The Effect of Core Stability Training with Ball and Balloon Exercise on Respiratory Variables in Chronic Non-Specific Low Back Pain: An Experimental Study

ABSTRACT

Background: Studies have shown the involvement of respiratory characteristics and their relationship with impairments in non-specific low back pain (NS-LBP). The effects of core stability with combined ball and balloon exercises (CBB) on respiratory variables had not been investigated.

Objective: To evaluate the effectiveness of CBB on respiratory variables among NS-LBP patients.

Study Design: pre- and post-experimental study.

Participants: Forty participants were assigned to an experimental group (EG) [n=20] and control group (CG) [n=20] based on the study criteria.

Interventions: The EG received CBB together with routine physiotherapy and the CG received routine physiotherapy over a period of 8 weeks. Participants were instructed to carry out the exercises for 3 days per week. The training was evaluated once a week and the exercises progressed based on the level of pain.

Outcome measures: Primary outcomes were maximum inspiratory pressure (MIP), maximum expiratory pressure (MEP) and maximum voluntary ventilation (MVV). The secondary outcomes were measured in the numeric rating scale (NRS), total faulty breathing scale (TFBS), cloth tape measure (CTM) and lumbo-pelvic stability. Results: The MIP increased significantly among the EG when compared with that in the CG ($p>0.05$).The EG showed a significant increase in MVV ($p=0.04$) when compared to the CG ($p=0.0001$). There was significant reduction in pain for both groups. The MEP, TFBS, chest expansion and core stability showed no changes in either group.

Conclusion: CBB was effective in improving respiratory variables among the NS-LBP patients.

Key words: respiration; low back pain; maximum voluntary ventilation; respiratory muscle

INTRODUCTION

Non-specific low back pain (NS-LBP) is considered to be a leading cause of disability throughout the world. Therapies termed as range of exercises are designed to reduce pain, strengthen the back musculature and promote stabilization of the lumbar segment(Barr et al., 2007, 2005). The selection and administration of exercises depend on the experience of the practitioner and patients acceptability, as per a recently published systematic review (Saragiotto et al., 2016). With reference to such exercise programs, literatures inferred that the core stability exercises with other forms of exercises improved lumbar stability and the motor control approach is not greater to other forms of exercise for treating patients with chronic LBP (Saragiotto et al., 2016)(Javadian et al., 2015).

Despite the popularity and wide usage of motor control exercises, the effectiveness of core stability exercises is debatable because of the difference in types of exercises depending upon the needs of patients being treated for LBP (Barr et al., 2005)(Barr et al., 2007). The National Institute for Health and Care Excellence (NICE) (2016) guideline for "low back pain and sciatica in over 16s: assessment and management" also advised that during selection of different types of exercises, the specific needs, preferences and capabilities of the patients ought to be considered. In addition, the NICE guideline identified that information on the type, frequency and duration of exercise are difficult to obtain specifically (National Institute for Health and Care Excellence, 2016). The main challenge that researchers face in many experiments is that all core stability these exercises have been tested for pain reduction, range of motion and other musculoskeletal parameters. The other difficulties faced by these experiments which are being unaddressed appropriately are can these exercises reverse muscle properties, neural firing patterns, improve proprioception and balance (Barr et al., 2005).

One of the most important fundamental constituents of core function is appropriate breathing patterns which can be optimized through diaphragmatic control. The diaphragm is a dome-shaped muscle which has been identified to have a costal, a lumbar and a sternal portion. The lumbar portion on the right has an attachment at the level of L1-L3 and on the left between L2 and L3 which is responsible for stability and posture (Bordoni and Zanier, 2013). Functionally, the crural region is responsible for appropriate breathing and a costal region prevents gastroesophageal reflux (Bordoni and Zanier, 2013). The abdominal canister which is considered as a functional and anatomical construct is bounded by fascial connection through diaphragm, abdominal and pelvic viscera (Lee et al., 2008). The abdominal muscles are constituted by transverse abdominis, rectus abdominis, internal and external oblique. These fascial structures work together synergistically. The connection between respiratory and pelvic diaphragm helps in controlling intra-abdominal pressure and also for steadiness of the human trunk. In addition, the thoracolumbar fascia which supports lumbar vertebrae on the sacral spine also plays an important role in respiration, load transfer and posture (Willard et al., 2012). Therefore, it could be said that when there is a problem with diaphragm or any of these connections there will be dysfunction in terms of respiration and stability.

Recent developments in NS-LBP have heightened the need to investigate members of the population who face respiratory compromise, which could involve altered breathing pattern, reduced respiratory muscle strength, endurance, reduced chest expansion and altered movement of the diaphragm (Kolar et al., 2012; Smith et al., 2006). Very few quantitative analyses showed the influence of respiratory characteristics indirectly among LBP patients, following eight weeks of respiratory muscle training (Janssens et al., 2015, 2013). Although evidence suggested that respiratory rehabilitation needs to be initiated in NS-LBP, whether respiratory compromise could be improved by undertaking exercises programs has not been revealed clearly. Therefore, it could be argued that having direct outcome measures related to respiratory compromise for testing an exercise regimen would be advantageous for LBP related studies by understanding the therapeutic effects of exercises on respiratory variables.

Furthermore, in order to overcome the difference in core stability exercises and to examine the influence and involvement of respiratory characteristics, this study adapted to earlier protocols of core stability exercises among NS-LBP patients (Hagins et al., 1999). In addition, Boyle et al, 2010 suggested "90/90 bridge" with ball and balloon exercises for improving suboptimal breathing pattern and trunk stability as in the protocol of this study. The 90/90 bridge with ball and balloon exercises was suggested to reduce pain immediately among LBP participants(Boyle et al., 2010). However, the clinical effectiveness of core stability exercise along with the ball and balloon exercises was not tested on NS-LBP populations. Ball and Balloon exercise approach which was implemented in this study is believed to enhance stability and improve neuromuscular control of diaphragm, abdominal muscles and diaphragm to promote suboptimal breathing. Therefore, this study hypothesized that inclusion of ball and balloon exercise, together with other core stability exercises, would be advantageous for the NS-LBP population by improving respiratory parameters. Therefore, the objective of this study was to research the effect of core stability with combined ball and balloon (CBB) exercises on respiratory muscle strength and endurance, breathing pattern, pain intensity, chest expansion and core stability among individuals with NS-LBP.

METHODS

Design

The trial had a prospective design with a pre- and post-trial, and this study followed the Consolidated Standards of Reporting Trial statement for Non-pharmacologic treatment (Boutron et al., 2008). This study received ethics approval from the local Research Ethics Committee [600-IRMI (5/1/6)]; written consent was obtained from each individual participant.

Participants

Male and female participants aged between 18 and 55 years were considered eligible for this study. All of them were diagnosed by physicians from the physician clinic to physiotherapy department clinic, as patients with chronic LBP between the last ribs and gluteal sulcus for a period of at least 6 months (Brumagne et al., 2008; Lawand et al., 2015). The patients had at least three episodes of LBP symptoms for the previous six months (Janssens et al., 2015), with intensity ranging between 2/10 and 5/10 in the numeric rating scale (NRS) and forced expiratory volume of > 80% in the 1st second (FEV1%). FEV1% of more than 80% is considered as normal pulmonary function values (Gibson et al., 2002). Participants were excluded if they had respiratory disease, pregnancy, numbness or neural signs on their legs or history of surgeries to the lumbar spine (Janssens et al., 2015). The study was conducted in a public university. The participants were recruited from 27 March, 2016 to 28 February, 2017. The flow of participants is presented in **Figure 1**.

Randomization-sequence generation

The patients were selected randomly and divided into two groups: the experimental group (EG) and control group (CG) and the patients were blinded until they had completed the exercise program. The research assistants were assigned randomly, with each one delivering the protocol for either one of the groups.

Interventions

Both of the groups received treatment for a period of 8 weeks, with exercises carried out for 3 days per week. The patients were selected blindly for the training and evaluated once a week by the research assistants under supervision of an investigator, and progression of the exercise was given according to the level of pain. If the level of pain remained the same or was reduced, then the exercise progressed. On the other hand, if the level of pain increased and the participants were unable to maintain +/- 10 mmHg using a pressure biofeedback device, exercise progression ceased. The CG received routine physiotherapy such as ultrasound, spinal flexion or extension exercises, whereas the EG received a predesigned exercise protocol together with routine physiotherapy (Boyle et al., 2010; Hagins et al., 1999)

Outcomes

The primary outcomes comprised of maximal inspiratory pressure (MIP), maximal expiratory pressure (MEP) for measuring respiratory muscle strength and maximum voluntary ventilation (MVV) for measuring respiratory muscle endurance using spirometer. Secondary outcome measures were chest expansion using Cloth Tape Measure (CTM), pain using NRS, faulty breathing pattern using Total Faulty Breathing Scale (TFBS) and core stability using pressure biofeedback device (Mohan et al., 2018). All of the outcome measures were evaluated at baseline and after 8 weeks of treatment**.**

Sample size

MIP was considered as one of the primary outcomes in this study and used to calculate the sample size with the G*power program 3.1.0 for two tails, paired test. The outcome of MIP was taken for sample size estimation with mean $\pm$ SD; 136 $\pm$ 34 cm H_2O and 94$\pm$26 cm $H_2O$for the high and low Inspiratory Muscle Training (IMT), respectively(Janssens et al., 2015). The estimated sample for obtaining a power of 80% minimum at a significant alpha level of 95% required a total of 34 participants. Therefore, at least 17 participants with NS-LBP were required for comparing respiratory characteristics among NS-LBP patients under specific treatment; and another 17 were needed to serve as a CG comparison in order to determine the difference between the values. However, 10% of the sample size was added to account for the possibility of drop-outs during the therapeutic treatment program. Therefore at least 20 participants per group were examined.

Statistical methods

The data were analyzed using Statistical Package for the Social Sciences (SPSS) software (version 21.0).The measurement variables were subjected to descriptive and inferential analysis. Description of demographic and study variables was presented as mean, standard deviation, frequency and percentage. Results were tested for normal distribution using the Shaipiro-wilk test. Demographic details between the groups were tested using the Mann-Whitney U-test. The Wilcoxon signed rank test was used to compare pre- and post-values of the EG and CG, based on the assumption of normality. Improvements were reported in different scores and changes in percentage. Comparisons between the two groups were made by using the Mann-Whitney U-test ($p<0.05$).

RESULTS

Demographic characteristics of the study samples are presented in **Table 1.**The results showed no significant differences in characteristics between the participants in the EG and CG ($p>0.05$). These findings indicated that the participants were similar with regard to demographic characteristics.

The clinical background and their results of baseline- and post-values are presented in **Table 2** and **Table 3** for primary and secondary variables, respectively. Three EG subjects and two in the CG dropped out during training as they were lost to follow-up due to lack of compliance and thus not considered in the final analysis. MVV values were lower in both baseline- and post-values in the CG when compared with those in the EG. MIP was reduced in the EG in both baseline- and post-values when compared with that in the CG. The MEP values were similar.

Primary outcome variables

There was a significant increase in percentage MIP score ($p=0.020$) in the EG, but the CG did not show a change ($p=0.421$). With regard to MEP, there was no significant increase in either the EG ($p=0.282$) or CG ($p=0.782$). This indicated no improvement in MEP for either group. The participants in the EG showed significant increase in percentage MVV score ($p<0.05$). The CG showed a similarly significant increase in percentage MVV score ($p<0.001$). Therefore, this study finding illustrated a significant improvement in respiratory muscle endurance following both treatments.

Secondary Outcome Variable

The participants in the EG and CG did not show improvement in chest expansion measurements for the axilla, 4th intercostal space (ICS) and xiphoid process, with $p>0.05$.With regard to the values of NRS, a significant reduction in scores occurred after treatment in both the EG ($p=0.034$) and CG ($p=0.046$). This signified an additional reduction in pain scores in the EG when compared to those in the CG. TFBS and core stability component scores did not change in either group.

Comparison between the EG and CG was calculated using different scores and percentage changes, which showed no differences of primary and secondary variables between the groups (**Table 3)**.

DISCUSSION

This study set out with the intention to evaluate the importance of CBB exercises among NS-LBP patients. Its general findings indicated that NS-LBP patients were experiencing reduced pain, improved inspiratory muscle strength and respiratory muscle endurance with the aid of a designed protocol.

Primary variable

The component of respiratory muscle force, which is inspiratory muscle strength, improved in the EG (2.89%) when compared with that in the CG (-3.63%). On the other hand, expiratory muscle strength did not improve in either group. More specifically, the exercise training program prescribed in this study utilized CBB exercises, whereas a recent study used equipment with a mouth piece(Janssens et al., 2015). Why the expiratory muscle strength did not improve could be due to insufficient exercise intensity in the exercise program utilized for the present study.

Similar results of improvement in inspiratory muscle strength were encountered in an earlier study on LBP, in which the results in a high-IMT group showed significant improvements following intervention(Janssens et al., 2015). Hence, it could be stated that the components of CBB exercises, which were designed in this present study and an earlier study, yielded significant improvement in respiratory parameters(Janssens et al., 2015). The probable reason for improvement in the inspiratory muscles could be due to the type of muscle spindle, as those muscles have a dense network of blood vessels, which would have been activated to improve the blood flow in resting and exercising muscle (Janssens et al., 2015). This signifies the inspiratory and expiratory muscle which are indulged in the exercise program through balloon exercise would have altered the breathing pattern, improved diaphragm excursion and promoted length-tension relationship through optimizing the zones of apposition (ZOA) which resulted in improvement of MIP values (Boyle et al., 2010). The CBB exercise also has the potential to increase the intra-abdominal pressure while blowing the balloon which would have improved the postural stability component of lumbar spine.

Improvements that were noted in respiratory muscle endurance among NS-LBP patients were similar to those in earlier studies of chronic obstructive pulmonary disease (COPD) and myasthenia gravis(Rassler et al., 2011; Scherer et al., 2000). Respiratory muscle training for COPD patients was carried out using a newly developed device containing a tube connected to a rebreathing bag (Scherer et al., 2000). This indicated that each study had different types of exercise protocol and equipment to assess the impact of respiratory muscle endurance with a difference in the measurement unit. However, this study utilized the CBB exercise protocol in which assessment of respiratory muscle endurance was carried out using a spirometer. According to the authors' knowledge, this was the first study to explore respiratory muscle endurance following CBB exercises among NS-LBP patients. Therefore, it was not possible to compare the results directly with earlier studies.

A possible physiological explanation for the decrease in values of respiratory muscle endurance among the EG could be due to the impact of exercises on the inspiratory muscles. Increasing work of the inspiratory muscles would have induced fatigue of the diaphragm following exercise in the CBB group. In general, each neuron has a function that activates other neurons. The central and peripheral fatigue of the diaphragm muscle in this study might be due to the failure of exercises in neural activation. In addition, it can be argued that this could be due to contractile dysfunction of the respiratory muscles(Janssens et al., 2013). Overall, it could be alleged that the intensity and duration of the exercises in this study need to be modified in future, in order to activate the appropriate neuronal network.

Secondary variable

An important finding was reduction in pain levels in both groups. It also was interesting that four patients in the EG had no pain at all following intervention. This finding suggested that the detected intensity of pain was reduced and CBB exercises were established and substantiated as an effective tool in improving NS-LBP. This was probably because this protocol enhanced posture and stability(Boyle et al., 2010). The findings were comparable with an earlier study in which pain was reduced following IMT (Janssens et al., 2015). However, the study by Janssens and co-workers could not be compared directly with the current study because of the difference in protocol and the scales used for assessing pain was different (Janssens et al., 2015).

Variables such as chest expansion, TFBS and core stability did not show changes that were considered convincing as unanticipated findings. The reason for no improvement could be due to the limited periods of training, which if extended probably would have yielded changes in these variables. This study asked the participants to perform three days per week, whereas an earlier one requested the participants to perform inspiratory muscle training seven days per week(Janssens et al., 2015).

Clinical significance

It has been observed that any statistical difference alone in treatment intervention may not be appropriate to present in the results (Cook et al., 2015). On the other hand, specification of target difference for the primary outcome measures used in the study by Cook and co-workers was considered as a key component of randomized controlled trials, and recommended by Difference Elicitation Trials (DELTA) in a recently published article that acted as guidance for researchers (Cook et al., 2015). When considering the statistics component, this study identified the primary outcome as MIP, MEP and MVV to witness the target difference. In general, the observed change in the outcome was detected usually through minimal clinically important difference (MCID).This study opted for distribution-based methods to calculate the MCID and choose its formula as 1.96 x √2 x SEM, where SEM= SD x √(1-test retest reliability) (Beckerman et al., 2001). The MCID value for MIP and MEP was 39.97 and 34.09, respectively. The results showed significant changes in MIP values following CBB exercises. However, when values of MIP were compared with those of MCID, the results showed 1.95 for MIP following CBB exercises in the EG. Even though the values were not met by MCID as predicted, the percentage change seemed to be increased in CBB exercises (2.89%). With regard to MEP, the MCID values were not met following CBB exercise sessions. Next, with respect to MVV, the standard deviation values were wider, and hence the calculation for MCID yielded 69.07, and this was not comparable with the changes made following CBB exercises. Moreover, the MCID values were calculated for the variables, and they were the only values available to the authors' knowledge. Therefore, further exploration is required in other populations with similar types of evaluations.

Clinical recommendations

It is inferred that NS-LBP patients with the faulty breathing pattern with the score of > 2 in TFBS and those with the NRS pain score between 2/10 and 5/10 would be an ideal candidate for this exercise approach as this will optimize the breathing and reduces pain.

Limitations

A possible limitation of these results might be the lack of appropriate training and understanding among the participants who performed MVV maneuvers. A few days training in MVV maneuvers before the actual reading would have achieved worthy results between the groups. Therefore, appropriate training for the participants is recommended for future studies. The study did not accounted psychological issues with relation to NS-LBP which might affect respiration. In addition, there were no normative values for the variables tested in this study to compare with those in the NS-LBP patients. Hence, developing normative values for the measurement of variables regarding healthy person and NS-LBP patients would be advantageous for this area of research.

Conclusions

CBB exercise was effective in improving inspiratory muscle strength and respiratory muscle endurance for NS-LBP. The data in this study suggests that CBB exercise sessions for people with NS-LBP might improve respiratory variables by optimizing breathing and enhancing posture and stability.

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References

Barr, K.P., Griggs, M., Cadby, T., 2007. Lumbar Stabilization. Am J Phys Med Rehabil 86, 72–80. doi:10.1097/01.phm.0000250566.44629.a0

Barr, K.P., Griggs, M., Cadby, T., 2005. Lumbar Stabilization. Am J Phys Med Rehabil 84, 473–480. doi:10.1097/01.phm.0000163709.70471.42

Beckerman, H., Roebroeck, M.E., Lankhorst, G.J., Becher, J.G., Bezemer, P.D., Verbeek, A.L.M., 2001. Smallest real difference, a link between reproducibility and responsiveness. Qual Life Res 10, 571–578. doi:10.1023/A:1013138911638

Bordoni, B., Zanier, E., 2013. Anatomic connections of the diaphragm: Influence of respiration on the body system. J Multidiscip Healthc 6, 281–291. doi:10.2147/JMDH.S45443

Boutron, I., Moher, D., Altman, D.G., Schulz, K.F., Ravaud, P., 2008. Extending the CONSORT statement to randomized trials of nonpharmacologic treatment: Explanation and elaboration. Ann Intern Med. doi:10.7326/0003-4819-148-4-200802190-00008

Boyle, K.L., Olinick, J., Lewis, C., 2010. The value of blowing up a balloon. N Am J Sports Phys Ther 5, 179–188.

Brumagne, S., Janssens, L., Janssens, E., Goddyn, L., 2008. Altered postural control in anticipation of postural instability in persons with recurrent low back pain. Gait Posture 28, 657–662. doi:10.1016/j.gaitpost.2008.04.015

Cook, J.A., Hislop, J., Altman, D.G., Fayers, P., Briggs, A.H., Ramsay, C.R., Norrie, J.D., Harvey, I.M., Buckley, B., Fergusson, D., Ford, I., Vale, L.D., 2015. Specifying the target difference in the primary outcome for a randomised controlled trial: Guidance for researchers. Trials 16, 1–7. doi:10.1186/s13063-014-0526-8

Gibson, G.J., Whitelaw, W., Siafakas, N., Supinski, G.S., Fitting, J.W., Bellemare, F., Loring, S.H., Troyer, A. De, Grassino, A.E., 2002. ATS/ERS Statement on respiratory muscle testing. Am J Respir Crit Care Med 166, 518–624. doi:10.1164/rccm.166.4.518

Hagins, M., Adler, K., Cash, M., Daugherty, J., Mitrani, G., 1999. Effects of Practice on the Ability to Perform Lumbar Stabilization Exercises. J Orthop Sport Phys Ther 29, 546–55. doi:10.2519/jospt.1999.29.9.546

Janssens, L., Brumagne, S., McConnell, A.K., Hermans, G., Troosters, T., Gayan-Ramirez, G., 2013. Greater diaphragm fatigability in individuals with recurrent low back pain. Respir Physiol Neurobiol 188, 119–23. doi:10.1016/j.resp.2013.05.028

Janssens, L., McConnell, A.K., Pijnenburg, M., Claeys, K., Goossens, N., Lysens, R., Troosters, T., Brumagne, S., 2015. Inspiratory muscle training affects proprioceptive use and low back pain. Med Sci Sports Exerc 47, 12–9. doi:10.1249/MSS.0000000000000385

Javadian, Y., Akbari, M., Talebi, G., Taghipour-Darzi, M., Janmohammadi, N., 2015. Influence of core stability exercise on lumbar vertebral instability in patients presented with chronic low back pain: A randomized clinical trial. Casp J Intern Med 6, 98–102.

Kolar, P., Sulc, J., Kyncl, M., Sanda, J., Cakrt, O., Andel, R., Kumagai, K., Kobesova, A., 2012. Postural function of the diaphragm in persons with and without chronic low back pain. J Orthop Sports Phys Ther 42, 352–62. doi:10.2519/jospt.2012.3830

Lawand, P., Lombardi Júnior, I., Jones, A., Sardim, C., Ribeiro, L.H., Natour, J., 2015. Effect of a muscle stretching program using the global postural reeducation method for patients with chronic low back pain: A randomized controlled trial. Jt Bone Spine 82, 272–277. doi:10.1016/j.jbspin.2015.01.015

Lee, D.G., Lee, L.J., McLaughlin, L., 2008. Stability, continence and breathing: the role of fascia following pregnancy and delivery. J Bodyw Mov Ther 12, 333–48. doi:10.1016/j.jbmt.2008.05.003

Mohan, V., Ahmad, N.B., Tambi, N.B., 2016. Effect of respiratory exercises on neck pain patients: A pilot study. Polish Ann Med 23. doi:10.1016/j.poamed.2016.01.001

Mohan, V., Paungmali, A., Sitilerpisan, P., Hashim, U.F., Mazlan, M.B., Nasuha, T.N., 2018. Respiratory characteristics of individuals with non-specific low back pain: A cross-sectional study. Nurs Health Sci 1–7. doi:10.1111/nhs.12406

Mohan, V., Paungmali, A., Sitilertpisan, P., 2017. The science of respiratory characteristics in individuals with chronic low back pain: Interpreting through statistical perspective. J Bodyw Mov Ther 1–2. doi:10.1016/j.jbmt.2017.03.017

National Institue for Health and Care Excellence, 2016. Low back pain and sciatica in over 16s: assessment and management [WWW Document]. URL https://www.nice.org.uk/guidance/ng59/resources/low-back-pain-and-sciatica-in-over-16s-assessment-and-management-pdf-1837521693637

Rassler, B., Marx, G., Hallebach, S., Kalischewski, P., Baumann, I., 2011. Long-Term Respiratory Muscle Endurance Training in Patients with Myasthenia Gravis: First Results after Four Months of Training. Autoimmune Dis 2011, 1–7. doi:10.4061/2011/808607

Saragiotto, B., Maher, C., Yamato, T., Costa, L., Menezes Costa, L., Ostelo, R., Macedo, L.,

2016. Motor control exercise for chronic non-specific low-back pain (Review). Cochrane Database Syst Rev CD012004. doi:10.1002/14651858.CD012004.www.cochranelibrary.com

Scherer, T., Spengler, C., Owassapian, D., Imhof, E., Boutellier, U., Scherer, T.A., Spengler, C.M., Owassapian, D., Imhof, E., Boutellier, U., 2000. Respiratory muscle endurance training in chronic obstructive pulmonary disease: impact on exercise capacity, dyspnea, and quality of life. Am J Respir Crit Care Med 162, 1709–1714. doi:10.1164/ajrccm.162.5.9912026

Smith, M.D., Russell, A., Hodges, P.W., 2006. Disorders of breathing and continence have a stronger association with back pain than obesity and physical activity. Aust J Physiother 52, 11–16.

Willard, F.H., Vleeming, A., Schuenke, M.D., Danneels, L., Schleip, R., 2012. The thoracolumbar fascia: Anatomy, function and clinical considerations. J Anat 221, 507–536. doi:10.1111/j.1469-7580.2012.01511.x

Table 1 Demographical Details of the Participants

Characteristics	Experimental (n=20)	Control (n=20)
Age (Years)	27.10±7.19	30.30±13.47
Gender (%)	Female - 14 (70%)	Female -14 (70%)
	Male - 6 (30%)	Male -6 (30%)
BMI (Kg/m^2)	22.73±4.05	24.76±4.94

Note: No significant differences in the participants' demographics between the groups (p>0.05)

Table 2 Comparison of the Primary Outcome Variables between Experimental and Control Group

Parameters	Group	Before (n=20 Both Groups)	After [Experimental: n=17, Control :n=18]	Different Score-Post – Pre (% Change)
MVV (l/min)	Experimental	85.13 ± 23.53	93.82±27.31[a]	8.69 (10.21%)
	Control	75.16 ± 28.06	89.21±26.88 [a]	14.05 (18.69%)
MIP (cm H_2O)	Experimental	67.40 ±15.62	69.35±14.90 [a]	1.95 (2.89%)
	Control	78.80±19.18	75.94±20.82	-2.86 (-3.63%)
MEP (cm H_2O)	Experimental	60.90±10.91	60.52±12.40	-0.38 (-0.62%)
	Control	62.90 ±15.48	63.77±15.23	0.87 (1.38%)

Note: [a]Significant change within the groups ($p<0.05$) from pre- to post-; [b]Significant change between the groups ($p<0.05$)

Table 3 Comparison of the Secondary Outcome Variables between the Experimental and Control Group

Parameters	Group	Pre-Values (n=20 Both Groups)	Post-Values (Experimental: n=17, Control: n=18)	Different Score-Post - Pre (% change)
Axilla (cm)	Experimental	1.47±.443	1.50 ± .500	0.03 (2.04%)
	Control	1.50±.513	1.20 ± .460	-0.3 (-20%)
4^{th} ICS (cm)	Experimental	1.45±.484	1.60 ± .523	0.15 (10.34%)
	Control	1.62 ± .455	1.60 ± .613	-0.02 (-1.23%)
Xiphoid (cm)	Experimental	2.27±.658	1.90 ± .544	-0.37 (-16.3%)
	Control	2.42±.466	2.40 ± .591	-0.02 (-0.83%)
Numerical Rating Scale	Experimental	Mild-18(90%) Moderate-2(10%)	None – 4 (20%) [a] Mild – 13 (60%)	0 (0 %)
	Control	Mild-15(75%) Moderate-5(25%)	Mild–17(85%) [a] Moderate –1(5%)	0(0%)

Total Faulty Breathing Scale	Experimental	Mild- 20(100%)	Mild- 17(85%)	0 (0%)
	Control	Mild- 20(100%)	Mild- 18(90%)	0 (0%)
Core Stability	Experimental	Level 2- 2(10%)	Level 2 – 4(20%)	1 (50%)
		Level 3-14(70%)	Level 3 – 10(50%)	
		Level 4-4(20%)	Level 4 – 3(15%)	
	Control	Level 2- 5(25%)	Level 2 – 2(10%)	
		Level 3-9(45%)	Level 3 – 10(50%)	3 (150%)
		Level 4-6(30%)	Level 4 – 5(25%)	
			Level 5- 1 (5%)	

Note:[a]Significant change within groups (p<0.05) from pre- to post-; [b]Significant change between the groups (p<0.05)

Figure 1 Flow Chart of the participants.