



Review Article

Breathe Away Your Back Pain: Unravelling the Power of the Diaphragm in Low Back Pain

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ABSTRACT

Low back pain (LBP) is the primary cause of years lived with a disability in the world, but it can be difficult to find a specific structural cause of LBP for the majority of people suffering from it. The focus is now from the passive structures to the neuromuscular regulation of the trunk, and among the various muscles the diaphragm has turned out to be an unexpected but important player. In addition to its well-known function as inspiratory muscle, the diaphragm is involved in postural control and spinal stabilization throughout the day, primarily by controlling and modulating the generation of intra-abdominal pressure (IAP) and the finely-timed co-activation with the transversus abdominis, pelvic floor and lumbar multifidus. This narrative review summarizes current evidence regarding the anatomically dual role of the diaphragm, its mechanism to stiffen and protect the lumbar spine, and imaging and physiological studies that have identified that people with LBP have abnormal diaphragm position, reduced excursion, increased fatigability, and disordered breathing. Epidemiological studies also suggest that breathing and continence disorders are more closely linked to LBP than obesity and physical inactivity. Different assessment methods from dynamic magnetic resonance imaging to bedside ultrasonography are described, and therapeutic options such as diaphragmatic breathing re-education, inspiratory muscle training, dynamic neuromuscular stabilization and manual diaphragm techniques are appraised. The literature as a whole supports the inclusion of breathing assessment and diaphragm-based training in the evaluation and treatment of LBP, recognizes heterogeneity, and calls for larger quality studies.

Keywords: Diaphragm, Low back pain, Intra-abdominal pressure, Core stability, Breathing exercises, Inspiratory muscle training.

INTRODUCTION

Low back pain (LBP), as a common musculoskeletal complaint, is a significant cause of disability around the world and a frequent symptom in clinical practice [1]. It occurs at all ages and can significantly decrease physical function, work capacity and quality of life. While LBP could be caused by a particular structural or pathological change, the majority of patients have a nonspecific LBP in which a specific discrete nociceptive source remains unknown [2]. The multifactorial nature of LBP, combined with the high rate of recurrence of LBP within 12 months after recovery, emphasize the need for multifactorial approaches to LBP, which go beyond identifying and treating isolated pathological abnormalities [3].

Historical views on LBP have focused on structural changes to the vertebral column, intervertebral discs, facet joints or soft tissues. Nevertheless, the anatomical abnormalities found are not necessarily associated with symptoms or the severity of symptoms, especially in individuals with non-specific LBP [4]. Research has thus focused more on functional factors related to movement, loading, motor control and stabilization of the trunk in recent years [5]. The idea of 'core' is therefore an important part of rehabilitation. It is often defined as a muscular cylinder with the diaphragm above, the pelvic floor below, and the abdominal and paraspinal musculature to the sides, with all of these parts playing roles in trunk stability, regulation of intra-abdominal pressure, postural control and coordinated movement [6].

Traditionally the diaphragm is viewed as a respiratory muscle, and it constitutes the upper limit of the abdominal cavity [7]. However, more and more evidence has emerged indicating that it serves a function beyond ventilation. There is an interaction between breathing and trunk control during various functional tasks where respiratory and/or postural demands are present at the same time, and coordinated activity of the diaphragm with the abdominal, pelvic floor, and paraspinal muscles is required to achieve spinal stability [8]. Changes in this coordination could affect spinal loading, type of movement strategies used, and the capacity of the trunk to respond appropriately to external perturbations.

This could then be a two-way street between diaphragmatic function and LBP. People with LBP may have impaired diaphragmatic excursion, abnormal breathing patterns, decreased coordination between respiration and postural activity or changes in diaphragmatic recruitment [9]. However, alterations in trunk movement, muscle activity and motor control caused by pain can affect normal ventilatory mechanics and diaphragm function. Rather, this interaction should not be interpreted as necessarily being limited to the diaphragm being a separate component of the respiratory system or just the top surface of the more traditional core model. It is however better understood as an interdependent respiratory/postural organ that is intimately related to trunk control [10].

Knowing this relationship might have important implications for the evaluation and rehabilitation of patients with LBP. Traditional rehabilitation approaches often center on enhancing the endurance of the paraspinal and abdominal muscles, increasing mobility of the spine, correcting movement patterns and building trunk endurance [11]. Evaluation of the breathing mechanics and diaphragmatic function results, however, can give more information about the interaction between the respiratory and postural systems. Patients may benefit from breathing assessment and therapeutic strategies, which may be implemented alongside current rehabilitation programs to incorporate the coordination of respiration, trunk stabilization and movement [12]. This approach might be relevant when changes in breathing patterns and/or a dysfunction of respiratory-postural coordination are associated with LBP.

Although there has been a rise in interest regarding the role of the diaphragm in the stability of the trunk and regulation of movement, there is still mixed evidence regarding the relationship between diaphragmatic dysfunction and LBP [13]. It is difficult to reach a consensus on this relationship due to variations in the methodology of assessment, definition of diaphragmatic dysfunction, patient demographics and clinical outcomes. A more comprehensive literature review is therefore needed to better understand the physiological mechanisms involved in

the respiratory-postural interaction and its clinical implications [14].

This narrative review aims to highlight the role of respiratory and postural control of the diaphragm, summarize the current evidence regarding the link between diaphragmatic dysfunction and LBP, and discuss the possible integration of an assessment and treatment of the diaphragm in the context of clinical rehabilitation.

REVIEW

FUNCTIONAL ANATOMY OF THE DIAPHRAGM: A DUAL-ROLE MUSCLE

Diaphragm is a muscular sheet extending from the thorax to the abdomen and dome shaped. This muscle origin from three different areas (the sternal portion from the xiphoid process, the costal portion from the inner surface of the lower 6 ribs and their costal cartilages, and the crural (lumbar) portion from the anterolateral bodies of the upper lumbar vertebrae and the arcuate ligaments) converge on a central tendon, with the crural (lumbar) portion labeled as the most significant attachment and the attachment to the xiphoid process and arcuate ligament most commonly associated with pain in the upper abdomen [15]. This latter attachment is of particular importance, as it anchors the diaphragm directly to the region implicated in LBP, and provides an anatomical pathway for the transfer of respiratory activity into lumbar mechanics [16].

For the health of the spine, two functions are most prominent: ventilation and stabilization. Researchers have described the diaphragm as a “network” muscle that has a role in not only respiration, but in postural, sphincteric (anti-reflux), circulatory and even emotional functions. Importantly, these are not done in order, but at the same time – the diaphragm has to continue to fulfill its postural requirements during its respiratory function and vice versa [17]. Table 1 summarizes the muscle's attachments and its many functional roles.

Table 1: Structural and functional overview of the diaphragm

Feature	Description
Sternal origin	Posterior aspect of the xiphoid process
Costal origin	Inner surfaces of the lower six ribs and their costal cartilages
Crural (lumbar) origin	Anterolateral bodies of L1–L3, anterior longitudinal ligament and medial/lateral arcuate ligaments
Insertion	Central tendon
Innervation	Phrenic nerve (C3–C5)
Respiratory function	Primary muscle of inspiration; descent enlarges the thoracic cavity
Postural / stabilizing function	Generates and modulates intra-abdominal pressure; increases lumbar spinal stiffness
Sphincteric function	Crural fibers reinforce the lower esophageal sphincter (anti-reflux)
Circulatory function	Assists venous and lymphatic return via cyclical pressure changes
Fascial continuity	Connects to pericardium, psoas major, quadratus lumborum and transversalis fascia

MECHANISMS OF DIAPHRAGMATIC CONTRIBUTION TO SPINAL STABILITY

Several complementary mechanisms explain how the diaphragm stabilizes the lumbar spine.

Intra-abdominal Pressure

When the diaphragm moves downward and contracts, it contracts simultaneously with the abdominal cavity and pelvic floor and the abdominal cavity acts as a pressurized cylinder. Cresswell and co-workers did some direct in vivo studies of trunk loading and found coordinated abdominal muscle activity and generation of IAP for the loading of the trunk, hence confirming the pressure mechanism [18].

Anticipatory (Feed-Forward) Activation

Diaphragm does not just respond to perturbation. When performing repetitive arm movements, the muscle is also shown to have tonic, movement-phased activity that occurs ahead of each predictable perturbation, with the EMG onset preceding that of the prime mover, the diaphragm. The muscle also appears to be pre-programmed to contribute to postural control, with onset of the EMG following that of the transversus

abdominis during rapid voluntary arm movements [19].

Coexistence of Breathing and Posture

Cleverly, the diaphragm is able to satisfy both requirements simultaneously. It is modulated throughout the respiratory cycle, thus stiffness of the spine varies with respiration making it stiffer towards end inspiration, but remaining throughout. Dynamic magnetic resonance imaging (MRI) has been used to demonstrate a mechanical stabilizing effect, in healthy subjects, of increasing the excursion and descent of the diaphragm during isometric loading of the lower limbs (over and above the tidal excursion), and at the highest levels of loading, the excursion of the diaphragm is greater during the lower-limb work than during isometric loading of the upper-limb [20].

The Integrated Cylinder

It is important that roof (diaphragm), floor (pelvic floor) and walls (abdominals) work together for effective stabilization. If any part of the cylinder doesn't move appropriately; if the diaphragm is not strong enough, or it moves out of sync with the pelvic floor (either in timing or movement) during breathing or coughing, or if the pattern of breathing keeps it in a respiratory position, then pressure regulation and hence spinal control is affected [21].

DIAPHRAGM DYSFUNCTION IN LOW BACK PAIN: THE EVIDENCE

If the diaphragm does have an important role to play in maintaining spinal stability, it should be detectable in individuals with LBP, and there is a developing but convincing body of evidence that it is (Table 2).

Similarly, using a dynamic MRI approach, Vostatek et al. [22] found a change in diaphragm posture behavior in patients with chronic LBP with smaller excursions in the same patients during postural limb tasks, which was interpreted as a decrease of stabilizing contribution that could be involved in the etiology of the disorder.

In addition to position and excursion, the LBP sufferers' diaphragm seems to be less fatigue resistant. The work of Janssens and colleagues has also found (cross section) inspiratory muscle weakness and endurance deficits, and changes in breathing in non-specific LBP, consistent with the impairment of being able to perform two simultaneous tasks to meet increased respiratory muscle activity demands [23].

These discrepancies may be attributed to small sample sizes, variations in LBP phenotypes and methods, and should be interpreted with caution, but do not necessarily question the overall trend [24].

Table 2: Summary of key studies on diaphragm structure and function in individuals with low back pain

Study	Design	Method	Key finding
Kolar et al. 2012 [25]	Case-control (18 CLBP, 29 controls)	Dynamic MRI + spirometry	Higher diaphragm position and smaller excursion during postural limb tasks in CLBP
Vostatek et al. 2013 [22]	Comparative imaging	Dynamic MRI	Altered diaphragm postural function in LBP
Janssens et al. 2013 [26]	Case-control (10 LBP, 10 controls)	Transdiaphragmatic twitch pressure after inspiratory loading	Greater diaphragm fatigability in recurrent LBP
Janssens et al. 2010 [27]	Case-control	Inspiratory loading + post urography	Inspiratory-muscle fatigue impairs postural control more in LBP
Mohan et al. 2018 [28]	Cross-sectional	Respiratory strength/endurance; breathing pattern	Reduced respiratory strength/endurance and altered breathing in NS-LBP
Mitchell et al. 2025 [29]	Experimental	Induced diaphragm fatigue	No measurable change in breathing mechanics/function in CLBP (contrasting result)

BREATHING PATTERN DISORDERS AND THE BREATH-BACK CONNECTION

Another line of evidence is also parallel, relating disordered breathing to LBP at the population and behavioral level. However, in a large Australian longitudinal cohort, Smith et al. showed that breathing disorders and incontinence were more strongly associated with development of back pain than was obesity or physical activity an intriguing finding in the context of how firmly these latter factors are entrenched in LBP risk thinking [30]. In a systematic review, Beeckmans and colleagues reported that respiratory disorders were more prevalent in people with LBP, but warned that causality would need to be investigated in a prospective study [31]. Beeckmans and colleagues also reported on a separate general-population cohort in Sweden – this cohort showed that respiratory disorders predicted troublesome future LBP.

People who suffer from LBP have different breathing patterns behaviorally. Altered breathing patterns occur in motor-control tasks of the lumbopelvic region in chronic LBP, suggesting that during increased postural demand, there is a competition between respiration and stabilization, which reduces stabilization and thereby increases the risk for pain, and when stabilization is reduced, respiration becomes guarded and shallow, which also increases the risk for pain [32]. It is speculated that faulty breathing is a cause and/or a consequence of motor-control dysfunction in the low back, with motor-

control dysfunction leading to altered breathing patterns, and altered breathing patterns causing motor-control dysfunction.

CLINICAL ASSESSMENT OF DIAPHRAGM FUNCTION

The assessment of the diaphragm is sub-ribcage, so is required to be made through a combination of observation, palpation, functional testing (Table 3) and, if available, imaging. At its basic level, breathing patterns at rest and under task loads can be observed, including the direction and dominance of thoracic versus abdominal excursion, the use of accessory muscles, and the expansion of the lower ribs during breathing. At the same time, in breath-hold or functional tasks (such as maintaining a neutral spine and steady IAP when loading the limbs), breathing and stabilization can be sustained together, formalized as part of the concept of dynamic neuromuscular stabilization and developmental-kinesiology [33].

The use of instrumented measures increases objectivity. Dynamic MRI synchronized with spirometry is the ultimate reference standard for characterizing diaphragm position and postural excursion, but is currently mainly used as part of research efforts, whereas maximal inspiratory pressure is used to measure the global strength of inspiratory muscles [34]. A combination of tests that measure ventilatory capacity and diaphragm postural behavior under load is recommended.

Table 3: Methods for assessing diaphragm structure and function.

Assessment method	What it evaluates	Practical considerations
Breathing-pattern observation	Thoracic vs abdominal dominance, accessory-muscle use, lateral rib expansion	Clinic; quick and low-cost but subjective
Palpation & functional load tests	Ability to maintain neutral spine and steady IAP during limb loading	Clinic; used within DNS / developmental-kinesiology assessment
Maximal inspiratory pressure (P _I max)	Global inspiratory-muscle strength	Clinic/lab; handheld manometer
Respiratory ultrasonography	Diaphragm thickness, thickening fraction, excursion	Bedside; increasingly accessible but operator-dependent
Dynamic MRI + spirometry	Diaphragm position and postural excursion	Research reference standard; costly, limited access

DISCUSSION

Literature reviewed indicates the diaphragm may be a therapeutic target in patients suffering from low back pain (LBP) as it has a dual role in both respiratory and postural control. From the traditional point of view of core stabilization, rehabilitation interventions focusing on the diaphragm can not only modify respiratory mechanics, but also intra-abdominal pressure (IAP), trunk stiffness, postural control, and interactions regarding the activation of other core stabilizing muscles [35]. The current evidence, although very varied, suggests that interventions targeting breathing and diaphragmatic function can be clinically useful in the treatment of NLSLB.

Dynamic neuromuscular stabilization (DNS) is a theoretical explanation for this interaction. This model suggests that proper regulation of IAP and the coordination of breathing and locomotor activity is crucial for optimizing stabilization of the trunk during functioning, and is physiologically plausible but evidence from high-quality clinical trials specifically for LBP is still limited. Thus, mechanisms suggested by DNS should not be equated with the current clinical evidence [36].

Diaphragmatic breathing re-education is a relatively simple technique that can be used to treat respiratory mechanics and trunk control at the same time. Slow diaphragmatic breathing, especially breathing that encourages expansion of the lower rib cage and the lateral expansion of the abdomen will be used to facilitate diaphragmatic excursion with decreasing excessive use of accessory respiratory muscles. The clinical studies have shown that breathing-focused interventions may benefit individuals with chronic or nonspecific LBP, particularly when used in addition to standard exercise treatment, but are not necessarily replacements for that treatment [37].

IMT involves a more direct loading of the respiratory muscles and could thus induce different physiological effects than breathing exercises without loading. This is of particular interest since impaired proprioceptive postural control has been reported to be an important component of persistent LBP, as noted by

Janssens et al [27]. It is therefore possible that loading of the respiratory muscles affects the sensorimotor mechanisms underlying spinal stability. The results also provide support for the idea that the diaphragm is not only a ventilatory muscle, but that alterations in strength or the recruitment of the diaphragm can impact postural regulation.

This is followed by Finta et al. [38] who showed that the integration of diaphragm training into the standard rehabilitation program resulted in thicker transversus abdominis and lumbar multifidus and lower pain levels, which is relevant since the transversus abdominis and multifidus are considered as key elements of the local spinal stabilization system. If they are thicker after diaphragm training, this can mean that the trunk muscles are now being recruited and/or adapted to their function. But modifications in muscle morphology cannot be considered a direct proof of a causal relationship between the reductions in pain and the morphometric changes, and more research is needed to see if the morphologic changes may lead to long-term clinical improvements.

Adjunctive and manual methods have also been studied. Therefore, diaphragm stretching and myofascial techniques could be useful when there is a restriction in the movement of the thoracoabdominal region or in soft tissue elasticity and/or function related to the rib cage and abdominal wall, which often occurs in chronic non-specific LBP patients with dysfunctional breathing [39]. However, the impact of manual techniques could be a complex series of mechanical and neurophysiological processes and therefore it is challenging to interpret observed clinical changes solely as a result of the diaphragm.

All the evidence together suggests a more holistic approach to rehab that views respiration and stabilization of the trunk as mutually dependent. However, there are significant differences between the interventions in terms of their theoretical foundations, treatment protocols, outcome measures, and methodological quality. Based on the current available evidence, there is currently no one definitive intervention that is consistently shown to be effective for LBP in the diaphragm region. Instead, it proposes

that breathing mechanics and diaphragmatic function assessment can be used along with traditional strength, mobility, motor control and functional capacity assessment [40].

CONCLUSION

The diaphragm is so much more than a bellows for the lungs! It is a key player in spinal stability, having the following activities: It is crurally anchored to the lumbar spine, it generates and modulates intra-abdominal pressure and it is co-activated, anticipating, and synchronized with the abdominal wall and the pelvic floor in a breath-by-breath phenomenon. This postural function is impaired in many patients with low back pain and breathing based interventions such as diaphragmatic re-education, inspiratory muscle training, dynamic neuromuscular stabilization and manual techniques have the potential to positively affect pain, stability and function. The current evidence is sufficient to support the inclusion of the breath in the assessment and management of low back pain, although further, larger trials are warranted. In a literal sense, a new skill in breathing can literally help patients to breathe out the back pain.

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AUTHOR CONTRIBUTIONS

Priyanshi Aggarwal: Conceptualization, literature search, interpretation of evidence, manuscript drafting, critical revision, and final approval of the manuscript.

Yashavi Bhardwaj: Literature review, data collection from published studies, manuscript drafting, critical revision, and final approval of the manuscript.

Rishika Yadav: Literature review, interpretation of findings, manuscript preparation, critical revision, and final approval of the manuscript.

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ABBREVIATIONS USED IN THE STUDY

CLBP: Chronic Low Back Pain

DNS: Dynamic Neuromuscular Stabilization

EMG: Electromyography

IAP: Intra-Abdominal Pressure

IMT: Inspiratory Muscle Training

LBP: Low Back Pain

MRI: Magnetic Resonance Imaging

NS-LBP: Nonspecific Low Back Pain

PImax: Maximal Inspiratory Pressure

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