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The effect of diaphragmatic stretch technique on diaphragmatic excursion in chronic obstructive pulmonary disease

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ABSTRACT

Chronic Obstructive Pulmonary Disease (COPD) is a preventable and treatable pulmonary disease that has extensive pulmonary and extrapulmonary pathological adaptations. Few of these pathological changes are airway remodelling, persistent airflow limitation, finally leading to pulmonary hyperinflation. The diaphragm, which is the primary muscle of inspiration, is put through an excessive load due to the hyperinflation leading to its flattening, shortening and contraction at a mechanical disadvantage. These patho-mechanical changes may lead to an increase in the work of breathing, a reduction in exercise tolerance and functional capacity, which makes it a potential target for therapeutic intervention. This single group pre and post-intervention study are aimed to find the effects of Diaphragmatic stretch technique on a diaphragmatic excursion in patients with mild or moderate COPD. The intervention was performed on the patients for two sets consisting of 10 breaths each with a 1-minute interval in between. The outcome measures recorded were diaphragmatic excursion and chest expansion which were taken before and immediately after the intervention. Results of the study showed a positive and statistically significant increase in the outcome measures following the intervention. The Diaphragmatic Stretch Technique has a considerable influence on patients with mild or moderate COPD without causing any exacerbations or adverse effects.

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INTRODUCTION

'Chronic Obstructive Pulmonary Disease' (COPD) is currently the fourth leading cause of death in the world, accounting for 6% deaths globally. Now, it is considered as a preventable and treatable disease caused by significant exposure to noxious gasses or particles (Singh *et al.*, 2019). The pathology of COPD includes decreasing parenchymal tethering of the airways, loss of alveolar surface area, narrowing of the peripheral airways,air trapping and pulmonary hyperinflation (Yamaguti *et al.*, 2008). These intrapulmonary changes can be traced to several pathological changes like peri-bronchial fibrosis, sub-mucosal gland hypertrophy, increased mucus hypersecretion,and an increase in airway smooth muscle mass. Airway wall remodelling in COPD can be mainly attributed to epithelial metaplasia leading to airway wall thickening with TGF-β being proposed as an essential mediator (Lee, 2017). These pathological changes exhibit as persistent airflow limitation, especially expiratory flow limitation, which prolongs expiration leading to pulmonary hyperinflation (Hellebrandova *et al.*, 2016).

The diaphragm is the primary muscle of ventilation, accounting for approximately 70% to 80% of inspiration force during quiet breathing. During normal quiet breathing, there is a descent of the diaphragm as the fibres contract. With a deeper breath, as the diaphragm reaches the end of its contraction, the fibres become more horizontally aligned, flattening the dome of the diaphragm and thereby increasing the thoracic size and intra-abdominal pressure. The resultant increase in thoracic size causes a reduction in the intrapulmonary pressure that is responsible for inspiration (Levangie and Norkin, 2000).

COPD is typically associated with weakness, shortening and mechanical disadvantage of the inspiratory muscles, especially diaphragm, mainly due to the changed length-strength relationship and their remodelling (Hellebrandova *et al.*, 2016). In persons with chronic obstructive pulmonary disease (COPD), chronic hyperinflation of the lungs results in a resting position of the diaphragm to be lower (more flattened) and shorter (by 28-40%) than normal (Levangie and Norkin, 2000; Yamaguti *et al.*, 2008). This hyperinflation creates a “threshold load” that the diaphragm has to overcome to initiate an inspiratory flow. These changes cause an increase in the work of breathing, leading to high oxygen cost, hypo-ventilation and reduction in exercise tolerance and functional capacity which makes it a potential target for therapeutic intervention (O’Donnell and Laveneziana, 2006).

The mainstay treatments for COPD has been pharmacological Therapy and pulmonary rehabilitation for several years, however, there has been an encouraging number of studies in the osteopathic and chiropractic literature that have tested the use of manual therapy techniques in chronic pulmonary diseases (Howell *et al.*, 1975; Noll *et al.*, 2009).

Manual Therapy has shown to target mainly the musculoskeletal structure surrounding the lungs, subtly rearranging and resetting the mechanics of respiration (for example, the flexibility of chest wall and thoracic expansion) in certain chronic respiratory diseases. This may indirectly lead to an improvement in functional capacity and exercise tolerance thereby having a positive impact on ventilation (Bockenhauer *et al.*, 2002; Engel and Vemulpad, 2011; Yamaguti *et al.*, 2008).

The Diaphragmatic Stretch Technique targets the diaphragm to improve its dome shape in the resting position (as opposed to the flattened state in COPD patients). It thrives on creating and maintaining a pressure gradient between the thorax and abdomen (Chaitow *et al.*, 2002). There was a lack of retrievable data available that tested the effect of Diaphragmatic stretching technique on diaphragmatic excursion in patients with COPD using Ultrasound as an outcome measure. This study aims to find the effects of Diaphragmatic stretch on a diaphragmatic excursion in patients with COPD.

MATERIALS AND METHODS

Inclusion criteria

1. Patients with clinically stable COPD who are referred for Physiotherapy/ Pulmonary Rehabilitation by a physician.

2. Patients with GOLD level 1 and 2 classifications of airflow limitation severity in COPD (post-bronchodilator FEV1) according to the GOLD criteria.

In patients with FEV1/FVC <0.70:

GOLD 1: MildFEV1 $\geq$ 80% predicted

GOLD 2: Moderate 50% $\leq$ FEV1 < 80% predicted

Exclusion criteria

1. Patients with a history of exacerbation of COPD in the past month.

2. Patients having unstable hemodynamic parameters (blood pressure, respiratory rate, arrhythmia).

3. Patients who have undergone recent surgery of the thorax, abdomen or head and neck.

4. Patients who have a recent history of trauma to the thorax, abdomen or head and neck

5. Patients with chest wall and trunkdeformities (example: scoliosis)

6. History of psychiatric illness or difficulty in comprehending commands and following instructions.

Study procedure

After the approval from the Ethical Committee of a Deemed to be University in Mangalore, Karnataka, eligible patients were selected based on the checklist of inclusion and exclusion criteria.

Table 1: Demographic data of participants

Age	Gender		COPD category as per GOLD criteria	
(66.85 ±8.37)	Male	Female	GOLD 1 Mild	GOLD 2 Moderate
20	12	8	11	9

Table 2: Pre and post intervention values of Diaphragmatic Excursion on the right side (in cms.) recorded using Ultrasound

Reference point	Pre-intervention value	Post-intervention value	Difference	P <0.05
Midclavicular line	2.56 ±0.56	2.86 ±0.59	0.29 ±0.21	0.000**
Midaxillary line	2.74 ±0.63	2.95 ±0.70	0.25 ±0.20	0.003**

Note: ** highly significant

Table 3: Pre and post intervention values of Diaphragmatic Excursion on the left side (in cms.) recorded using Ultrasound

Reference point	Pre-intervention value	Post-intervention value	Difference	P <0.05
Midclavicular line	2.57 ±0.54	2.79 ±0.52	0.24 ±0.24	0.004**
Midaxillary line	2.69 ±0.63	2.85 ±0.6	0.35 ±0.25	0.312

Note: ** highly significant

Table 4: Pre and post intervention values of chest expansion (in inches) recorded using inch tape

Reference point	Pre-intervention value	Post-intervention value	Difference	P <0.05
4th intercostal space	34.98±2.95	35.69±2.85	0.76 ±0.71	0.000
Xiphoid process	36.10±3.22	36.73 ±3.26	0.62 ±0.64	0.000

They were also categorised as having mild or moderate COPD based on their PFT values cross-referenced with the inclusion criteria. After explaining the purpose of the study to the subjects, written informed consent was obtained before inducting them into the study.

The demographic data were collected, and pre-intervention values of both the outcome measures were taken. The primary outcome measure that is Diaphragm mobility was assessed using Ultrasound by a consultant radiologist. Therapist performed the secondary outcome measure that is Chest Expansion using an Inch tape as per standard guidelines.

After this initial procedures, the therapist performed the Diaphragmatic Stretch Technique with the co-operation of the patient in 2 sets (each set consisting of 10 deep breaths) with a 1-minute interval between the sets. Immediately after the intervention, the two outcome measure was assessed as before.

Method to perform the technique

Diaphragmatic stretch technique

The subjects were asked to sit on a couch or stool without back support with the trunk slightly rounded to relax the Rectus Abdominis muscle for the technique.

The therapist positions themselves behind the patient to perform the technique and places their hands around the thoracic cage with the fingers over the bilateral subcostal margin. The therapist firmly holds on to the lower ribs and eases it caudally at the subcostal margin while the patient is instructed to exhale.

This hold exudes gentle downward traction without any compression to the ribcage and is maintained while the patient takes the next deep inhalation (Chaitow *et al.*, 2002).

Description of outcome measures

Diaphragm excursion

The patient's diaphragm was visualised and documented using Ultrasound 'B' Mode while the patient was in sitting position. The probe was placed in the midclavicular as well as midaxillary lines in the subcostal/ lower ribcage area so that bilateral diaphragm could be seen. The reference points of the diaphragm at maximal inspiration and maximal expiration were taken thrice, and the average of the three was documented (Okura *et al.*, 2017).

Chest expansion

The patients were instructed to breathe in and out maximally while standing or sitting with their hands behind their heads. Measurements were taken at the 4^{th} intercostal level and xiphoid process level for the documentation of upper and lower chest expansion, respectively (Olsén *et al.*, 2011).

Sample size estimation

A pilot study involving five clinically stable patients with COPD was conducted with the same study procedure, which later became the foundation to derive a sample size of 20 patients for this interventional study.

RESULTS AND DISCUSSION

A total of 32 patients who were diagnosed with clinically stable mild or moderate COPD were selected. Out of this, seven patients had to be excluded as they had co-morbidities (recent pleural tapping < 20 days back; acute exacerbation < 1 month back). In addition to that, five patients dropped out due to lack of interest bringing the final 20 patients as per the sample size. Table 1, summarises the demographic data of the patients taken at the start of the study.

Diaphragmatic excursion on the left side, after the intervention, had a difference of 0.24 $\pm$0.24(p=0.004) at the midclavicular line and 0.35 $\pm$0.25(p=0.312) at the midaxillary line. On the Right side pre and post-intervention values had a difference of 0.29 $\pm$0.21 (p=0.00) at the midclavicular line and 0.25$\pm$0.20(p=0.003) at the midaxillary line, as summarised in Table 2 and Table 3.

Table 4 summarises the chest expansion values before and after the intervention. There was a difference of 0.76 $\pm$ 0.71 (p=0.000) at the level of 4^{th} intercostal space and 0.62 $\pm$0.64(p=0.000) at the level of the xiphoid process after the intervention.

The present study aimed at finding the effect of Diaphragmatic stretch technique on patients with mild and moderate COPD on diaphragmatic excursion and chest expansion. A statistically significant difference in these outcome measures was found after the intervention was administered.

The muscle spindle, which is the sensory organ for the muscle, maybe stimulated due to the muscle stretching, which may be the reason for the result. This directly targets and activates the sensory afferent stimulus, accelerating neuromuscular response. The stretch also renders a mechano-receptor stimulation leading to activation of sympathetic chain ganglia and related structures. These stimulations may contribute to improved sympathetic tone in the lung, increased tension in the muscle, finally improving the viscoelastic properties of the muscle. The technique done in this study may also have had an impact on the respiratory mechanics and the chest wall mobility leading to an increase in chest expansion (Minoguchi *et al.*, 2002; McHugh and Cosgrave, 2009; Bhilpawar and Arora, 2013).

The improved chest wall mobility also points in the direction of stimulation of Golgi tendon organ, which is a receptor in the musculotendinous junction, which would have imposed an inhibitory effect on the muscles working at a mechanical disadvantage (Kokkonen *et al.*, 2007). Astudy done by Noll *et al.* (2008) has reported a positive result on pulmonary function after the patients underwent the Redoming of Diaphragm technique (Noll *et al.*, 2008). In a study done by González-Álvarez *et al.* (2016) the diaphragm stretch technique was performed on healthy subjects which has shown an improvement in the posterior chain kinematics (González-Álvarez *et al.*, 2016). Bhilpawar and Arora (2013) conducted a study with a combination of manual Therapy including the diaphragmatic stretch technique or redoming of diaphragm technique which showed a significant improvement in chest expansion and improvement in respiratory rate (Bhilpawar and Arora, 2013).

In a study conducted by Abdelaal *et al.* (2015) showed a significant amplification of FVC,FEV1 and 6MWT after the administration of Redoming of the Diaphragm technique (Abdelaal *et al.*, 2015). Braga *et al.* (2016) found that the manual therapy techniques aimed at the diaphragm and ribs had a marginal effect on thoracic mobility (Braga *et al.*, 2016). The future scope for this study includes involving larger populations of COPD categorised to various disease severity and subgroups, performing the intervention for more number of sessions with the addition of different outcome measures, assessing the more long term effects of the diaphragmatic stretch technique.

CONCLUSION

The Diaphragmatic Stretch Technique has a clinically and statistically significant effect on the diaphragmatic excursion and chest expansion in patients with mild to moderate COPD. The technique is well tolerated by the patient with COPD without any difficulty or exacerbation

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Conflict of Interest

The authors declare no conflicts of interest.

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