

The respiratory diaphragm in osteopathic vision: a literature review

Luiza Minato Sagrillo^{1,2}, Letícia Fernandez Frigo^{1,2}

ABSTRACT

Introduction: Considering the osteopathic reasoning, and possible to establish a two-way interaction of direct contact or indirect of the respiratory diaphragm Several abdominal and thoracic viscera, as well as, of your skeletal inserts relations. **Objective:** This study aimed to investigate how anatomical and physiological relations of the diaphragm in both painful processes of the spine, in bodies Associates. **Method:** This study was a literature review, with searching online data PubMed, the published articles in the last ten years as associating keywords this study. **Results:** Ten articles contemplated the criteria for inclusion and exclusion this research and related disorders such as diaphragmatic as possible causes of low back and neck pain, and gastroesophageal reflux disease, as well as, stressed its importance as respiratory-venous-lymphatic pump. **Conclusion:** The respiratory diaphragm is no link anatomical and physiological interaction between the various body systems, and therefore, may be involved in dysfunctional chains que manifest signs and symptoms and local said. It is involved in several causes of pain on which to observe biomechanical changes in functional or column viscera next or correlated.

Key-words: diaphragm; low back pain, reflux esophagitis; neck pain; phisiotherapy; osteopathic manipulation; lymphatic system; pain perception

INTRODUCTION

Osteopathy was established by Dr. Andrew Taylor Still in 1874. In 1899, Still launches the first book explaining the principles of this philosophy (Philosophy of Osteopathy Research and Practice). The Unity of the Body, one of the central principles of osteopathic philosophy, brings the view that the human being is unique and indivisible, and thus must be evaluated and treated. The understanding comes from the notion that all constitutive systems of the body act in an integrated and interrelated way, and that good health would depend on the homeostasis resulting from the harmony of actions between them.

The balance between health and disease will always depend on the dynamic interaction between the intrinsic components of physical, mental and emotional states⁽¹⁾. Thus, a dysfunction in a system will affect itself and the whole set, in a sequence of compromising homeostasis derangements.

In the physical context, a structure that properly portrays this interaction of actions is the respiratory diaphragm. A classical view, it would state that this is the most important respiratory muscle, which generates pressure gradients⁽²⁾, innervated by the phrenic nerve from the roots of C3 to C5 and mechanically produces specialized movements in the

rib cage⁽³⁾. Although these aspects are well known, applying the osteopathic principle of Body Unity, such a simplification of their functions does not represent the totality of possible actions and the influences of that muscle on the different systems of the whole body.

For a better understanding of the anatomical, physiological and clinical aspects involved in the osteopathic approach, a detailed look at this muscle is necessary. Thus, this study aims to investigate, through a literature review, the anatomical and physiological relations of the diaphragm in both the painful processes of the spine as associated organs.

METHODS

We searched the Pubmed database with the following keywords: diaphragm / diaphragm; Low back pain; Gasto- reflux reflux / reflux esophagitis; Cervicalgia / neck pain; Physiotherapy / phisiotherapy; Osteopathic manipulation / osteopathic manipulation; Lymphatic system / lymphatic system; Perception of pain / pain perception. As inclusion criterion, we used: articles published in the last ten years, in the Portuguese and English languages, dealing with the diaphragm

Corresponding author: Luiza Minato Sagrillo. Centro Universitário Franciscano (UNIFRA), R. Venâncio Aires, 2741 - Centro, Santa Maria - RS, Brasil, 97010-000.
E-mail: lu.sagrillo@hotmail.com

¹ Centro Universitário Franciscano, Santa Maria (RS), Brazil.

² Universidade Federal de Santa Maria (RS) Brazil.

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muscle and its physiology and topographic anatomy; Articles that relate this muscle to painful processes and that were non-surgical intervention for the purpose of evaluation and / or treatment. As exclusion criteria, articles of oncological, surgical or drug use were used; Bibliographic review articles; Abstracts, dissertations, theses and non-indexed journal articles. The research was carried out by an evaluator, from January to March 2016.

RESULTS

897 papers were found, of which only 10 papers included the inclusion and exclusion criteria of this study. The papers were presented in table 1 containing the relevant information for each study.

DISCUSSION

The diaphragm muscle and the (perception of) lumbar and cervical pain

Although thin (2 to 4 mm), the diaphragm muscle is compartmentalising, separating the thoracic and abdominal cavities. This division is fundamental for the functionality of the lungs, since, in the presence of congenital diaphragmatic hernias, serious respiratory complications are expected ⁽⁴⁾. It has a central tendinous portion (phrenic center) that gives origin to the muscular peripheral portion, with costal, lumbar and sternal insertions.

Diaphragmatic dysfunction is an important and recognized factor as one of the causes of low back pain and pain in the sacroiliac joints. People who suffer from diaphragmatic dysfunction often have early fatigue of diaphragm, altered and decreased respiratory excursion, as well as inadequate proprioceptive function ⁽⁵⁻⁷⁾. The diaphragm is an important dynamic stabilizer of the trunk. It is activated when a person carries weights, causing all the stabilizing muscles of the trunk (abdominal and multifidus) to contract and decrease the load on the lumbar spine. From the moment, it is demanded too much with a high respiratory rate or the act of carrying weights for prolonged periods, the diaphragm goes into fatigue, impairing lumbar mechanics and thus being a possible cause of low back pain ⁽⁶⁾.

In a study by Janssens et al. (2013), the authors verified that weakness and fatigue of the diaphragm muscle were more pronounced in people with low back pain. In this study 10 healthy subjects and 10 with low back pain were studied and the researchers concluded that people with low back pain had a high degree of diaphragm fatigue when exposed to activities that overwhelmed them ⁽⁶⁾.

In another study by Janssens et al. (2015), the authors performed inspiratory muscle training (IMT) on 28 subjects with non-specific low back pain and observed that IMT may facilitate the proprioceptive involvement of the trunk in the

postural control of these individuals and, therefore, may be a useful rehabilitation tool to treat low back pain ⁽⁸⁾.

Kolar et al. (2010) verified that in people with chronic lumbar problems, the diaphragm continues to be higher and flatter, with the ventral portion moving a smaller percentage, which according to the authors, it may contribute to the etiology of the disorder ⁽⁵⁾. There is a close relationship between the reduction of diaphragmatic movement and the intensity of pain in people suffering from low back pain ⁽⁷⁾. Vostatek et al. (2013) in their study compared 17 subjects with low back pain and 16 healthy subjects to identify changes in movement and shape of the diaphragm when the postural requirements of the body are increased and, observed that when the lower limbs are required, the diaphragm is activated to stabilize the spine and allow the work to be performed; In people with chronic pain, this happens to a lesser extent ⁽⁷⁾.

For an osteopath, it is not difficult to establish dysfunctional tension chains which drive your clinical reasoning based on establishment of the fascial anatomical relations, justifying, often, symptoms referred to the distance of the focus of primary tension. It should be remembered that all these repercussions are bidirectional, which is, they may also be transmitted from the structures to the diaphragm.

The thoraco-lumbar Fascia (TLF) system allows the tensions generated by movement and breathing along the spine to be transmitted correctly, creating synergy with the lowering of the diaphragm, a kind of "sleeve" which surrounds the lumbar vertebrae, allowing stabilization. A deficient TLF leads to instability of the spine ⁽⁹⁾. Probably, the functional loss of this fascial system may disturb the operation of the diaphragm, causing a cascade of pathological events, such as pain and biomechanical alterations in the mentioned regions and in the sacroiliac region secondary to diaphragmatic dysfunctions ⁽¹⁰⁾.

The diaphragm may also be directly related to neck pain through poor use of breathing patterns. Yeampattanaporn et al. (2014) indicate that the poor use of respiratory patterns with the use of accessory muscles, especially of the sternocleidomastoid and upper trapezius muscles, leads to a shortening of this musculature, eventually causing anterior head and cervical pain, as well as hypomobility of the thoracic cavity. The authors verified that the re-education of respiratory patterns for 30 min in 36 subjects with chronic neck pain, there was relieved the sensation of cervical pain, increased cervical range of motion, and increased thoracic expansion due to the lower use of accessory and greater musculature use of diaphragmatic muscles ⁽¹¹⁾.

This may also be explained through osteopathy by the vision of the facilitated segment. A segment is the same as a metamer, a functional unit composed of two vertebrae plus their nervous, vascular, joint, and other elements. When an osteopathic lesion reaches a segment, which may be a normal mechanical loss or an exaggerated afferation, it may cause a state of neural facilitation or hyperexcitation, which may



Table 1 - Overview on selected articles.

Article	Author	Subjects	Investigation	Conclusion
Regional recruitment of rat diaphragmatic lymphatics in response to increased pleural or peritoneal fluid load.	Moriondo et al. (2007)	24 male Wistar rats	To observe the role of respiratory activity in modulating the lymph flow of the diaphragm under normal conditions and explain the development of pleural or peritoneal effusion in diseases characterized by an altered respiratory pattern or impaired diaphragm contraction.	Predominant recruitment of lymphatics from the tendon regions of the diaphragm into peritoneal ascites and pleural effusion has been observed, suggesting a functional adaptation of the diaphragmatic network when there is an increase in drainage necessities.
Positive effect of abdominal breathing exercise on gastroesophageal reflux disease: a randomized, controlled study.	Eherer et al. (2012)	19 subjects with gastroesophageal reflux disease (GERD)	Actively training the diaphragm muscle using respiratory training exercises may positively influence the gastroesophageal reflux.	This non- pharmacological intervention could help reduce the symptomatic burden of this disease.
Postural function of the diaphragm in persons with and without chronic low back pain.	Kolar et al. (2012)	18 subjects with low back pain and 29 healthy.	To examine the function of the diaphragm during limb postural activities in patients with chronic low back pain and healthy controls.	Patients with chronic low back pain appear to have both an abnormal position and a steeper slope of the diaphragm, which may contribute to the etiology of the disorder.
Greater diaphragm fatigability in individuals with recurrent low back pain	Janssens et al. (2013)	10 subjects with low back pain and 10 controls.	To determine if individuals with low back pain have a higher diaphragm fatigability compared to healthy controls.	Individuals with low back pain are prone to diaphragmatic fatigue and an association with reduced postural control.
Inspiratory muscle training improves antireflux barrier in GERD patients.	Nobre and Souza et al. (2013)	12 subjects with gastroesophageal reflux and 7 healthy subjects	To verify if inspiratory muscle training (IMT) improves gastroesophageal junction (GEJ) motility and gastroesophageal reflux (GER).	IMT improved GEJ pressure, reduced proximal GER progression, and reflux symptoms were reduced.
Increase of lower esophageal sphincter pressure after osteopathic intervention on the diaphragm in patients with gastroesophageal reflux.	Da Silva et al. (2013)	22 subjects received osteopathic manipulative technique (OMT) and 16 subjects were from the control group.	To compare pressure values, in the esophageal manometer, of lower esophageal sphincter (LES) before and immediately after the osteopathy intervention in the diaphragm muscle.	The technique of osteopathic manipulation produces a positive increase in the LES region after its accomplishment.
Diaphragm postural function analysis using magnetic resonance imaging.	Vostatek et al. (2013)	17 subjects suffering from chronic low back pain and 16 healthy subjects.	To identify changes in movement and shape of the diaphragm when posture requirements in the body are increased (load applied to the distal portion of the extended lower extremities and flexion of the hips).	When the lower limbs are worked, the diaphragm is activated to stabilize the spine and allow the work to be performed; In people with chronic pain, this happens to a lesser extent.
Immediate effects of breathing re-education on respiratory function and range of motion in chronic neck pain.	Yeampattanaporn et al. (2014)	36 subjects with chronic neck pain	Effects of re- education of respiratory muscles on symptoms of cervical pain and respiratory function	Respiratory re- education may alter breathing patterns and increase chest expansion. This change leads to an improvement in cervical ROM, better contraction of the diaphragm, and reduced activity of accessory muscles.



Table 1 - Continued...

Article	Author	Subjects	Investigation	Conclusion
Inspiratory muscle training affects proprioceptive use and low back pain.	Janssens et al. (2015)	28 subjects with non-specific low back pain	Inspiratory muscle training (IMT) affects proprioception during postural control in individuals with low back pain.	The IMT may facilitates the proprioceptive involvement of the trunk in postural control in individuals with low back pain and, therefore, may be a useful rehabilitation tool for these patients.
Diaphragmatic lymphatic vessel behavior during local skeletal muscle contraction.	Moriondo et al. (2015)	10 male Wistar rats	To evaluate the mechanism by which the tensions developed in the diaphragmatic tissue during the contraction of the skeletal muscle support the local lymphatic function.	The contraction of the skeletal muscle fibers of the diaphragmatic dome simultaneously enhances the pressure gradients that support the entry of pleural fluid into diaphragmatic lymphatic vessels and the propulsion of lymph along the network.



affect the various elements of a metamer. It is known that innervation of the diaphragm muscle occurs through the right and left phrenic nerve and these originate from the cervical segments C3 to C5 (cervical vertebral level) ⁽³⁾. Thus, it may be said that the cervical is benefited by neural facilitation at the moment that the deep breathing is stimulated through the use of diverse breathing patterns.

The phrenic nerve has the same embryonic origins of the brachial plexus and some shoulder muscles, such as the subclavian and subscapularis ⁽¹²⁾, which may explain spasms of these muscles in phrenic dysfunctions. According to some authors, the phrenic nerve is related to the entire cervical and brachial plexus ⁽³⁾, and receives afferents from the pericardium, liver (Glisson's capsule), gallbladder, vena cava and peritoneum ⁽¹³⁾. Thus, visceral dysfunctions may sensitize the phrenic nerve, through neural or direct diaphragmatic contact. Besides respiration, the phrenic nerve participates in swallowing, vocalization and expectoration, and may be involved in its dysfunctions ⁽⁵⁾.

In addition, it is important to remember that pain perception is diminished if breathing is performed with a sequence of deep inspirations, a condition in which the diaphragm bulges in the abdominal direction ⁽¹⁴⁾. This event seems to reflect the involvement of baroreceptors. Thus, the respirations increase systolic pressure with a decrease in heart rate ⁽¹⁴⁾. It is known that when the baroreceptor sites of the carotid body and the aortic arch in the adventitia layer of vessels are naturally stimulated by the cardiac cycle, especially in systole, the nociceptive stimulus is reduced by the activation of these ⁽¹⁵⁾.

The respiratory-venous-lymphatic pump

During breathing in, the diaphragm contracts, bulging in the direction of the abdomen, reducing pressure and facilitating the entry of air into the lungs. In the phrenic center there is the foramen of the inferior vena cava through which the vein of the same name (beyond the phrenic nerve) passes, which is responsible for draining all the blood from the lower portion of the body. The action of the respiratory diaphragm generates pressure gradients between the thoracic and abdominal cavities, producing cycles of compression and suction on the intracavitary circulatory systems, especially in the inferior vena cava ⁽²⁾. Studies have shown that adequate action of the respiratory diaphragm is preventive for problems related to venous drainage ⁽¹⁶⁾. In cases of stasis with consequent venous congestion, especially involving the lower limbs, it is important to include the respiratory diaphragm in the evaluation approach of the osteopath. The venous stasis of the lumbar veins which drain the lumbar intervertebral discs and form the azygous system to the right and hemiazygos to the left may be related to the diaphragmatic dysfunction, leading to the low back pain.

This pump dynamics of the respiratory diaphragm is also important for lymphatic drainage, especially of the abdominal cavity. There is an efficient system of drainage and lymphatic absorption, especially of the peritoneal cavity, which is dependent on the rhythmicity and flexibility of the diaphragm ⁽¹⁷⁾.

In the experimental study performed by Moriondo et al. (2007) aimed to observe the role of respiratory activity in the modulation of the lymph flow of the diaphragm, it was observed that there is a prevailing recruitment of lymphatic vessels in the tendon regions of the diaphragm in cases of peritoneal ascites and pleural effusion, suggesting an important adaptation of the diaphragmatic lymphatic network when there is an increase in drainage necessities ⁽¹⁸⁾.

In another experimental study by Moriondo et al. (2015), the authors observed with more specificity that the contraction of skeletal muscle fibers of the diaphragmatic dome simultaneously improve the pressure gradients which support the entrance of the pleural fluid in diaphragmatic lymphatics and lymph propulsion along the network. This indicates that, the geometrical arrangement of the lymphatic mesh appears to be suitable for exploring the cyclical stresses exerted on the lymphatic vessel wall by skeletal muscle fibers during fiber shortening in the inspiratory phase and expiratory relaxation, resulting in an efficient coupling of inspiratory activity in the draining peritoneal and pleural fluid ⁽¹⁹⁾.

Diaphragm and the gastro-esophageal system

By the esophageal hiatus (diaphragmatic opening) passes the esophagus, which is a muscular tube which comes from the mouth and ends in the stomach. The esophagus attaches to the diaphragm through the phrenoesophageal ligament. The diaphragmatic muscle, which are around the esophageal hiatus and form the lower esophageal sphincter, are responsible for releasing the passage of food from the esophagus to the stomach and also for preventing food from returning to the esophagus ⁽²⁰⁾. Thus, if the diaphragm does not present good function, this sphincter may relax and part of the gastric contents returns to the esophagus causing the phenomenon called acid reflux. Sometimes it is normal for something in the stomach to flow back into the esophagus, there is problem when it turn chronic, producing symptoms which indicate the existence of tissue lesions in the esophagus - this is called Gastroesophageal Reflux Disease (GERD) ⁽²¹⁾.

In a study by Eherer et al. (2012), the authors observed that by actively training the diaphragm muscle of 19 subjects with GERD through exercises of respiratory patterns, it was possible to positively influence reflux, reducing the symptom burden of the disease which it was evaluated through a quality of life questionnaire and measure of pH ⁽²⁰⁾. Corroborating with the findings of this study, Nobre and Souza (2013) performed inspiratory muscle training (IMT) on 12 subjects with GERD



and 7 healthy subjects and verified that the training improved gastroesophageal junction motility, reducing sphincter pressure and progression of GER, relieving symptoms of the disease ⁽²¹⁾.

In osteopathy, Da Silva et al. (2013), found that there was a 9 to 27% increase in lower esophageal sphincter pressure in subjects who underwent osteopathic technique whereas in the placebo group there was a decrease in pressure - highlight that the higher the sphincter pressure, the chances are lower for contents of the stomach to return to the esophagus. In this study, the authors used the technique of stretching the diaphragm in 22 people of the intervention group and performed simulated technique in another 16 people of the placebo group. The researchers also highlight that, although only one technique was performed instead of a complete treatment for the pathology, the results obtained are extremely relevant, showing that osteopathy may achieve fantastic results in the treatment of GERD ⁽²²⁾.

CONCLUSION

The respiratory diaphragm presents direct or indirect relationships with various body systems, such as the musculoskeletal, fascial, visceral, vascular (arterial, venous and lymphatic), central and peripheral nerves, as well as neurovegetative, participating in the command and control of countless mechanical and organic functions. It is a legitimate representative of the osteopathic principle of the "Unity of the Body", since it constitutes the link of anatomical and physiological interaction between the systems mentioned, and thus, it may be involved in dysfunctional chains that manifest local signs and symptoms and referred, typical of process of illness.

The diaphragm is involved in several causes of pain where biomechanical changes in the spine or functional of the proximal or correlated viscera may be observed. It is observed, in these cases, a less proprioceptive capacity, less movement of the vertebrae, reduced functional collaboration of tissues (nervous, venous and fascial) which are involved in the proper functioning of the lumbar and cervical region during respiratory movements and, also, of associated viscera function.

AUTHORS' CONTRIBUTIONS

This study was conducted by Luiza Minato Sagrillo under the guidance of Professor Leticia Fernandez Frigo as Monograph of the Postgraduate Course in Physiotherapy and Osteopathy from the Centro Universitário Franciscano, Santa Maria (RS), Brazil.

CONFLICT OF INTEREST

The authors declare that they have no competing interests.

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