The effect of diaphragm manipulation on neck pain patients with forward head posture: case study

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Introduction

Neck pain is one of the most common, disabling, and costly musculoskeletal disorders among people of all ages with a 12-month prevalence of 30%-50% in the general population and is more prevalent among women (1).Maintaining the same incorrect posture for a long period of time is the main reason for neck pain. Overuse of smartphones and computers or long hours of working at desks are some of the greatest reasons for incorrect postures leading to neck pain (2)

Abnormal posture induces biomechanical changes in people with neck pain, the prominent one of which is forward head posture (FHP) (3)and is characterized by hypertension of the upper cervical(C1-3) and flexion of the lower cervical vertebrae(C4-7)(4). In this posture the head is not in the line with the vertical axis of the body and the cervical spine is in a protracted position. These alteration induce more gravitational load on the cervical motion segments which subsequently need more muscular effort results in not only myofascial pain, but also a compressive load of the cervical spine(5). According to Janda (6), FHP and round shoulder posture occur simultaneously, creating a condition known as upper crossed syndrome. These postural changes induce muscle imbalances in which some muscle such as levator scapulae, sternocleidomastoid, anterior scalene, posterior cervical extensor, upper trapezius and pectoralis muscles become short or stiff and some others such as deep cervical neck flexor, rhomboid, and serratus anterior muscles become inhibited or weak.postural alterations of the cervical and thoracic spine can result in impaired chest expansion and length-tension curve of the diaphragm, thereby inducing respiratory dysfunction(7,8) Under these circumstances, accessory respiratory muscles such as SCM and anterior scalene become overactive(9,10).Faulty breathing pattern has been report in 84% of patients with chronic neck pain(9).

On the other hand, the phrenic nerve which provides the sensory and motor control of the diaphragm originates from C3-5 and sometimes C6 nerve roots and passes through the fascia of the anterior scalene. Overloading of this muscle that is commonly seen in FHP compresses the phrenic nerve over time and may eventually lead trophic changes of the phrenic nerve and resultant diaphragm dysfunction (11). Due to the common cervical nerve roots, any disorder to phrenic nerve or the structures supplies by the phrenic nerve such as diaphragm can affect other neurons at the same level like the axillary nerve, suprascapular nerve, musculotendinous and subclavian nerve; also any injury to these nerves and the muscle innervated by them can affect the phrenic nerve and diaphragm. For example, overactive scalene muscles that receive innervation from C4-C6 cervical nerve root in neck pain patients with FHP can modify the function of the phrenic nerve and diaphragm negatively(11,12).

Furthermore, it is proposed that there is a fascial bridge between the cervical region and diaphragm muscle through transversalis and thoracolumbar fascia. Due to this mechanical connection any anomalous muscular tension in the diaphragm or neck muscles can negatively affect the other (12).

Based on the above points, it seems that the FHP not only cause pain and breathing problems in patients with neck pain, but also the existence of a vicious cycle between this posture and resultant respiratory problems can make this situation worse. Therefore, breaking this cycle is very important, and it seems that correcting this posture is a priority in treating these patients and reducing their disability. So far studies in this area all have examined the effect of exercise and other local physical therapies in the neck area on FHP. The functional, neurological, and fascial interdependent relationship between the diaphragm and the cervical spine can be a basis for the use of manual treatments such as myofascial release on the diaphragm to affect the cervical spine.

Myofascial release of the diaphragm is an intervention intend to indirectly stretch the diaphragm muscle fibers to reduce muscle tension, normalize fiber length, and promote the efficiency of muscle contraction (13).Although diaphragm myofascial has been used in clinical practice, to the best of the authors' knowledge, the current study is the first research investigating the effect of diaphragm release on FHP and chest expansion in patients with neck pain. Therefore, the purpose of this study was to assess the effect of diaphragm manipulation on FHP, chest expansion, pain score, and functional disability of patients with neck pain. We hypothesized that this osteopathy technique could help balance the muscles around the neck and improves the cervical spine posture in these patients through diaphragm neurological and fascial communication with the cervical spine and restoring normal mobility to the chest and reduce pain score. If effective, this, in turn, improves breathing efficacy, reducing the load on the accessory respiratory muscles in the neck and improving the performance of the diaphragm as the main breathing muscle.

Anatomy of the diaphragm: origin and insertion

An accurate knowledge of the anatomy of diaphragm is necessary in order to perform a proper manual evaluation of the muscle, with particular focus on hands' positioning.

According to its insertions, the diaphragm can be divided in costal, lumbar, and sternal portions. The sternal part arises with two small fiber bundles from the posterior aspect of the xiphoid process, near to the apex; the costal (or lateral) portion arises from the inner and superior aspect of the last six ribs, with interdigitation with the transverse muscle of the abdomen (14).

The lumbar portions arises from the medial, intermediate, and lateral ligaments, before reaching the vertebral bodies, delimitate with their internal muscular bundles, at the level of D11, the esophageal hiatus for the passage of the esophagus and vagus nerves. The right medial ligament, thicker and longer than the left one, terminates in a flattened tendon on the anterior aspect of L2-L3 (sometime up to L4) (14.). Laterally to the right ligament, there is a small ligament (called accessory or intermediate), whose tendon is inserted at the level of L1–L2.

Between this ligament and the right medial one, there is a vertical split crossed by the large splanchnic nerve and the medial root of the azygos vein (14).The left medial ligament ends with a flattened tendon between L2 and L3; even in this case an accessory ligament is present, forming a split for the large splanchnic nerve and the medial root of hemiazygos vein (14). The tendons of these two ligaments constitute, at the level of D12, a tendinous arch (called the median arcuate ligament), through which the aorta and the thoracic duct cross the diaphragm (14). The lateral ligaments arise in the form of two thick tendons at the level of the arch of the psoas muscle, constituting the medial arcuate ligament; the latter passes above the psoas muscle, joining the vertebral body of L1 and its transverse apophyses, and more laterally, above the quadrates lumborum muscle, joining the transverse process of L1 and the apex of the 12° rib, forming the lateral arcuate ligament (14).

The respiratory diaphragm muscle is innervated by the phrenic nerve (C3–C5) and the vagus nerve (cranial nerve X); the first receives pulses from groups of medullary neurons of the pre-Bötzinger complex and from neurons of the parafacial retrotrapezoid complex (correlated in turn with the retroambiguus nucleus of the medulla); however, it is worth to mention that these connections are still unclear (14). The vagus nerve is part of the parasympathetic autonomic system, originating from the ambiguus nucleus of the medulla (14).

The normal position of the diaphragm can be seen in the chest X-ray. On the anterior–posterior projection, the dome of the right hemidiaphragm is located at the level of 5°–6° rib for what regard the anterior part, whereas the posterior one usually lies at the level of the 10° rib (15). The left hemidiaphragm is slightly higher (about one intercostal space). In 10% of people, both domes have the same height, becoming difficult to be differentiated in the lateral projection (15). Computed tomography and magnetic resonance imaging are also useful in the morphological evaluation of the diaphragm, even though they are used in second analysis, due to their costs and availability (15). Fluoroscopy and ultrasounds are techniques employed for the real-time evaluation of the moving diaphragm, even though affected by visibility limitations (15). In most cases, the diaphragm shows a symmetrical respiratory excursion of ~2–10 cm, not related to the vital capacity of the lungs (15). The ribs open out laterally in caudal direction during inspiration, and the opposite during expiration. By aging, the diaphragm becomes thinner and more frequently located in expiratory position, especially in males.

Manual therapy and diaphragm

A few studies examined the manual evaluation of the diaphragm; although a review of the literature was not among the aims of this paper, some short texts on the topic need to be mentioned.

Potential therapeutic approaches involving the diaphragm muscle have been proposed among gentle myofascial release techniques, in the context of the therapeutic techniques addressed to other diaphragms of the human body.The myofascial technique is the application of a low load, long duration, stretch into the myofascial complex, with the aim to restore the optimal length of this complex (16). The operator palpates the fascial restriction and the pressure is applied directly to the skin, into the direction of the restriction, until resistance (the tissue barrier) is manually perceived (16). Once found, the collagenous barrier is engaged for a few minutes, without sliding over the skin or forcing the tissue, until the band starts to yield the complex and a sensation of softening is achieved (16).

The aim of this study was to compare the effectiveness of diaphragm manipulation in patient with neck pain and not only on improves the cervical spine posture but also on that of decrease pain score and thoracic expansion.

Material and method

Subject

The subject was 38 years old female participated voluntarily in my study with a history of chronic nonspecific neck pain. The inclusion criterion was neck pain lasting for at least 3 months. Participant were asked not to have any other treatment during the time of the training, and was required to be able to learn the usage of the diaphragm trainer and to be able to get to the location of the training. Exclusion criteria were the following: diagnosed specific causes of low neck pain, balance problems of neurological origin, malignant tumors, serious organ diseases, respiratory diseases, previous surgical interventions affecting the neck or the limbs and the subjects being uncooperative. The participant was asked to indicate immediately if an acute inflammatory disease occurred. The participant gave written informed consent. The study is in compliance with the principles of the Osteopathy and was approved by the National University of medical sciences (NUMSS) (identification number: S2009015). The trial was registered on www.manualosteopath.com (identification number: S2009015).

Study design

This study will compared the immediate effect of diaphragm manipulation osteopathy techniques of NUMSS on pain score, craniovertebral angle (CVA), and thoracic expansion.

Intervention

The subject was received diaphragm manipulation technique in supine position.The therapist stood at the side of the patient. The therapist made manual contact bilaterally under the costal cartilages of the lower ribs (7th to 10th) with hypothenar regions of the hands and three fingers. During the patient's inspiration, the therapist was gently pulling the points of hand contact toward the head and slightly laterally, while elevating the ribs simultaneously. During exhalation, the therapist deepened hand contacts towards the inner costal margins, (17). The release technique was performed once a day; each technique lasted for 5 to 7 minutes (18). All release techniques were done by the same physiotherapist.

Measurements

Craniovertebral angle (CVA): CVA was measured to assess the head posture. It is the angle between the line connecting the middle point of the ear tragus to C7 and the horizontal line that passes through the C7 (Fig. 1). CVA shows the position of the head relative to the C7 vertebra, which in patients with FHP is less than 49 degrees; the lower measured angle shows severe FHP. To determine the exact place of the C7 spinous process, patients were asked to bend their neck forward. This bony landmark becomes prominent in this position and this region was checked in a relaxed neck position, too; then, a marker was attached there. In the present study, this angle was measured using photography from the left sagittal view. A digital camera with a 35–70 zoom lens was placed on a tripod and the lens aperture and the zoom were set to the F-stop8 and 70 mm, respectively. The center of the lens was 4 meters away from the individuals with the subject in approximately the center of the lens to reduce the lens error. To minimize the parallax error, the camera was positioned perpendicular to the ground and parallel with the subject's pelvis. A set square was placed 90 degrees on the wall behind the subjects to determine the proper frame angle for camera placement. To ensure that the head does not rotate, a circular frame, parallel to the patient's eye, was attached to the wall in front of the patient's eyes, and the patient was asked to look at it. The patient's neck and upper thoracic area was naked and was photographed from the same distance. The same conditions will apply to everyone taking photos. These configurations were adjusted for each subject. Participants were asked to stand straight and comfortable, with straight knees and half of their body weight on each foot, the hands hanging beside the body, shoulder-width legs apart, and looking forward eyes. Also, to capture their natural posture, they were asked to relax and not to keep their posture in an erected or straight position (19). After capturing, the photos were transferred to a laptop and the CVA angle was extracted by Image J software (https://imagej.nih.gov/ij/). High reliability was reported for CVA measurement in a previous study (19).

Chest expansion (CE) measurement: The patient was asked to put her hands on the head during the standing position. The starting point of a tape measure was placed on the xiphoid process and then wrapped around the chest. The assessor measured the circumference of the patient's chest (at xiphoid level) after maximum possible inhalation and exhalation, respectively (20) (Fig.3). The difference between these two values shows the amount of chest expansion. Mohan et Al. reported the reliability of this method as excellent (ICC > 0.85 and SEMs < 5%) (21).

Pain intensity was assessed with the visual analog scale (VAS) (22). VAS is a unidimensional measure of pain intensity, which has been widely used in diverse adult populations (23). It is a continuous scale comprised of a horizontal line 10 cm in length. The scale is anchored by "no pain" (score of 0) and "worst imaginable pain" (score of 10). A higher score indicates greater pain intensity (23). Test–retest reliability is good (r=0.94, P<0.001) (23). VAS scores are shown to correlate highly with other pain measure scores (r=0.62–0.91), and they are sensitive to measuring changes in pain associated with treatment or time (23).

Outcome

The data collection was done in two steps. The first step was before starting the treatment and the second step was after the end of the treatment immediately. The primary outcome was head posture measurement the secondary outcomes were the extent of chest expansion and the score of visual analog scale. Following the examination, the initial treatment focused on improving craniovertebral angle (CVA), increasing chest expansion, and deceasing VAS score. After treatment, her craniovertebral angle increased from 50 to 61(Fig.2), Chest expansion increased from 78.5cm.to80.5cm. (Fig.4), and decreased VAS from 6/10 to 2/10(table1)

Table 1

	before	after
Craniovertebral angle (CVA)	50	61
Chest expansion (CE)	78.5cm	80.5cm
Visual analog scale (VAS)	6/10	2/10

Discussion

This case report describes how the diaphragm manipulation was used within the management of a 38 year old female subject presenting with neck pain. The outcome indicated that diaphragm manipulation can improve Craniovertebral angle (CVA), chest expansion, and decreased visual analog scale. Improved chest expansion was observed after treatment. Improved xiphoid level chest expansion after diaphragm myofascial release is consistent with the findings of previous studies (17, 18, 19) and could be partially related to diaphragm attachments. Muscular fibers of the diaphragm are attached to the sternum (xiphoid process), lower 6 ribs, and lumbar vertebrae (the L1, L2, and L3 vertebrae and arcuate ligaments) (14). Thus, the dysfunction of the diaphragm may reasonably be expected to interfere with optimal rib cage mobility, and decreasing stiffness of the diaphragm would allow a greater rib cage motion.

In a previous study, a physical therapy program including exercise therapy could improve chest mobility in neck pain patients (24). Regarding the effect mechanism of neck exercise on ribcage mobility, it can be said that any muscle attached to the chest wall can influence its mobility to some degree. For example, weakness of upper back erector spinae and middle and lower trapezius muscle reduces the ability to straighten the upper back, thus interfering with the ability to expand the chest. Moreover, thoracic spine and rib cage motions are found to be interdependent. When there is a thoracic kyphosis or round shoulder, as they are common postural malalignment in the patients with neck pain, the ribs are depressed and the chest mobility is limited (24, 25).

The present study had some limitations. Only the females with neck pain was in this study which makes it difficult to generalize the results to men. Another limitation was only one case study the improvements in the outcome measures were maintained in the short term. Further research is needed to follow the long-term effects of diaphragm manipulation in more neck pain patients with FHP.

Conclusion

The results of the current study showed that diaphragm manipulation was improvements in forward head posture, chest expansion and pain. Therefore, diaphragm manipulation could be useful in the management of neck pain patients with FHP.

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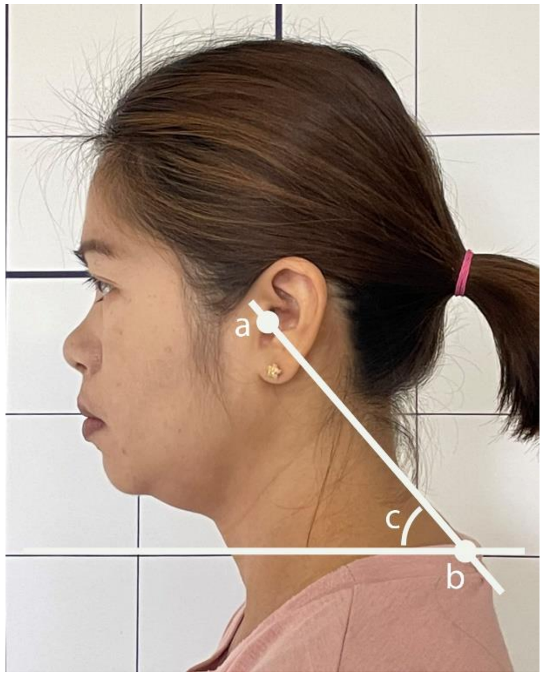
Figures



Figures 1

Pretest: Craniovertebral angle. a:tragus; b:C7 spinous process; c.Craniovertebral angle.

Figures 2

Posttest: Craniovertebral angle. a:tragus; b:C7 spinous process; c.Craniovertebral angle.

Figures 3
Pretest: Chest expansion

Figures 4
Posttest: Chest expansion