Current Science International
ISSN: 2077-4435

Volume : 08 | Issue : 01| Jan.- Mar. 2019
Pages**:** 186-192

Response of diaphragmatic excursion to resisted inspiratory exercises using pneumatic compression in elders with low back pain

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Received: 05 Jan. 2019/ Accepted 10 Jan. 2019 / Publication date: 30 Mar. 2019

ABSTRACT

Background*:** Low back pain is the most common health problem among older adults that results in pain and disability. Recent studies have revealed that Low back pain remains ubiquitous among older adults at their retirement ages. In the chronic Low back pain patients there were significantly smaller excursions of the diaphragm with respiration compared to the healthy ones. ***Purpose: The aim of this study was to determine the response of diaphragmatic excursion to resisted inspiratory exercises using pneumatic compression in elders with low back pain. ***Subjects and Methods:*** forty patients (twenty males and twenty females) with chronic low back pain. Their ages ranged from 60 to 70 years, their height ranged from 1.71 to 1.75m and their weight ranged from 71 to 79kg with body mass index were ranged from 23.4 to 26.4 kg/m^2. The patients were selected randomly from Outpatient clinic of Department of Rheumatology and Rehabilitation of Kasr El-Aini Hospitals and randomly divided into two equal groups: Group A (Study group): composed of twenty patients (nine males and eleven females) with low back pain who received resisted inspiratory exercises using pneumatic compression and traditional physical therapy in form of transcutaneous electrical nerve stimulation (TENS) and Ultrasound on lower back and Group B (Control group): composed of twenty patients (eleven males and nine females) with low back pain who received traditional physical therapy in form of TENS and Ultrasound on lower back only. ***Results:*** The results of this study revealed that there was significant increase of Diaphragmatic excursion at post treatment in compare to pre-treatment in the Group A (Study group) not in the Group B (Control group) and there was clinical difference and higher percent of improvement in favor to study group than control group, there was significant reduction of Visual Analouge Scale (VAS) at post treatment in compare to pre-treatment in the GroupA (Study group) and in the GroupB (Control group) while this significant reduction in favour to study group in compared to control group and there was significant reduction of Roland and Morris Disability Questionnaire at post treatment in compare to pre-treatment in Group A (Study group) and in Group B (Control group) while there was clinical difference and higher percent of improvement in favor to study group than control group. ***Conclusion:*** Resisted Inspiratory Exercises using Pneumatic Compression can improve diaphragmatic excursion in elders with low back pain and can improve their back pain.

***Keywords*:** Diaphragmatic Excursion, Inspiratory Exercises, Pneumatic Compression and Low Back Pain)

Introduction

Low back pain is the most common health problem among older adults that results in pain and disability (Prince *et al.,* 2015).

In population-based studies, the 1-year prevalence of low back pain in community-dwelling seniors ranged from 13 to 50% across the world (Fernández *et al.,* 2013).

Low back pain (LBP) is a very frequently occurring phenomenon in Egypt. Among adults in the general population, 70-85% were believed to experience at

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least one episode of LBP at some time during their lives. In a current study found that the prevalence of LBP complaints was 79.3%. Nurses in Egypt, like their counterparts in Africa and developed countries, also suffer from LBP (Amany *et al.,* 2014).

Like among young adults, the majority of low back pain (LBP) among older adults has no definite pathology (e.g., fracture or inflammation) and is diagnosed as non-specific LBP. These patients experience LBP that is altered by posture, activity, or time of the day. Non-specific LBP may originate from different pain sources (Middleton and Fish, 2009).

Diaphragm is an important component of spine lumbar stability. In presence of low back pain, there may be some alterations in this muscle like other muscles that are responsible for lumbal stabilization (Dulger *et al.,* 2018).

The breathing pattern is involved in core stabilization and motor function ; in fact the diaphragm, in synergy with other muscles, forms the "core region". The aim of this brief review is to provide a concise summary on the role of breathing and core stability exercises in the prevention of low back pain (Cavaggioni *et al.,* 2015).

There are many changes that appear with aging leading to a decline in lung function as in other systems. The main changes in the respiratory system of the elderly are loss of chest wall compliance, decrease in strength of elastic recoil of lung parenchyma, decrease in respiratory muscle strength and decreased responsiveness to hypoxemia and hypercapnia (Lalley, 2013).

In the chronic low back pain group there were significantly smaller excursions of the diaphragm with respiration (the diaphragm splinted) compared to the healthy group in study conducted to compare between diaphragm excursion in low back pain patients and healthy others who did not suffer from low back pain. Abnormal coordination of the diaphragm observed during inspiration with limbs demandtasks in the Low back pain group. This abnormal coordination suggested increased sheer forces on the lumbar spine compared to the healthy group (Hagins and Lamberg, 2011).

Many studies investigated the connection between respiratory muscles and Low back pain (LBP). It was showed that people with LBP have an abnormal
diaphragm position. Individuals with LBP exhibit major diaphragm fatigue compared to healthy one. Moreover, it is important to highlight that the whole breathing pattern is affected by LBP in terms of dyspnea, allergies and Chronic Obstructive Pulmonary Disease (Kolar *et al.,* 2012).

Certain study was conducted to investigate the effects of resisted breathing exercise on the trunk functions of chronic low back pain patients. Twenty-four patients with chronic low back pain were randomly divided into groups of respiratory effort and lumbar stabilization exercises. The exercises were performed for 45 minutes, 3 times per week for 6 weeks. Lumbar stabilization was measured as the compensation of the sagittal angle joint in relation to the lumbar external load. After the intervention, the resisted breathing and lumbar stabilization exercise groups showed a significant difference in lumbar spine stabilization between the first and second stress tests and the control group also showed a significant difference after the intervention. The tests of lumbar spine stabilization revealed no significant differences between the groups. So, the results of this research demonstrate that resisted breathing exercise therapy is effective at improving the lumbar stability and daily living activities of chronic low back pain patients (Ki *et al.,* 2016).

Materials and Methods:

Forty elders from both sexes (men and women), suffering from non-specific low back pain, were selected randomly from Outpatient clinic of Department of Rheumatology and Rehabilitation in Kasr El-Einy Hospitals, Cairo. Their ages ranged from 60 to 70 years, their height ranged from 1.71 to 1.75m and their weight ranged from 71 to 79kg with body mass index were ranged from 23.4 to 26.4 kg/m^2. The exclusion criteria included all patients suffered from specific low back pain with clear symptoms, patients suffered from chest diseases, scoliosis and previous trauma to the spine, patients with belly abdomen and heavy smokers.

Patients were divided into two equal groups: GroupA (Study group): composed of twenty patients (nine males and eleven females) with low back pain who received resisted inspiratory exercises using pneumatic compression and traditional physical therapy in form of transcutaneous

electrical nerve stimulation (TENS) and Ultrasound on lower back and GroupB (Control group): composed of
twenty patients (eleven males and nine females) with low back pain who received traditional physical therapy in form of TENS and Ultrasound on lower back only.

Full instructions were given to all participants about the study protocol. Participants and parents signed a consent form. The Ethical Research Committee of Faculty of Physical Therapy has approved the study protocol.

Assessment procedures:

Ultrasonography:

Neuromuscular ultrasound is an evolving technique that is now being used to image the diaphragm in normal and pathologic conditions given recent advances that allow high-resolution images. It is now being used more commonly for the evaluation of diaphragm structure and function. Ultrasonography is portable, ubiquitous in medical facilities, has no risk of ionizing radiation and allows visualization of structures below and above the diaphragm (Haber *et al.,* 2012).

This technique was done in the Department of Chest Diseases in Kasr El-Einy Hospitals, Cairo University, Egypt. This technique was done for both groups two times, the first before the beginning of the program and the other after finishing the program. The aim of this technique was to assess diaphragmatic excursion by using an objective method.

Visual analogue scale:

Visual analogue scale (VAS) is the most common pain scale for quantification of endometriosis-related pain and skin graft donor site-related pain. A review came to the conclusion that VAS and numerical rating scale (NRS) were the best adapted pain scales for pain measurement in endometriosis. For research purposes and for more detailed pain measurement in clinical practice, the review suggested use of VAS or NRS for each type of typical pain (Sinha *et al.,* 2017).

This scale was done for both groups by the subjective evaluation from the patients towards their back pain. The scale was done for both groups two times, the first before the beginning of the program and the other after the end of the program.

Roland-Morris Low Back Pain and Disability Questionnaire:

Objective and subjective measures of pain, functional impairment and health-related quality of life (HRQoL) in patients with lumbar degenerative disc disease and patients with chronic non-specific low back pain are very important in detecting the exact pathomechanism of these cases. In a prospective 2-center study, back and leg pain (visual analogue scale [VAS]), functional disability (Oswestry Disability Index and Roland–Morris Disability Index) and HRQoL were collected for consecutive patients undergoing lumbar spine surgery. These examinations included Roland-Morris Low Back Pain and Disability Questionnaire used for functional assessment of pain and disability (Oliver *et al.,* 2016).

This questionnaire was done for both groups by the subjective evaluation from the patients towards their back pain. The questionnaire was done for both groups two times, the first before the beginning of the program and the other after the end of the program.

Treatment procedures:

Resisted inspiratory exercises using pneumatic compression:

Intermittent pneumatic compression (IPC) is a mechanical method of delivering compression to swollen limbs that can be used to treat venous leg ulcers and limb swelling due to lymphoedema. Intermittent pneumatic compression (IPC) uses an air pump to inflate and deflate an airtight bag wrapped around the selected area of the body. This technique is also used to stop blood clots developing during surgery. Delivering the IPC therapy in a rapid manner by inflating and deflating the

IPC device more quickly resulted in more ulcers being healed than with a slower deflation regime (Nelson *et al.,* 2014).

Training program in the form of resisted inspiratory exercises using pneumatic compression. The exercise consisted of 10 sets, 4-5 repetitions in each set with rest (2-3min) in between sets, 3 times per week for 12 weeks. The patient lied on the back on a flat surface or in bed, with the knees bent then he breathed in slowly through the nose, so that the stomach moves out against the abdominal sleeve of pneumatic compression device fixed on upper aspect of abdominal cavity below xiphoid process, then he exhaled through pursed lips. The training was applied by group (A) only.

Traditional physical therapy:

Transcutaneous Electrical Nerve Stimulation (TENS):

Transcutaneous electrical nerve stimulation (TENS) is a nonpharmacological intervention that activates a complex neuronal network to reduce pain by activating descending inhibitory systems in the central nervous system to reduce hyperalgesia (Vance *et al.,* 2014).

Application: 20 min. on lower back 3 times per week for 12 weeks.
This technique applied by group (A) and Group (B) for 12 weeks.

Therapeutic Ultrasound:

Therapeutic Ultrasound was shown to be effective on pain, some particular parameters of quality of life (QOL), functional performance and depression in patients with chronic low back pain (CLBP) (Hastalarda *et al.,* 2010).

Application: (1.2Watt/centimeter square): 5 minetes on lower back 3 times per week for 12 weeks. This technique applied by group (A) and Group (B) for 12 weeks.

Statistical analysis:

Descriptive statistical analysis was used for data collection to calculate means and standard deviations. Differential statistical analysis was used in form of 2 x 2 Mixed MANOVA test to compare the tested variables of interest at different measuring periods at both groups. With the initial alpha level set at 0.05.

Results:

A. Physical characteristics of participants:

Table (1): Physical characteristics of participants in both groups.

Items	Control group	Exercise group	Comparison		
	Mean ± SD	Mean ± SD	t-value	P-value	S
Age (years)	62.95±3.45	62.6±3.03	0.34	0.735	NS
Body mass (Kg)	76.65±2.87	77.7±1.45	-1.459	0.153	NS
Height (m)	1.73±0.01	1.73±0.01	0.00	1.00	NS
BMI (kg/m2)	25.58±0.96	25.94±0.49	-1.482	0.147	NS

*SD: standard deviation, P: probability, S: significance, NS: non-significant.

B. Multiple pairwise comparison tests (Post hoc tests):

Table 2: Mean ±SD and p values of Diaphragmatic excursion pre and post-test at both groups.

Diaphragmatic excursion	Pre test	Post test	MD	% of change	p- value
	Mean± SD	Mean± SD			
Control group	50.85±19.17	51.35 ±18.67	-0.5	0.98	0.781
Study group	55.2±18.1	60.75±20.57	-5.55	10.05	0.004*
MD	-4.35	-9.4			
p- value	0.465	0.139			

*Significant level is set at alpha level <0.05 SD: standard deviation
MD: Mean difference p-value: probability value

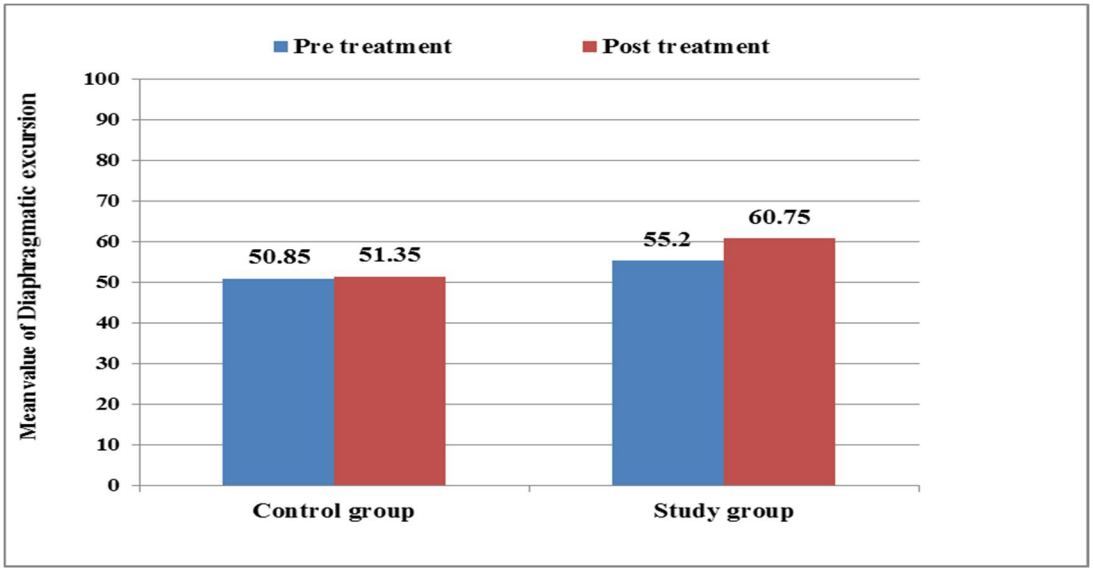

Fig. 1: Mean values of Diaphragmatic excursion pre and post tests in both groups.

Table 3: Mean ±SD and p values of VAS pre and post-test at both groups.

VAS	Pre test Mean± SD	Post test Mean± SD	MD	% of change	p- value
Control group	8.05±0.75	5.8 ±2.14	2.25	27.95	0.0001*
Study group	8.4 ±0.59	4.55±1.57	3.85	45.83	0.0001*
MD	-0.35	1.25			
p- value	0.114	0.042*			

*Significant level is set at alpha level <0.05 SD: standard deviation
MD: Mean difference p-value: probability value

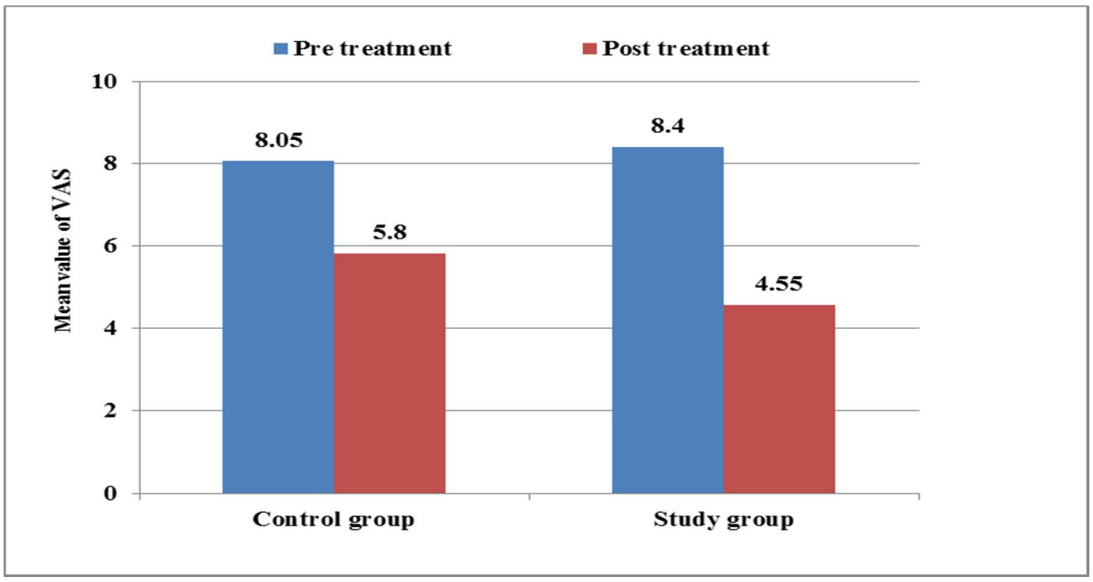

Fig. 2: Mean values of VAS pre and post tests in both groups.

Discussion

The aim of this study was to examine the response of diaphragmatic excursion to resisted inspiratory exercises using pneumatic compression in elders with low back pain.

The result of the present study revealed that there was a significant improvement in diaphragmatic excursion, visual analogue scale and Roland-Morris disability questionnaire in post treatment in compared with that in pre treatment in group A (study group) while there was a significant improvement in visual analogue scale and Roland-Morris disability questionnaire not in

diaphragmatic excursion in post treatment in compared with that in pre treatment in group B (control group), while the improvement in group A more than in group B with accurate statistical index.

Our study results were consistent to the study of Alaparthi *et al.* (2016) when they performed trial to evaluate the effects of inspiratory breathing exercises and flow and volume-oriented incentive spirometry on pulmonary function and diaphragm excursion in patients undergoing laparoscopic abdominal surgery. Pulmonary function (Forced Vital Capacity) and diaphragm excursion showed statistically significant improvement in incentive spirometry and inspiratory breathing group in compare to control group.

Similarly, Rezkallah *et al.* (2017) conducted that the results of study with forty patients assigned to two equal groups showed that diaphragmatic excursion in elderly significantly improved post-treatment in the study group that received (threshold inspiratory muscle trainer and inspiratory breathing exercises) in quiet breathing more than control group.

In addition to Renu and Shaili, (2015) agreed with results of this study when they examined the effect of early mobilization program with inspiratory breathing exercises versus incentive spirometry on diaphragmatic excursion and on peak expiratory flow rate in the patients with abdominal surgery, thirty adult participants both males and females randomly allocated by coin method comprising 15 in each group. Demographic data and pre-post intervention values for all the outcome measures in the form of diaphragmatic excursion and peak expiratory flow rate were obtained. The study showed improvement in diaphragmatic excursion and peak expiratory flow rate in both groups. So, inspiratory breathing exercise and incentive spirometry demonstrate improvement in diaphragmatic excursion and peak expiratory flow rate in postoperative abdominal surgery patients.

In contrast, Moulim *et al.* (2011) disagreed with results of this study through results of trial done to determine whether preoperative inspiratory muscle training is able to attenuate the impact of surgical trauma on the respiratory muscle strength, in the lung volumes and diaphragmatic excursion in obese women undergoing open bariatric surgery. Randomized controlled trial was done in Meridional Hospital, Cariacica/ES, Brazil. Thirty-two obese women undergoing elective open bariatric surgery were randomly assigned to receive preoperative inspiratory muscle training (inspiratory muscle training group) or usual care (control group). Respiratory muscle strength (maximal static respiratory pressure - maximal inspiratory pressure and maximal expiratory pressure), lung volumes and diaphragmatic excursion. After training, there was a significant increase only in the maximal inspiratory pressure in the inspiratory muscle training group. The maximal expiratory pressure, the lung volumes and the diaphragmatic excursion did not show any significant change with training.

Lawrence *et al.* (2002) also contrasted with results of this study, they suggested from previous literature review that persons with moderate to severe COPD and marked hyperinflation of the lungs without adequate diaphragmatic movement and increase in tidal volume during inspiratory muscle training may be poor candidates for instruction in this training. Persons with COPD who have elevated respiratory rates, low tidal volumes that increased during inspiratory training would not be very effective in improving diaphragmatic movement by training in these patients.

Conclusion

It can be concluded that diaphragmatic excursion improved and increased significantly with resisted inspiratory exercises using pneumatic compression in addition to TENS and Therapeutic Ultrasound on lower back such as in Group A (study group) more than TENS and Therapeutic Ultrasound on lower back only such as in Group B (control group).

The results obtained in the present study revealed that the physiological response of the diaphragmatic excursion on elders with low back pain was significantly appeared and increased with resisted inspiratory exercises using pneumatic compression and the low back pain got improved.

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