pure flexion results. When the external oblique of one side works with the internal oblique of the opposite side, flexion and rotation of the trunk to the side of the internal oblique occurs.
Muscle: **Internal Obliques (Obliquus Internus)**

D: Situated under the external obliques with fibers running at nearly a right angle to the external muscles.

O: Arise from the lateral half of the inguinal ligament, the anterior two-thirds of the iliac crest, and the thoracolumbar fascia.

I: Posterior fibers run almost vertically inserting into the lower borders of the cartilages of ribs ten through twelve. Other fibers from the iliac crest spread over the lateral abdominal wall ending in an aponeurosis which joins with the aponeurosis of the transversus abdominis forming the conjoint tendon which runs inferiorly inserting into the linea alba. Fibers from the inguinal ligament run downward and medially as they terminate in a tendinous sheet which inserts into the pubis.

A: Contraction results in compression and tensing of the abdominal wall, helping to fix the thorax against the pull of the diaphragm. When one side of internal obliques acts, it pulls down and sideward on the front of the thorax and abdomen, flexing, laterally flexing, and rotating the trunk to the same side. When both sides act together, pure flexion results as the costal cartilages are drawn toward the pubis. When the internal oblique of one side works with the external oblique of the other side, flexion and rotation of the trunk to the side of the internal oblique occurs.

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Muscle: **Transversus Abdominis**

D: Large, flat sheet of parallel muscles lying beneath the internal obliques which forms the third layer of the abdominal wall; deepest of the abdominal muscles; most fibers cross the abdomen horizontally except for the most inferior of them.

O: Arises from the lateral one-third of the inguinal ligament, the anterior three-fourths of the iliac crest, the inner surfaces of the costal cartilages of ribs six through twelve, and the thoracolumbar fascia (lumbodorsal fascia) of the lumbar vertebrae.

I: Generally fibers run horizontally beneath the rectus abdominis ending in the deepest layer of the abdominal aponeurosis or linea alba. The most inferior fibers course downward inserting into the pubis.

A: Contraction aids the obliques in the compression of the abdomen, increasing the pressure on the abdominal organs. Works with other abdominal muscles and the diaphragm to raise the intraabdominal pressure and to stabilize the thorax especially during strong compression of the latissimus dorsi. More active during forced expiration.

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D = Description, O = Origin, I = Insertion, A = Action
Muscle: **Rectus Abdominis**

**D:** Twin-bellied muscle; each belly wrapped in a fascial sheath separated by the abdominal aponeurosis (linea alba); composed of parallel fibers crossed by three tendinous intersections which attach the rectus sheath firmly to the rectus muscle.

**O:** Arise from the crest of the pubis as narrow, thick musculature.

**I:** Fibers course vertically upward inserting on the xiphoid process of the sternum and the costal cartilages of ribs five through seven; muscles are broad and thin superiorly.

**A:** Contraction draws the ribs and sternum downward.

Acts as a primary flexor of the trunk.

Contraction of one belly of the rectus abdominis helps to laterally flex the trunk to the same side.

When the body is fixed from above, contraction of the rectus abdominis results in the upward rotation of the pelvis.

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III. **Muscles of the Posterior Abdominal Wall**

Although other posterior abdominal wall muscles exist, only the **quadratus lumborum** will be described due to its possible role in respiratory function especially during exhalation.

Muscle: **Quadratus Lumborum**

**D:** Flat sheets of muscle located in the laterodorsal part of the abdominal wall, in the lumbar region; located on each side of the spinal column beneath the iliocostalis.

**O:** Arises from the iliac crest and the iliolumbar ligament which attaches to the transverse processes of the fifth lumbar vertebra medially and the iliac crest laterally.

**I:** Fibers course vertically upward, converging slightly, until they insert into the transverse processes of lumbar vertebrae one through four and the medial half and lower border of the last rib.

**A:** Primarily regarded as a lateral flexor of the vertebral column resulting in lateral flexion of the side on which the muscle is contracting; with a fixed point from above, the side of the pelvis to which it is attached tilts upward.

When both muscles act together with the serratus posterior inferior, the last ribs are depressed and stabilized against the contraction of the diaphragm.

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D = Description, O = Origin, I = Insertion, A = Action
Anterior Thoracic Wall - Inside Surface
Posterior View
Anterior View
Anterior View

Rectus Abdominis (8)

Transversus Abdominis (7)
PRIMARY RESOURCES


