International Journal of Physiotherapy and Research,
Int J Physiother Res 2017, Vol 5(4):2171-77. ISSN 2321-1822
DOI: https://dx.doi.org/10.16965/ijpr.2017.165

Original Research Article

COMPARISON OF CORE MUSCLE STRENGTH IN CHRONIC OBSTRUCTIVE PULMONARY DISEASE AND IN AGE, GENDER AND BMI MATCHED HEALTHY INDIVIDUALS

Priya D. Deshmukh *1, Rachna Arora 2.

*1 MPTh in Cardiovacular and Respiratory sciences, Physiotherapy school and centre, T.N.M.C & B. Y. L. Nair ch. Hospital, Mumbai, India.

2 Assistant Professor, Physiotherapy school and centre, T.N.M.C & B. Y. L. Nair ch. Hospital, Mumbai, India.

ABSTRACT

Background: Numerous studies in COPD have shown that deconditioning is a major contributory factor resulting in the reduced strength and endurance. However, most of the studies have assessed upper extremity and lower extremity strength. Upper extremity and lower extremity strength and endurance exercises are the mainstay of Pulmonary rehabilitation programme. However, core muscles strength assessment and strengthening are not included in pulmonary rehabilitation programme. Hence, there is a need to assess the strength of core muscles in COPD patients.

Materials and Methods: This Cross sectional comparative observational study included 70 participants (35 COPD patients + 35 Healthy matched individuals). Patients with COPD and age, gender and BMI matched healthy individuals are recruited in study after taking their consent to participate in the study. Core muscle strength will be measured by Stabilizer's pressure biofeedback unit, with the help of Richardson and Jull's core muscle grading method. Wilcoxon signed rank test (non parametric test for paired sample) was used for the comparison of core muscle strength between study group and control group (Age, gender and BMI matched healthy individuals) At 95% Confidence interval, level of significance was 0.05.

Results: There was a reduction in core muscle strength in Study group as compared to the control group which was statistically not significant, (p=0.105). Odds ratio of core muscle strength, showed the risk of having reduced core muscle strength in study group (COPD) was 5.66 times greater than that of control group (Matched healthy individuals).

Conclusion: There is no statistically significant difference in the strength of the core muscles in patients with COPD as compared to the age, gender and BMI matched healthy individuals. However, odds ratio shows reduced strength of core muscle in COPD patients. It has moderate association with functional capacity and weak association with degree of obstruction and BMI in patients with COPD.

KEY WORDS: Chronic Obstructive pulmonary disease, Core muscles.

Address for correspondence: Dr. Priya D. Deshmukh. MPTh in Cardiovacular and Respiratory sciences, Physiotherapy school and center, T.N.M.C & B. Y. L. Nair ch. Hospital, Mumbai. 400008, India. **E-Mail:** deshpriya89@gmail.com

Access this Article online

Quick Response code	International Journal of Physiotherapy and Research ISSN 2321- 1822 www.ijmhr.org/ijpr.html	
	Received: 21-04-2017	Accepted: 05-06-2017
	Peer Review: 21-04-2017	Published (O): 20-07-2017
DOI: 10.16965/ijpr.2017.165	Revised: None	Published (P): 11-08-2017

INTRODUCTION

The "core" is the centre of the functional kinetic chain. It serves as a muscular corset working as a unit to stabilize the body, in particular the spine, with or without limb movement. In alternative medicine, the core has been referred as the ‘Power house’; the foundation of all activities. The core of the body includes both passive and active structures. The passive structures are the thoraco lumbar spine and pelvis whereas the active structures are the trunk musculature [1].

Akuthota and Nadler described the “core” as a box with the abdominals in the front, paraspinals and gluteals in the back, the diaphragm as the roof, and the pelvic floor and hip girdle musculature as the bottom [1]. Two types of muscle fibers comprise the core muscles: slow-twitch and fast-twitch. Slow-twitch fibers make up primarily the local muscle system (the deep muscle layer). These muscles are shorter in length and are suited for controlling inter-segmental motion and responding to changes in posture and extrinsic loads. Key local muscles include transversus abdominus, multifidi, internal oblique, deep transverse spinalis, and the pelvic floor muscles [2].

On the other hand, fast-twitch fibers comprise the global muscle system (the superficial muscle layer). These muscles are long and possess large lever arms, allowing them to produce large amounts of torque and gross movements. Key global muscles include erector spinae, external oblique, rectus abdominis muscles, and quadratus lumborum (which McGill states is a major stabilizer of the spine) [3].

According to Pilates, core strength and stability is of tremendous benefit for breathing [4]. Most of these core muscles also assist in respiration, like diaphragm and abdominal muscles. Studies conducted on singers showed that strong core muscles help singers to enhance the endurance of respiratory muscles and in turn increase the breathing capacity. Core muscles work by contracting the abdominal muscles, creating higher pressure in abdomen, allowing diaphragm relaxation and carefully controlled upward rise. The strong core muscles also support the muscles of spine and lower ribs which in turn help to enhance rib movement, resulting in improved breath capacity [5,6].

The various core muscles aid in both inspiration and expiration, which require changes in the pressure within the thoracic cavity. The respiratory muscles work to achieve this by changing the dimensions of the thoracic cavity.

The diaphragm, serves as the roof of the core. It is a crucial muscle for breathing, contracts during inhalation, thus enlarging the thoracic cavity (the external intercostals muscles also participate in this enlargement). This reduces intra-thoracic pressure enlarging the cavity creates suction that draws air into the lungs. When the diaphragm relaxes, air is exhaled by elastic recoil of the lung and the tissues lining the thoracic cavity in conjunction with the abdominal muscles which act as an antagonist paired with the diaphragm’s contraction.[7] Also, diaphragm imparts stability on the lumbar spine by contraction of the diaphragm and increasing intra-abdominal pressure. Ventilatory challenges on the body may cause further diaphragm dysfunction and lead to more compressive loads on the lumbar spine [8]. Thus, diaphragmatic breathing techniques may be an important part of a core-strengthening program.

Abdominal muscles (external oblique, internal oblique, rectus and transverse) are considered the main expiratory muscles (Ex M). The abdominals serve as a vital component of the core. In particular, the transverses abdominis has received attention. Its fibers run horizontally around the abdomen, allowing for hooplike stresses with contraction. Isolated activation of the transversus abdominis is achieved through “hollowing in” of the abdomen. The transversus abdominis has been shown to activate before limb movement in healthy people, theoretically to stabilize the lumbar spine [9].

The internal oblique has similar fiber orientation to the transversus abdominis, yet receives much less attention with regard to its creation of hoop stresses. Together, the internal oblique, external oblique, and transversus abdominis increase the intra-abdominal pressure from the hoop created via the thoraco-lumbar-fascia, thus imparting functional stability of the lumbar spine [10]. The external oblique, the largest and most superficial abdominal muscle, acts as a check of anterior pelvic tilt. As well, it acts eccentrically in lumbar extension and lumbar torsion [11]. Finally, the rectus abdominis a paired, strap-like muscle of the anterior abdominal wall. Contraction of this muscle predominantly causes flexion of the lumbar spine. Also their contraction compresses the abdominal content, causes the costal ribs to descend, and pushes the diaphragm towards the thorax. Along with the action of the internal intercostals muscle, abdominal muscles increase intrathoracic pressure, diminishing lung volume and facilitating expiratory flow [12]. Moreover, the activity of Expiratory muscles increases in proportion to ventilatory demands [13]. Expiratory muscle contraction also drives the execution of different expulsive efforts such as coughing [14].

During quiet breathing, there is little or no muscle contraction during expiration. This process is simply driven by the elastic recoil of the lungs in healthy individuals. In certain conditions, such as in COPD the elasticity of the lung is lost. Forced or active expiration occurs in COPD patients, which also occurs during exercise [7].

“Chronic obstructive pulmonary disease (COPD) is a preventable and treatable disease with some significant extra pulmonary effects that may contribute to the severity in individual patients. It is a progressive disorder with pulmonary component characterized by a partially reversible expiratory airflow limitation [15]. COPD is a common disease that can substantially impair one’s quality of life and increase the risk of premature death.

In COPD there is inflammation of the peripheral airways and destruction of lung parenchyma or emphysema and its vasculature in highly variable combinations. It encompasses both emphysema and chronic bronchitis. The airflow limitation is associated with an abnormal inflammatory response of the lungs to inhaled noxious particles or gases. Consequently, there is a loss of elastic recoil and increased airway resistance, which limits both inhalation and exhalation capacity. At a later stage of the disease, a thickening of the vessel walls occurs, which has a negative effect on the gas exchange, and can lead to both hypoxia (low oxygen levels) and hypercapnia (high carbon dioxide levels) [16].

Expiratory airflow limitation and loss of the lung’s elastic recoil promotes air trapping with an increase in end-expiratory lung volume (EELV), a decrease in inspiratory capacity (IC), and lung hyperinflation. Consistent reduction in IC during physical activities reflects dynamic hyperinfla-tion [17]. The dynamic hyperinflation results in a deterioration of the length-tension relationship of the diaphragm muscle, which leads to increased respiratory effort. In patients with COPD, the resting position of the thorax is in more inspiratory mode, there is decreased thoracic excursion. There are changes in alignment of fibres of diaphragm with hyperinflation. The diaphragm become more flattened [18]. The angle pull of the diaphragm fibres becomes more horizontal with decreased zone of apposition and decreased range of contraction as the disease progresses (diaphragm weakness) resulting in an inward pull of lower ribs during inspiration [18, 19].

Expiratory Muscle recruitment has been observed in patients with either chronic obstructive pulmonary disease (COPD) or asthma, at rest and during loaded breathing [21,22]. Although the clinical significance of this activation is unclear, Expiratory muscles contraction is considered to be a mechanism that provides the system with functional reserve [12-14, 20].

Dodd DS, et al, in his study of chest wall mechanics during exercise in patients with severe chronic airflow obstruction sughested that airflow obstruction can induce adaptive changes in the expiratory muscle of COPD patients. Although the clinical significance of this activation is unknown, contraction of the expiratory muscle might represent a compensatory mechanism in obstructive lung diseases. The Expiratory muscle contraction can store both elastic and gravitational energy within the thorax and abdomen, facilitating the beginning of the following inspiratory cycle [20].

There are several reports showing that expiratory muscle strength and endurance can be impaired in patients with COPD and therefore decrease in functional reserve [22,23].

Also, in COPD patients, there is skeletal muscle dysfunction due to local systemic or both the mechanisms. Systemic factor may cause widely distributed loss of muscle function, whereas local factor involves chronic inactivity as result of breathlessness. These lead to deconditioning resulting in muscle dysfunction predominantly in locomotor muscles such as quadriceps. Most of the researchers have given emphasis to the quadriceps, as it is a primary locomotor muscle and readily accessible. They found that a decreased strength of the quadriceps muscle.

The study showed that quadriceps and anterior abdominal wall muscle (Expiratory muscle) have similar fibre type distribution. As quadriceps consist of 43% type 1 fibres and 57% type 2 fibres whereas abdominal muscle consists of 46% type 1 fibres and 54% type 2 fibres. So, there may be muscle dysfunction present in abdominal muscles [24].

During inspiration, diaphragm contracts, flattens and moves caudally, resulting in increased intra-abdominal pressure. This increased pressure prevents further descent and stabilizes the central crux of the diaphragm enabling the lateral costal fibres of diaphragm to elevate the lower ribs (bucket handle movement). During active or forced expiration, abdominals contract resulting in increased intra-abdominal pressure. This causes an upward movement of diaphragm and downward pressure on pelvic floor muscles.

Hence, Pelvic floor muscles acts as a functional unit in spinal stability. It helps in breathing and withstands increased intra-abdominal pressure and prevents urinary incontinence. Many researchers concluded that in COPD patients due to chronic coughing, continuous high intra-abdominal peak pressure is generated. This causes pelvic floor muscle dysfunction leading to the greater degree of urinary incontinence compared to the general population [25].

Furthermore, kyphotic or forward shoulder posture is commonly seen in COPD patients [26]. A study indicated increased end-expiratory level and active expiration in sitting with a forward-leaning trunk compared to sitting leaning back. Sitting with a forward-leaning trunk and resting the forearms on the thighs is a modified position for relaxation in chest physical therapy [27-32]. Therefore, for the relief from dyspnea, this forward-leaning posture is often assumed in patients with COPD [33].

This posture is associated with a decreased lumbar lordosis, resuling in lengthening of erector spinae. So, the distance between xiphisternum and pubic symphysis is reduced resulting in shortening of abdominal muscles [34].

This approximation of ribs to the pelvis results in increased intra-abdominal pressure and makes difficult for the diaphragm to descend caudally during inspiration [35].

To summarize, COPD patients demonstrate an altered length tension relation of diaphragm, paraspinals, pelvic floor muscles and abdominals which can influence the strength of the core muscles. Hence, it can be hypothesized that there can be an alteration in strength of the core muscles in these subjects.

MATERIALS AND METHODS

Study design: Cross sectional comparative observational study

Inclusion and Exclusion criteria:

In the Study group Patients with airway obstruction based on GOLD classification were included in the study.

Excluded the subjects with following conditions Acute exacerbation of COPD, Severe Osteoporosis, Any musculoskeletal dysfunction of the lower limbs, Co morbid cardiovascular and neurological disease, Unwilling to participate in the study

In Control group: Age, gender and BMI matched healthy individual were included in the study.

Excluded the subjects with following conditions such as Co morbid cardiovascular and neurological disease, Any history of addictions such as smoking, alcohol consumption etc., Subject participating in any fitness programme, Any musculoskeletal dysfunction, Unwilling to participate in the study

Sample size: 70 (35 COPD patients + 35 Healthy matched individuals) Universal sampling, patients coming to the physiotherapy OPD.

Study period & Duration: 15 months

Parameters used for the assessment of study objectives:

Richardson and Joule's grading of core muscle strength.

6 Minute Walk Distance (in meters).

Body Mass Index (Kg/m2)

FEV1%

Procedure: Subjects coming to the chest or medicine OPD were screened, out of which 35 COPD patients who met the inclusion criteria were enrolled in the study group after taking their consent.

In the control group, relatives of the patients coming in the OPD or admitted in the hospital and healthy normal individuals from the society were screened, then age, gender and BMI matched healthy 35 individuals meeting the inclusion criteria were enrolled after taking their consent to participate in the study.

Core muscle strength assessment: Core muscle strength was measured by Stabilizer's pressure biofeedback unit, with the help of Richardson and Jull's core muscle grading method. This grading method was used as it is reliable and valid method of testing core muscle strength [36].

The subjects were instructed to be in supine lying position. The inflatable bag was placed in lumbar hollow and pressure was raised till 40mm of Hg. Subjects were instructed to flex both lower limbs. Two trial sessions were carried out prior to the grading of core muscle. 'Drawing in maneuver' i.e. core activation was taught to the subjects. Subjects were instructed to take their umbilicus upward and inward and maintaining this they were tested as per the following grades.

Grade 1:

Single leg slide was performed with contralateral leg support, the test leg slides the heel down the surface of the examination surface. **(Poor control)**

Unsupported leg slide was performed with the heel of the test leg held approximately 5 cm from the examination surface. **(Below average control)**

Grade 2:

Single leg slide with the contralateral leg unsupported. The test leg slides the heel down the surface of the examination surface. **(Good control)**

Unsupported leg slide with the contralateral leg unsupported, and the test leg wase held approximately 5cm from the examination surface. **(Excellent control)**

Subjects were allocated a grading at the point at which they were not maintaining the core muscle contraction [36].

All COPD subjects and age, gender and BMI matched healthy individual were assessed for their weight in kgs and height in meters and then body mass index (BMI) was calculated. All COPD subjects were made to do 6 minute walk test to find out the functional capacity of them.

RESULTS

Statistical analysis: The SPSS software 20 was used for data analysis. Wilcoxon signed rank test (non parametric test for paired sample) was used for the comparison of core muscle strength between study group and control group. Spearman correlation test (non parametric test) was used to find the correlation between core muscle strength and BMI (body mass index), severity of disease (as per Gold's classification) and functional capacity (6 minute walk test).

Participant's demographics: On comparing the 2 groups, a strong correlation was seen for age ($r=0.987$) and BMI ($r=0.971$) suggesting that both the groups are matched which was statistically strongly significant. ($p< 0.0001$).

In the study group, according to the severity of disease (as per Gold's classification) 4 (11.4%) were mild, 17 (48.6%) were moderate, 10 (28.6%) were severe, 4 (11.4%) were very severe.

According to the core muscle grading in study and control group, 5 (14.3%) and 4 (11.4%) were graded 0, 20 (57.1%) and 17 (48.6%) were graded 1a, 9 (25.7%) were graded 1b in both groups, 1 (2.9%) and 4 (11.4%) were graded 2a , 0 and 1 (2.9%) were graded 2b, respectively.

The median of core muscle strength in study group and in control group was 1.

There was a reduction in core muscle strength in Study group as compared to the control group which was statistically not significant, ($p=0.105$).

Odds ratio of core muscle strength showed the risk of having reduced core muscle strength in study group (COPD) was 5.66 times greater than that of control group (Matched healthy individuals).

There was a moderate linear positive correlation between core muscle strength and 6 MWD ($r_s = 0.372$, $p = 0.028$) which was statistically significant. There was a weak linear positive correlation with FEV1% ($r_s = 0.274$, $p = 0.112$) which is statistically not significant.

There was a weak linear negative correlation of core muscle strength with BMI ($r_s = - 0.10$, $p = 0.757$) and severity of disease ($r_s = - 0.288$, $p = 0.094$) which was statistically not significant.

Table 1: Showing the comparison of various parameters between the groups.

	AGE	BMI	GENDER			FEV1%	6MWD
			FEMALE	MALE	TOTAL		
Study Group Mean + SD [95% CI]	57.20 ± 9.72 (53.86 - 60.54)	21.50 ± 3.18 (20.40 -22.59)	34 (48.6%)	36 (51.4%)	70 (100%)	56.500 ± 17.89 (50.77 - 62.65)	302.37 ± 61.09 (281.37 - 323.34)
Control Group Mean + SD [95% CI]	56 ± 10.10 (52.53 - 59.48)	21.93 ± 3.14 (20.85 - 23.01)					

CONCLUSION

There is no statistically significant difference in the strength of the core muscles in patients with COPD as compared to the age, gender and BMI matched healthy individuals. However, odds ratio shows reduced strength of core muscle in COPD patients.

It has moderate association with functional capacity and weak association with degree of obstruction and BMI in patients with COPD.

Clinical Implication: Core strengthening exercise programme should be encorporated as an integral part of rehablitation along with pelvic floor muscle strengthening exercise and diaphragmatic breathing exercise in COPD patients in pulmonary rehablitation programme.

Core strengthening exercise programme should also be emphasized in normal healthy individual's exercise programme.

Conflicts of interest: None

REFERENCES

[1]. Akuthota V, Nadlar SF. Core strengthening. Arch Phys Med Rehabil 2004;85.

[2]. Hides, J.A., C.A. Richardson, and G.A. Jull. Multifidus muscle recovery is not automatic after resolution of acute, first-episode low back pain. Spine. 1996;21:2763Y2769.

[3]. McGill, S.M. Low back stability: from formal description to issues for performance and rehabilitation. Exercise Sport Sci. Rev.2001;29:26Y31.

[4]. K. Ganeshan, MPT, PILATES – Gateway to core stability.

[5]. Claudia Freidlander, CPT, Sports specific training for vocal athlete- how exercise can support your vocal techniques. part 1.

[6]. Shweta S. Devare Phadke, Sukhada Prabhu, Sujata Yardi. Study of respiratory capacity and core muscle strengthening in Indian classical singers. SRJI Vol 2 Issue 3 Year 2013.

[7]. Wade, O. L. Movements of the thoracic cage and diaphragm in respiration. The Journal of physiology. 1954;124(2):193.

[8]. McGill SM, Sharratt MT, Seguin JP. Loads on spinal tissues during simultaneous lifting and ventilatory challenge. Ergonomics 1995;38:1772-92.

[9]. Hodges PW, Richardson CA. Inefficient muscular stabilization of the lumbar spine associated with low back pain. A motor control evaluation of transversus abdominis. Spine 1996;21: 2640-50.

[10]. McGill S. Low back disorders: evidence-based prevention and rehabilitation. Champaign (IL): Human Kinetics; 2002.

[11]. Porterfield JA, DeRosa C. Mechanical low back pain: perspectives in functional anatomy. 2nd ed. Philadelphia: WB Saunders; 1998.

[12]. Epstein SK. An overview on respiratory muscle function. Clin Chest Med 1994;15:619–39.

[13]. Fuller D, Sullivan J, Fregosi R. Expiratory muscle endurance performance after exhaustive submaximal exercise. J Appl Physiol 1996;80:1495–502.

[14]. A Ramírez-Sarmiento, M Orozco-Levi, E Barreiro, R Méndez, A Ferrer, J Broquetas,J Gea .Expiratory muscle endurance in chronic obstructive pulmonary disease Thorax 2002;57:132–136.

[15]. Rabe KF, Hurd S, Anzueto A, Barnes PJ, Buist SA, Calverley P, et al. Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease: GOLD Executive Summary. American Journal of Respiratory and Critical Care Medicine. 2007 Sep 15;176:532-55.

[16]. Margareta Emtner, PT, PhD, Associate Professor, Uppsala University, Sweden Epstein SK. COPD - An overview on respiratory muscle function. Clin Chest Med 1994;15:619–39.

[17]. O'Donnell DE, Bertley JC, Chau LK, Webb KA. Qualitative aspects of exertional breathlessness in chronic airflow limitation: pathophysiologic mechanisms. *Am J Respir Crit Care Med*. 1997;155(1):109–115.

[18]. Similowski T, Yan S, Gauthier AP, Macklem PT, Bellemare F: Contractile properties of the human diaphragm during chronichyperinflation.1991, 325:917-923.

[19]. Cynthia Norkins, Pamela k. Levangie, The thorax and chest wall, Ed, 3- pg.no.182.

[20]. Dodd DS, Brancatisano T, Engel LA. Chest wall mechanics during exercise in patients with severe chronic airflow obstruction. Am Rev Respir Dis 1984;129:33–8.

[21]. Ninane V, Rypens F, Yernault JC, De Troyer A. Abdominal muscle use during breathing in patients with chronic airflow obstruction. Am Rev Respir Dis 1992; 146: 16–21.

[22]. Ninane V, Yernault JC, De Troyer A. Intrinsic PEEP in patients with chronic obstructive pulmonary disease. Role of expiratory muscles. Am RevRespir Dis 1993;148:1037–42.

[23]. Suzuki S, Suzuki J, Okubo T. Expiratory muscle fatigue in normal subjects. J Appl Physiol 1991;70: 2632–9.

[24]. W D-C Man, N S Hopkinson, F Harraf, D Nikoletou, M I Polkey, J Moxham, Abdominal muscle and quadriceps strength in chronic obstructive pulmonary disease,Tho rax 2005;60:718–722.

[25]. Button BM, Sherburn M,Chase J, et al. Pelvic floor muscle dysfunction. 2005.

[26]. O'Sullivan BS, Schmitz JT. Physical rehabilitation assessment and treatment. 5th ed. Philadelphia: FA Davis Company. publ; 2001;561-588.

[27]. Willeput R, Sergysels R: Respiratory patterns induced by bent posture in COPD patients. Rev Mal Respir 1991;8:577–582.

[28]. Bhatt SP, Guleria R, Luqman-Arafath TK, Gupta AK, Mohan A, Nanda S: Stoltzfus JC Effect of tripod position on objective parameters of respiratory function in stable chronic obstructive pulmonary disease. Indian J Chest Dis Allied Sci 2009;51:83–85.

[29]. Brannon FJ, Foley MW, Starr JA, Saul LM: Cardiopulmonary Rehabilitation: basic theory and application. FA Davis: Philadelphia; 1993.

[30]. Kisner C, Colby LA: Therapeutic exercise: foundations and techniques. FA Davis: Philadelphia; 1996.

[31]. Shaffer TH, Wolfson MR, Bhutani VK: Respiratory muscle function, assessment, and training. Phys Ther 1981;61:1711–1723.

[32]. Simpson LS: Effect of increased abdominal muscle strength on forced vital capacity and forced expiratory volume. Phys Ther 1983;63:334–337.

[33]. Sharp JT, Drutz WS, Moisan T, Foster J, Machnach W: Postural relief of dyspnea in severe chronic obstructive pulmonary disease. Am Rev Respir Dis 1980;122:201–211.

[34]. Ki-song Kim, Min-kwang Byun, et all,Effects of breathing maneuver and sitting posture on muscle activity in inspiratory accessorymuscles in patients with chronic obstructive pulmonary disease Multidisciplinary Respiratory Medicine 2012;7:9.

[35]. Orozco-Levi M. Structure and function of the respiratory muscles in patients with COPD: impairment or adaptation?. European Respiratory Journal. 2003 Nov 2;22(46 suppl):41s-51s.

[36].Martin SL. A study to determine the relationship between core muscle strength and chronic lower back pain in amateur female road runners and nonrunners (Doctoral dissertation).2006.

How to cite this article:

Priya D. Deshmukh, Rachna Arora. COMPARISON OF CORE MUSCLE STRENGTH IN CHRONIC OBSTRUCTIVE PULMONARY DISEASE AND IN AGE, GENDER AND BMI MATCHED HEALTHY INDIVIDUALS. Int J Physiother Res 2017;5(4):2171-2177. **DOI:** 10.16965/ijpr.2017.165