

Diaphragmatic Breathing: The Foundation of Core Stability

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SUMMARY

MANY FITNESS AND REHABILITATION EXPERTS WOULD AGREE THAT DIAPHRAGMATIC BREATHING IS THE MOST FUNDAMENTAL DEMONSTRATION OF CORE FUNCTION. AS SUCH, ONCE PROPER BREATHING PATTERNS ARE ESTABLISHED, CLIENTS WILL HAVE A SOLID FOUNDATION TO FURTHER DEVELOP CORE FUNCTION. IF WE CONSIDER THE NOTION THAT BREATHING IS A FUNDAMENTAL COMPETENCY OF CORE STABILITY, WE MUST BE CERTAIN THAT BREATHING PATTERNS ARE HEALTHY BEFORE PROGRESSING OUR CLIENTS TO MORE ADVANCED CORE EXERCISES. THIS ARTICLE WILL REVIEW THE CONCEPT OF CORE STABILITY AND DISCUSS THE ROLE OF PROPER RESPIRATORY MECHANICS ON CORE FUNCTION.

INTRODUCTION

Core stability training has become hugely popular in the fitness industry. Interestingly enough, there is no clear consensus as to what core stability training involves or even which muscles comprise the core (32). That said, much of the literature suggests that diaphragmatic activity can assist with stabilization of the trunk (9,12,14,19–22), which suggests that breathing patterns that optimize diaphragmatic control

are integral to the generation of core stability. It is estimated that 10% of the population suffers from dysfunctional breathing patterns; these percentages jump to 30% among asthma sufferers and 83% in those suffering from anxiety (7), creating a need for strength and conditioning professionals to be able to assess and help improve breathing pattern function. This article will investigate the influence that upper-chest and/or quick breathing patterns may have on core stability and will suggest basic breathing assessment methods and breathing retraining ideas.

According to Kibler et al. (17), core stability is the ability to control the position and motion of the trunk over the pelvis to allow optimum production, transfer, and control of force and motion to the terminal segment in integrated athletic activities. In other words, proximal stability sets the stage for distal mobility. As stated by Cook (6), “The best core training programs require the spine to be held in a natural or neutral position while breathing and while moving the arms and legs in motions that mimic the functional ways the core will be stressed in a given sport or activity.” Examples of this might include an athlete performing a set of push-ups while resisting the forces that challenge neutral spine without interruption of breathing or an individual carrying groceries into the house, maintaining a neutral alignment of the spine under the load of

the grocery bags as they continue to breathe.

Maintaining neutral spine during activity is believed to preserve the integrity of the spine and protect varying structures from injury (24,25,30,38). According to Panjabi (30) 3 subsystems work together to maintain this integrity, the central nervous subsystem (control), the skeletal subsystem (passive), and the muscular subsystem (active). The Panjabi model suggests that dysfunction of any one subsystem will compromise stability and potentially cause back pain (30). Additionally, a dysfunction in any component of any subsystem can lead to compensation from other systems, long-term adaptation by one or more subsystem or injury to one or more components of any subsystem. In effect, stability of the spine is not only reliant on muscular strength but proper sensory input to the central nervous system. Methods of training for core stability should therefore consider protection of the passive structures of the spine, optimization of motor control, and improving muscular strength and endurance. This article will present research and various theories that illustrate how diaphragmatic breathing can positively influence the muscular and control subsystems, equally so, how poor

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breathing patterns can be disruptive to the muscular and control subsystems. These influences suggest that breathing in a more diaphragmatic manner may be an ideal pathway to effective trunk stability training. The first part of this article will explore how the diaphragm contributes to posture and core stability; the second part will discuss how adaptations in breathing patterns and posture are thought to challenge the stability of the core.

PART I: LOCAL MUSCLES OF THE CORE

Bergmark and Richardson referred to the core by describing local and global units (1,33). The local muscles are viewed as lying deep or possessing deep components that attach to the spine. The local muscles are believed to brace vulnerable spinal structures thereby allowing superficial global muscles to perform acts such as walking and lifting. The local unit model suggests the transversus abdominus muscle (TrA) forms the walls of a cylinder while the muscles of the pelvic floor and diaphragm form its base and lid (33). This cylinder of compression influences intra-abdominal pressure (IAP) that is thought to contribute to spinal stability (11–13,21). The diaphragm is actually 2 separate muscles, the right and left hemidiaphragms, which together resemble a dome. The diaphragm's costal attachments are on the inner surface of the lower 6 ribs and the sternal attachment on the xiphoid process. The right hemidiaphragm's lumbar attachment is on the anterior portions of L1–L3, whereas the left hemidiaphragm's lumbar attachment is on the anterior portions of L1–L2. Upon inhalation, the diaphragm contracts, the dome flattens and moves downward into the abdominal cavity. During this contraction, the fibers of the diaphragm, which attach onto the lower ribs, create a horizontal expansion. The plunger-like action of the diaphragm, combined with the resistance created by the pelvic floor and an eccentric contraction of the entire abdominal wall, creates

a negative pressure in the thoracic cavity that forces air into the lungs while increasing pressure in the abdominal cavity.

DUAL ROLE OF THE DIAPHRAGM: RESPIRATION AND POSTURAL STABILIZATION

Lewit (22) suggests that if healthy breathing patterns are not in place, then no other movement pattern can be. He believed that if an individual did not demonstrate proper breathing patterns, the diaphragm likely lacked the coordination, endurance, and strength to function in its role of a postural stabilizer. Based on Lewit's work, breathing may well be considered a competency in which further movement development is based upon, and developing efficient breathing patterns should be prioritized.

Although early research by Hodges placed special relevance on the TrA in core stability, more recent research by Hodges suggests that the inner unit is a dynamic system and seems to rely on the integration of the pelvic floor, TrA, diaphragm, and multifidus (11,13,37). Kolar et al. (21) have discovered significant involvement in the diaphragm during limb movements. Another study by Kolar demonstrated a connection between back pain, core function, and diaphragm function. He examined 18 patients with chronic low back pain (LBP) and 29 without LBP. Measurements during tidal breathing and isometric flexion of the upper and lower extremities against external resistance with tidal breathing were performed. He noted that those in the LBP group had smaller diaphragm excursions and higher diaphragm position (20). The researchers stated, "The respiratory movement of the diaphragm is synchronized with its stabilization function. Dysfunction of this synchronization in people with weak body stabilizing function of the diaphragm leads to overloading of spinal segments." This suggests that insufficient and uncoordinated diaphragm activation can compromise the stability of the spine.

O'Sullivan and Beale (28) studied subjects with LBP attributed to the sacroiliac joints and compared them with control subjects without pain. By comparing respiratory rate and diaphragm and pelvic floor movement using real-time ultrasound during a task that required load transfer through the lumbopelvic region (the active straight leg raise test), he noted that participants with pain had an increase in respiratory rate, descent of their pelvic floor, and a decrease in diaphragm excursion compared with the control subjects who had normal respiratory rates, less pelvic floor descent, and optimal diaphragm excursion. Roussel et al. (35) have had similar findings, discovering that more than half of patients with chronic nonspecific LBP exhibited altered breathing patterns during performances in which core stability is challenged.

According to McGill (23), a core stability exercise can be defined as "any exercise that channels motor patterns to ensure a stable spine through repetition." One might think of "repetition" as arm or leg movement while holding neutral; however, in the beginning phases of core development, we could also interpret "repetition" as the diaphragmatic excursion during breathing. McGill noted a reduction in the support offered to the spine if there is both a load challenge to the low back combined with a breathing challenge as in the case of an individual shoveling snow (26), postulating that the "modulation of muscle activity needed to facilitate breathing may compromise the margin of safety of tissues that depend on constant muscle activity for support." In other words, the body will prioritize breathing over stabilization. This presents a risk to less fit motor systems resulting in a high degree of variability in stability and could result in temporary losses in stiffness. However, those with fit motor systems seem to meet the simultaneous breathing and spine stability challenge with less variance of stability. Hodges et al. (13) discovered similar findings, noting a reduction of postural activity

of the diaphragm when respiration demand is increased. He hypothesized that during strenuous exercise when breathing is labored, spinal control will be compromised, which could lead to increased potential for injury to spinal structures and reduced postural control. Much is still unknown regarding the cause/effect relationship of breathing and postural stability, but it is possible that optimal breathing patterns can improve the diaphragm's postural stabilizing capacity, allowing individuals to extend activity and intensify training while limiting the loss of core stability.

PART II: DYSFUNCTIONAL BREATHING PATTERNS

Although breathing is regulated and coordinated by the autonomic nervous system, proper breathing is not automatic. Physical, chemical, and emotional factors can alter the rate and volume of the breath (4,7) and cause breathing pattern problems. Recalling Panjabi's model, the body will compensate for these factors and create varying pathways to keep up with respiratory demands by either involving the upper-chest accessory muscles or by quickening the rate of the breath. This is a completely normal adaptive response if an athlete is running; however, problems may arise if the athlete cannot recover to a slower more diaphragmatic method of breathing during rest. Likewise, if the athlete demonstrates a chest or quick breathing pattern at rest, it can create further adaptive and dysfunctional patterning when the respiratory system is subsequently challenged. If this is the case, the faulty breathing pattern may perpetuate on a subcortical level and lead to an ingrained motor program, even when the initial trigger no longer exists (7). In other words, breathing patterns, much like any other motor pattern, can become a habit whether it is healthy or not.

Given the complex nature of breathing problems, there is no gold standard definition of dysfunctional breathing, and it is often broadly described as disturbances in breathing functionality that impact health (7). Despite the

varied causation of dysfunctional breathing, most patterns present in the same fashion. These patterns include increased breathing frequency and chest breathing. It is important to note that these patterns are not exclusive of each other, as an individual may display more than one pattern at a given time. These breathing patterns can be seen by simply observing thoracic and/or abdominal movement, upper-thoracic muscle activity, and duration of inhalation and exhalation.

Increased and/or over breathing in extreme cases is referred to as hyperventilation and is closely associated with anxiety and apprehension (18). Stress tends to exacerbate quick and upper-chest breathing patterns and can indicate a general dysfunction of an individual's ability to alternate between heightened activity levels and rest periods, limiting full recovery before resumption of activity. Recalling that respiration is prioritized over spine stabilization, stressed clients who are prone to poor breathing patterns can be at risk for losing the protective trunk stabilization efforts of the diaphragm. Ironically enough, good breathing patterns can be an effective tool individuals can use to manage stress, therefore it should be encouraged during stressful times (4,7,34).

One of the major problems with a rapid breathing pattern is the affect it has on the body's pH. Blood pH is tightly regulated by a system of buffers that continuously maintain it in a normal range of 7.35–7.45 (slightly alkaline). Breathing at an increased rate increases the amount of carbon dioxide exhaled, which can lead to alkalosis (elevated pH). During respiratory alkalosis, red blood cells bind more tightly to the oxygen they are carrying, which decreases the amount of blood getting to the brain and muscles (the Bohr effect). Additionally, less oxygen is released by the blood. Lack of adequate blood supply creates a cascade of events such as increased muscle tension, reduced motor control (40) perpetuation of trigger points, increased muscle spasm, and increased pain

sensitization (3,38), the result of which can alter motor control and ultimately spinal stability (28,29). Dysfunctional breathing is also known to adversely affect postural balance and proprioceptive function of the lower limbs (16). Other complications resulting from quick breathing include changes in magnesium, calcium, and potassium levels, which can also interfere with the motor control mechanisms that govern the core.

POSTURE AND BREATHING

Postural adaptation has been linked to breathing dysfunction (5,8,22,38). Breathing influences muscular function and posture because the habitual use of breathing muscles during respiration affects how these muscles are used for nonbreathing movement and postural support (7). The reverse is also true whereby everyday posture affects the habitual use of the breathing muscles. As stated by Sahrman (36), "repeated movements and sustained alignments associated with everyday activities are the inducers of tissue adaptations." Sahrman posits that when everyday activities involve repeated movements in a specific direction, the movement in that direction occurs more readily and easily because of tissue changes. Furthermore, once a joint develops a tendency to move easily and readily in a direction, that movement will occur with all activities involving that joint and not just the one that induced the joint changes. If we apply this logic to chest dominant breathers, the sternocleidomastoid muscles, upper traps, and pectoral muscles shorten creating an overly kyphotic and forward head posture. This suboptimal posture has a destabilizing effect on the trunk (21,22,24,30). It will probably never be clear which came first, the breathing pattern problem or the posture problem. Regardless, both need to be addressed to optimize core stability and overall performance (3,4).

A study by Obayashi et al. (27) illustrates how posture and respiration influence one another. Subjects breathed into a SpiroTiger (Autospiro

AS-407; Minato Medical Science Co., Osaka, Japan) training device for 10 minutes 3 times per week. The researchers measured the thoracic and lumbar curvatures, pulmonary function, and isometric trunk flexion as well as extension strength.

- Thoracic kyphosis decreased by 5.5°.
- Lumbar lordosis decreased by 3.1°.
- Pulmonary function improved force vital capacity from 4.1 to 4.3 L and forced expiratory volume in 1.0 seconds from 3.4 to 3.7 L.
- Trunk flexion strength improved by 10.6% (from 695 to 769 N), whereas trunk extension strength was unchanged.

They discovered that exercising respiratory muscles improved posture, most likely because of the stimulation of the local core stabilizers (27). Although participants were not engaging in diaphragmatic breathing, it does suggest that there can be positive postural effects from breathing training.

JANDA'S BLUEPRINT TO ADDRESSING MUSCLE IMBALANCE

Janda and Richardson suggested that certain muscles have a tendency to become short and tight and some have a propensity to lengthen and weaken, often as a result of postural or movement habits (15,33). Table 1 lists the global muscles of the core, which are believed to shorten and tighten, and

the local muscles that are believed to lengthen and weaken (33). The overactivity of the global muscles and subsequent underactivity of the local muscles is believed to create muscle imbalance and suboptimal posture that Janda characterized as upper crossed syndrome (UCS) and lower crossed syndrome (LCS). Individuals with UCS and/or LCS present with a forward head posture, overly kyphotic thoracic spine, and an anteriorly rotated pelvis. In order for optimal stabilization and respiration to occur, the underlying muscle imbalances must be addressed by creating a stretching/strengthening plan to bring the pelvis and rib cage in a more neutral alignment. Mobility work should be a routine that is not only included in training sessions but performed at regular intervals throughout the day. Specific stretching and strengthening plans fall outside the scope of this article; however, the following list includes a generalized plan for a client or athlete presenting with UCS and LCS. It is important to note that this is one example of postural distortion that is associated with breathing dysfunction. Each client should undergo a postural assessment at which time a mobility plan can be specifically designed for the individual's needs.

- Lower cross: Janda outlined muscles that needed to be stretched as well as muscles that needed to be

strengthened. An overly kyphotic posture and/or anterior pelvic tilt will compromise rib cage expansion in addition to altering proper alignment of the rib cage and pelvis necessary for creation and sustainability of IAP. Mobilization efforts should be directed to improving extension and rotation of the thoracic spine. Stretching should focus on the iliopsoas, rectus femoris, tensor fascia lata muscles, erector spinae, adductors, and piriformis muscles. Strength training should focus on the gluteals and TrA.

- Upper cross: Upper-chest breathers will overuse accessory breathing muscles that can lead to UCS. Likewise, those with a forward head posture as seen in UCS will not have the structural or functional opportunity to breathe well. Stretching should be directed to the levator scapulae, scalenes, sternocleidomastoid muscles, pectoralis muscles, and the upper-trapezius muscles, whereas strengthening should be emphasized among the inferior scapular fixators (middle and lower trapezius, rhomboids, and serratus anterior muscles).

ASSESSMENTS

Despite the lack of a widely accepted standard of normal breathing, there are some widely accepted aspects to normal breathing that are described within the assessment descriptions. Table 2 summarizes the more common

Table 1
Local and global muscles

Global muscles—prone to shortness/tightness	Local muscles—prone to lengthen/weakness
Rectus abdominus	Gluteus medius and maximus
Erector spinae	Transversus abdominus
Iliopsoas	Multifidus
Suboccipitals	Deep neck flexors
Levator scapulae	Lower trapezius
Suboccipitals	Deep neck flexors
Lateral fibers external obliques	Internal obliques
Adductors of the thigh	Serratus anterior
Data obtained from Richardson et al. (33).	

Table 2
Common signs of dysfunctional breathing patterns

Common signs of dysfunctional breathing patterns
Inhalation is initiated with lifting of the chest
Limited lateral rib cage expansion
Mouth breathing
Hypertonic anterior cervicals, including sternocleidomastoid muscles, and scalenes
Elevated shoulder girdle
Frequent sighing
Resting breathing rate above 12–14 breaths
Forward head posture

signs that indicate dysfunctional breathing patterns. This is hardly an exhaustive list; however, it will serve as a good beginning in discerning if breathing issues are present and requires no equipment other than a quiet setting. As the diaphragm does have concurrent stabilizing and respiratory roles, assessment positions should include sitting and standing. This will help account for the varying stabilizing demands of different postures.

- **Lateral rib cage expansion:** Ideal diaphragm breathing involves an expansion of the lower ribs predominantly in a lateral direction. With the client facing away from you, gently place your hands on the sides of the lower ribs with your thumbs close to the spine (as seen in Figure 1). Instruct the client to inhale deeply and note if there is any lateral widening of the trunk. If your hands rise upward first, this is a sign of

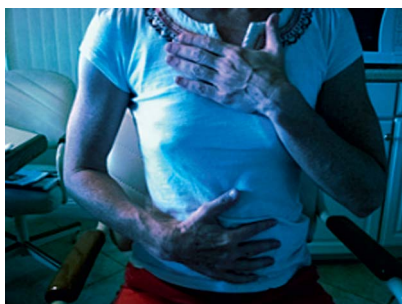


Figure 1. Lateral rib expansion test.

dysfunctional breathing. Ideally, your hands should move apart from each other about 1.5–2 inches and the belly should rise (31). Normal resting respiration involves approximately 10–12 breaths/min (7). When asked to breathe deeply, clients should be able to slow this rate and take 10 seconds for a full inhalation/exhalation (about 6 breaths/min). Individuals who are chest breathers or quick breathers are challenged when instructed to take a deep breath.

- **High low test:** Instruct the client to place one hand on the upper chest while the other is placed on the



Figure 2. High low test.

lower abdomen (as seen in Figure 2). Cue the client to take a few relaxed breaths noting positional changes to the client's hands. Ideally, the hand on the belly should rise before the hand on the chest and additionally, the hand on the chest should move slightly forward and not upward toward the chin.

BREATHING RETRAINING

Although breathing retraining has been shown to be successful (3,7), it can take several weeks and continual practice throughout the day, which will likely present the largest barrier for athletes and strength and conditioning specialists.

The following list is meant to serve as a starting point for retraining breathing habits. Chaitow suggests that short bouts (10 minutes) of practice, performed several times throughout the day are most effective in tackling breathing pattern dysfunction (4). It should be noted that there are contraindications for breathing exercise that may preclude clients from retraining work, as such, when in doubt, the client should be referred to a physician.

- **Pursed lipped breathing:** One of the best ways to re-tone the diaphragm and retrain breathing is to use a slow exhalation pattern, breathing through pursed (as narrow an aperture as possible) lips (34,39). This method of breathing helps reduce quick breathing and higher CO₂ levels during and after training or during stressful situations that can illicit a quick breathing pattern. Instruct clients to breathe in through the nose (2–4 seconds) and very slowly out through the mouth with pursed lips (4–8 seconds). Clients should be encouraged to repeat this process twice daily for at least 30 reps. A few cues to encourage pursed lip breathing include blowing through a straw, and blowing slowly and steadily at a candle so as to make it flicker but not go out.
- **Guiding the breath:** The goal in retraining clients breathing patterns is to reduce their upper thoracic efforts during early phases of

inhalation, to increase exhalation time, and increase abdominal displacement. Find a relatively quiet area in the gym and have your client lie on their back. Place your hand on the client's upper chest, apply a slight downward pressure to the sternum during their exhalation and hold it there while they inhale and exhale. This tactile feedback will help guide their breath into the lower ribs and belly. As you remove your hand, ask them to actively hold the chest in this depressed exhalation position while they continue to breathe. Once your client develops a sense of proper breathing, they should be encouraged to practice on their own.

- Reducing shoulder movement (4): This exercise is intended to discourage the elevation of the shoulder girdle while breathing. Instruct your client to sit in a chair with forearms and elbows comfortably supported by the arms of a chair. During the inhalation (through the nose) have them gently push down onto the arms of the chair, as they exhale (through pursed lips) instruct them to ease the downward pressure of the arms.
- Breathing and bracing: An important element of core training is learning how to brace and breathe concurrently (with the exception of performing maximal lifts). There has been much debate between those who follow McGill's core stabilizing approach of bracing and Hodge's strategy of hollowing. Hollowing involves drawing the navel toward the spine, which is believed to create TrA activation. Bracing is a voluntary mild isometric contraction of the core in a 360° manner, with the goal to stiffen the spine against an external force. Recent research has shown however that hollowing actually reduces spinal stability (41). Bracing has been shown to be a superior method compared with abdominal hollowing (10). An important aspect of bracing is that it should be tailored to the demands of the task, and breathing should remain continuous. McGill (24) does suggest that in the cases of very heavy lifting or

maximal exertions that breath holding is appropriate. While instructing how to brace, it is important to cue an activation of the entire perimeter of the mid section and not simply the rectus abdominus (evidenced by the rectus "doming" up). This faulty bracing pattern will negatively influence normal diaphragm function, encouraging an upper-chest pattern (28). A tactile tip to help correct a rectus abdominus dominant firing pattern is to have the client wrap their hand around their waist line (finger tips just above the waist line) and ask them to try and push their hand away during bracing.

- Blowing up a balloon: Breathing while bracing requires the ability to control the nonrespiratory activity of the diaphragm, and maintain IAP while exhaling. This requires eccentric control of the diaphragm. The blowing up a balloon exercise is believed to help develop this pattern of co-contraction of the diaphragm and abdominal wall (2). Position the client supine with knees bent and feet flat on the ground. Have the client inhale through the nose and exhale through the mouth maintaining neutral spine. Instruct your client to then inhale through the nose and slowly exhale into the balloon. Ideally, the client will be able to inhale again without pinching off the balloon with their teeth, lips, or fingertips. This requires maintenance of intra-abdominal pressure to allow inhalation through the nose without the air coming back out of the balloon and into the mouth. It is important to tell the client not to strain the neck or cheeks during this process. After the fourth breath in, have the client take a break, and then repeat 4 more times. As the client demonstrates the ability to inflate the balloon while holding neutral spine and not stressing the muscles of the neck or cheeks, have them progress to performing the exercise seated, and ultimately performed standing.
- Once breathing patterns are normalized at rest, progression should introduce a spinal stability exercise

while the breathing rate is elevated. One such method suggested by McGill is to have the individual ride a bike at an intensity that elevates ventilation, followed immediately by dismounting the bike and assuming the side-plank posture. McGill believes that combining the efforts of holding neutral spine in side plank while breathing is elevated will groove the motor patterns that coordinate postural control and respiratory function of the diaphragm (24). The diaphragm is the primary muscle of respiration and a postural stabilizer, as such, it is possible that optimizing breathing patterns will improve the capacity of the diaphragm to perform its role as a stabilizer of the trunk. Strength and conditioning specialists should consider breathing pattern assessment and retraining for athletes because better breathing habits may positively affect core stability and ultimately improve the overall conditioning of the athlete.



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