ZONE OF APPOSITION (ZOA)

ZOA POSITION & MECHANICAL FUNCTION

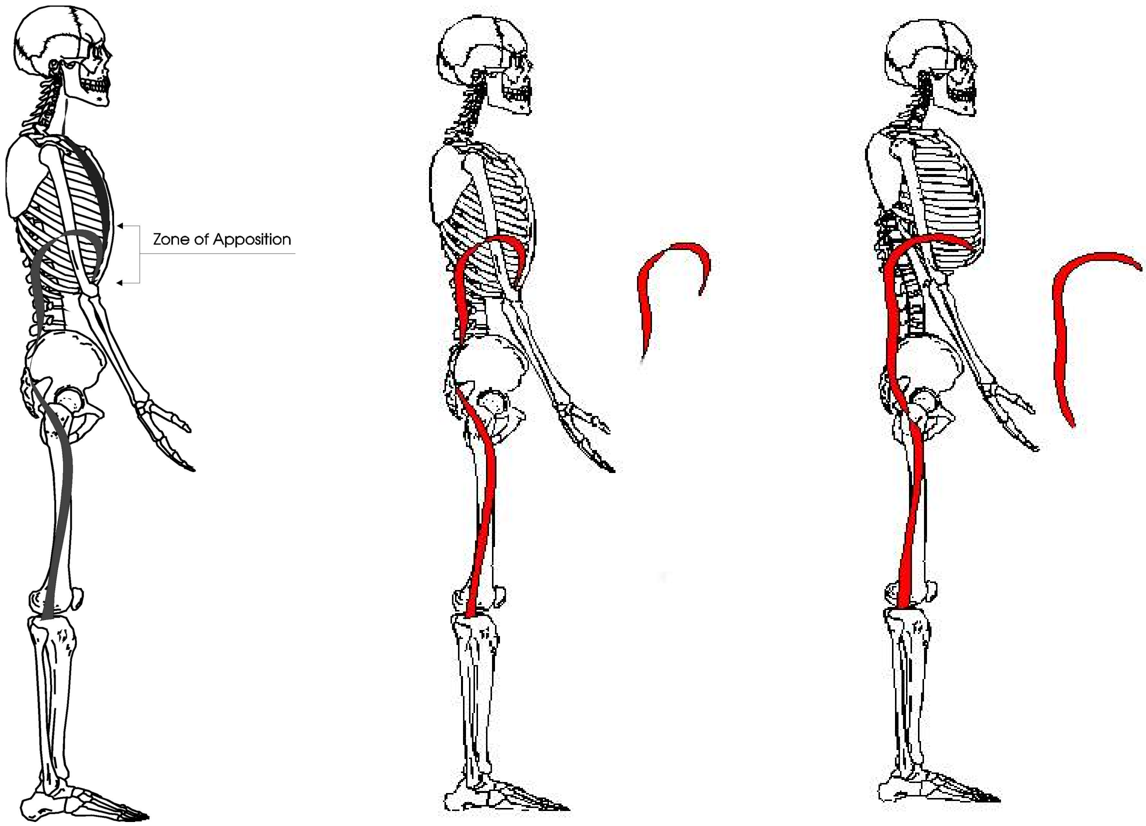
By Ron Hruska MPA, PT

The diaphragm's mechanical action and respiratory advantage depends on its relationship and anatomic arrangement with the rib cage[8,16]. The cylindrical aspect of the diaphragm that apposes the inner aspect of the lower mediastinal (chest) wall, constitutes the zone of apposition. Its region extends from the diaphragm's caudal insertion near the costal margin, cephalid to the costophrenic angle, where the fibers break away from the rib cage to form the free diaphragmatic dome[16,17]. The area of apposition of diaphragm to rib cage has a cephalad extreme at the beginning of dullness by percussion and a caudal extreme just above the costal margin[16]. For many of us the cephalid extreme begins immediately below T8 or below the cephalid aspect of the diaphragm's dome. The zone of apposition, for the most part, is not influenced by height of diaphragm dome but rather by the orientation of the rib cage. Individuals with elevated anterior, externally rotated ribs will have a decrease in their zone of apposition on one side or both sides of their thoraco-abdominal, depending on their pattern of diaphragm opposition, abdominal weakness and use.

The area of apposition of diaphragm to rib cage makes up a substantial but variable fraction of the total surface area of the rib cage. It accounts for more than one half of the total surface at residual volume and decreases to zero at total lung capacity[16]. During quiet breathing in the upright posture, it represents one fourth to one third of the total surface area of the rib cage[16]. The zone of apposition has anatomic importance because it is controlled by the abdominal and oblique muscles and directs diaphragmatic tension. Accessory respiratory muscle overuse, chest wall mobility and lung hyperinflation are all influenced by diaphragm and zone of apposition resting positions at the end of exhalation[10].

The rib cage and abdominal pathway are therefore always mechanically coupled through the zone of apposition[1]. Abdominal muscle resting tension opposes the inspiratory action of the diaphragm by facilitating an increase in pressure in the abdominal compartment rather than outward protrusion of the abdomen during diaphragmatic contraction[19]. Therefore, the zone of apposition and dome shape of the diaphragm are maintained during inspiration by abdominal muscle resting tension supporting the abdominal viscera and stomach up against the diaphragm's undersurface.

In summary, the dome of the diaphragm corresponds to the central tendon and the cylindrical portion corresponds to the portion directly apposed to the inner aspect of the lower rib cage called the zone of apposition. In relationship to its function, the diaphragm can be considered as an elliptical cylindroid capped by a dome (see figures). In standing humans at rest, this zone of apposition represents about 30 percent of the total surface of the rib cage. When the diaphragm contracts during inspiration its muscle fibers shorten. The axial length of the apposed diaphragm diminishes and the dome of the diaphragm descends relative to its costal insertions. The height of the zone of apposition in normal subjects actually decreases by about 1.5 cm during quiet inspiration, while the dome of the diaphragm remains relatively constant in size and shape. Thus, the most important change in diaphragmatic shape, the one responsible for most of the diaphragmatic volume displacement during breathing, is a piston-like axial displacement of the dome related to the <u>shortening of the apposed muscle fibers</u>[5]. The most important change in diaphragmatic change, ie shortening of the apposed diaphragm muscle, is also dependent therefore on <u>opposition of the anterolateral abdominal muscle</u> for diaphragmatic respiratory mechanical advantage, action and position[11].



Zone of Apposition Optimal ZOA Sub-Optimal ZOA

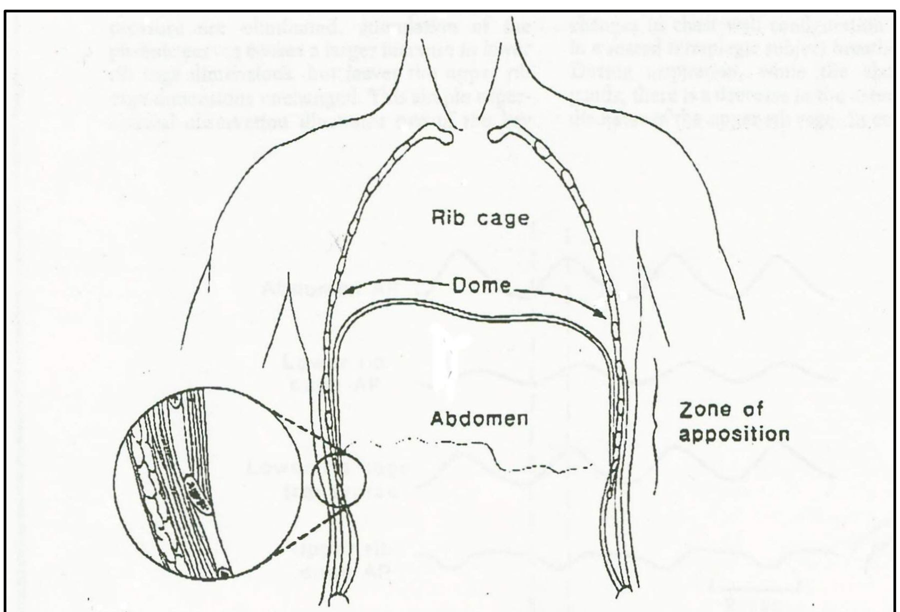


Figure 3. Frontal section of the chest wall at end-expiration illustrating the functional anatomy of the diaphragm. Note the orientation of the costal diaphragmatic fibers *(inset)*: these fibers run cranially and are directly apposed to the inner aspect of the lower rib cage (zone of apposition).

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ZOA RESTORATION

By Ron Hruska MPA, PT

Apposition of the diaphragm can be lost unilaterally, almost always on the left or bilaterally; resulting in a left Anterior Interior Chain pattern (L AIC) or Posterior Exterior Chain pattern (PEC), respectfully. Reasoning and clinical evidence-based support of the prominent L AIC pattern is offered on-line at **www.posturalrestoration.com**.

Abdominal muscle, internal obliques and transverse abdominis are primarily responsible for ipsilateral diaphragm leaflet opposition and for ipsilateral lower leaflet opposition upon contraction during inspiration, resulting in contralateral upper rib cage and apical chest wall expansion, especially during trunk rotation or gait. Loss of ipsialteral or bilateral abdominal opposition and diaphragm apposition results in hyperinflation. Studies have demonstrated that changes in diaphragm dimensions produced by chronic hyperinflation occur exclusively in the zone of apposition. Contraction of the diaphragm has been demonstrated to reduce the proportion of surface area apposed to the rib cage[3].

Reducing physical and physiological symptoms associated with hyperinflation, paradoxical breathing and accessory respiratory muscle overuse requires repositioning and re-training of the diaphragm for normal zone of apposition activity.

Using the Postural Restoration Institute™ L AIC manual technique one can guide the rib cage and diaphragm into a position where the left leaflet of the diaphragm regains proper mechanical advantage to efficiently contract via the central tendon and where the dome can rest at expiration since tangential force is no longer needed for postural stabilization.

Proper position of the diaphragm is reached when expansion of the abdominal wall is no longer required during maximal opposition (internal rotation of the ipsilateral rib cage) at inspiration. Although simultaneous “belly” expansion and chest wall expansion is desirable upon inhalation via the nose without using accessory muscles of the neck; contralateral apical flexibility and chest wall mobility is needed during ipsilateral diaphragm apposition contraction for diaphragmatic breathing to occur effortlessly with assistance from external barometric pressure, chest wall re-coil, pleural elastic properties and negative internal mediastinal pressure.

A good example of active established ZOA occurs when one can perform a successful standing reach test, fingers to toes in standing, and inhale with anterior mediastinal compression and posterior mediastinal expansion. Passive ZOA can be reached through PRI manual techniques, if active ZOA is unobtainable. Maximum ZOA is completed passively, in supine, when at the end of the exhalation phase the trans-diaphragmatic strength during active ZOA contraction is the strongest at thoraco-lumbar flexion and the weakest at thoraco-lumbar extension. At the end stage of a L AIC manual restoration technique the anterior lower leaflet of the sighing patient will easily depress caudally and “drop” posteriorly, through internal rotation of the rib cage.

ZOA REFERENCES

1. Boynton B, Barnas G, Dadmun J, Fredberg J: Mechanical coupling of the rib cage, abdomen, and diaphragm through their area of apposition. J Appl Physiol 70:3, 1991.
2. Buchholz I: Breathing, voice, and movement therapy: Applications to breathing disorders. Biofeedback Self-Regul 19:2, 1994.
3. Cassart M, Pettiaux N, Gevenois PA, Paiva M, Estenne M. Effect of chronic hyperinflation on diaphragm length and surface area. Am J Respir Crit Care Med. 156:504-508, 1997.
4. Clanton TL, Diaz PT: Clinical assessment of the respiratory muscles. Phys Ther 75:11, 1995.
5. DeTroyer A, Estenne M: Functional anatomy of the respiratory muscles. Clin Chest Med 9:2, 1988.
6. Estenne M, Derom E, DeTroyer A. Neck and abdominal muscle activity in patients with severe thoracic scoliosis. Am J Respir Crit Care Med. 1998 Aug;158 (2):452-457.
7. Flynn T: The thoracic spine and rib cage. Musculoskeletal evaluation and treatment. Butterworth-Heinemann, Newton, MA. 1996.
8. Goldman M, Mead J: Mechanical interaction between the diaphragm and the rib cage. J Appl Physiol 35:2, 1973.
9. Hodges P, Gandevia S, Richardson C: Contractions of specific abdominal muscles in postural tasks are affected by respiratory maneuvers. J Appl Physiol 83:3, 1997.
10. Hruska RJ: Influences of dysfunctional respiratory mechanics on orofacial pain. Dent Clin North Am 41:2, 1997.
11. Hruska RJ: Management of pelvic-thoracic influences on temporomandibular dysfunction. Ortho Phys Ther Clin North Am 11:2, 2002.
12. Hutt D, Parisi R, Edelman N, Santiago T: Responses of diaphragm and external oblique muscles to flow-resistive loads during sleep. Am Rev Respir Dis. 1991 Nov;144(5):1107-11.
13. Lee D, Vleeming A. The pelvic girdle. An approach to the examination and treatment of the lumbo-pelvic-hip region 2nd Edition Churchill Livingstone, 1999
14. Maskill D, Murphy K, Mier A, et al: Motor cortical representation of the diaphragm in man. J Phys Great Britian 443:119, 1991.
15. McKenzie DK, Gandevia SC, Gorman RB, Southon, FCG: Dynamic changes in the zone of apposition and diaphragm length during maximal respiratory efforts. Thorax 49:7, 1994.
16. Mead J: Functional significance of the area of apposition of diaphragm to rib cage. Am Rev Respir Dis 11:31, 1979.
17. Petroll WM, Knight H, Rochester DF: Effect of lower rib cage expansion and diaphragm shortening on the zone of apposition. J Appl Physiol 68:2, 1990.
18. Reddy V, Sharma S, Cobanoglu A: What dictates the position of the diaphragm – the heart or the liver? J Thorac Cardiovasc Surg 108:4, 1994.
19. Reid WD, Dechman G: Considerations when testing and training the respiratory muscles. Phys Ther 75:11, 1995.
20. Walpin L: Sitting: there is more to it than meets the eye…or seat. Physical Therapy Products, Sept 1996: 64-67.
21. Vleeming A, Mooney V, Dorman T, Snijders C, Stoeckart R. Movement stability and low back pain. The essential role of the pelvis. Churchill Livingstone, 1997.