Immediate Effect of Thoracic Core Conditioning on Patients with Obstructive Airway Disease Using Stretch Pole

Dr. Rahul Ashokrao Maid[1], Dr. Hetal Manoj Mistry[2], Dr. Hutoxi Writer[3], Dr. Chaya V. Verma[4]

[1]MPTh, Assistant Professor at Nanded Physiotherapy College and Research Center, Nanded

[2]Associate Professor, PT School and Center, TNMC and BYL Nair Charitable Hospital, Mumbai- 400008, Maharashtra, India

[3]Professor, PT School and Center, TNMC and BYL Nair Charitable Hospital, Mumbai-400008, Maharashtra, India

[4]Professor and HOD, PT School and Center, TNMC and BYL Nair Charitable Hospital, Mumbai-400008, Maharashtra, India

Abstract: ***Background**: In obstructive airway disease impairments such as shortened muscle length and weakness, reduced chest configuration, chest movement, and reduced thoracic mobility in all the three planes increases the effort of breathing involving more of accessory muscles of respiration. Hence, the purpose of the study is to find the immediate effect of thoracic core conditioning using stretch pole in patients with obstructive airway disease. **Methodology**: Subjects were screened for inclusion and exclusion criteria and written consent was taken. 60 COAD subjects included in the study divided into two groups experimental (with stretch pole) and control group (without stretch pole). Pre intervention and post intervention all outcome measures were assessed in form of thoracic expansion at three different level, peak expiratory flow rate, six minute walk distance, oxygen saturation and rate of perceived exertion. **Results**: On comparing the differences between both groups, statistically significant increase was found in experimental group that was with stretch pole in thoracic expansion at 3rd , 5th and 10th ICS (p=0.000), PEFR (p=0.000), 6MWD (p=0.000) and SPO2 (p=0.000). However, there was no statistically improvement in rate of perceived exertion. **Conclusion**: Therefore, we can conclude that there is an immediate effect of thoracic core conditioning by using stretch pole on patients with obstructive airway disease with reference to thoracic expansion at three levels, PEFR, 6MWD, RPE and SPO2.***

Keywords: Obstructive airway disease, Thoracic core conditioning, Peak expiratory flow rate, Six minute walk distance, Rate of perceived exertion and oxygen saturation

1. Introduction

Obstructive airway disease is defined as, "Obstructive airway disease is a preventable and treatable disease with some significant extra pulmonary effects that may contribute to the severity in individual patients. Its pulmonary component characterized by airflow limitation that is not fully reversible. The airflow limitation is usually progressive and associated with an abnormal inflammatory response of the lung to noxious particles or gases."Types of obstructive lung diseases are asthma, COPD, bronchiectasis, obliterative bronchiolitis (OB). [1]

Although COPD shares similar characteristics with all other obstructive lung diseases, such as the signs of coughing and wheezing, they are distinct conditions in terms of disease onset, frequency of symptoms and reversibility of airway obstruction.[1]

According to the World Health Organization, approximately 210million people throughout the world have COPD and it is likely to become the third leading cause of death globally by 2030.[2]

Chronic obstructive pulmonary disease (COPD) is a prevalent disease affecting 6-8% of the population in India.[3]COPD is also associated with a significant reduction in quantity as well as quality of life.[3] Mortality and morbidity associated with COPD is currently greater in Asia than that in developed countries.[4]

COPD is a chronic inflammatory disease of the airways and lung parenchyma associated with airway narrowing, alveolar wall The pathological consequences of the COPD inflammation induce series of physiological changes which eventually impact the quality of life and survival in the natural progress of COPD. Firstly, elastin proteolysis results in reduction in elastic recoil pressures in the lungs, also since the integrity and movement of air in the bronchioles are primarily reliant on elastic coil pressures induced by surrounding elastic tissue, the damage to the elastin in COPD results in significant airway narrowing with reduction in air-flow in the bronchioles and air-trapping in lungs; secondly, fibrotic remodeling of the airways results in fixed airway narrowing causing increased airway resistance which does not fully revert even with bronchodilators; thirdly, extensive alveolar and bronchiolar epithelial cells and pulmonary capillary apoptosis in histological feature such as emphysema and physiological feature such as decreased surface area of alveoli for gaseous exchange and ventilation-circulation mismatch (V/Q). Emphysema also reduces lung elastic recoil pressure which leads to a reduced driving pressure for expiratory flow through narrowed and poorly supported airways in which airflow resistance is significantly increased.[5-7]

The diagnosis is made on the basis of symptoms such as chronic cough, coughed up mucous, dyspnea, increased respiratory work, increased production of secretions, hyper

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reactivity, and a long history of smoking and symptom development.

The diagnosis is confirmed with a lung function test, where FEV% is less than 0.70. FEV% is the ratio of FEV1 (forced expiratory volume in one second) to FVC (FVC = forced vital capacity and VC = vital capacity, where the highest value of FVC and VC is used) (FEV% = FEV1/FVC).

COPD is classified into four stages according to GOLD classification based on the FEV1 value.
Mild: FEV1/FVC < 0.70 FEV1> 80% of predicted
Moderate: FEV1/FVC < 0.70 50% to 79% < FEV1< 80% of predicted
Severe: FEV1/FVC < 0.70 30% to 49% < FEV1< 50% of predicted
Very severe: FEV1/FVC<0.70 less than 30% FEV1 < 30% of predicted

In obstructive airway disease impairments such as shortened muscle length and weakness, reduced chest configuration, chest movement, and reduced thoracic mobility in all the three planes increases the effort of breathing involving more of accessory muscles of respiration.[8]

Obstructive airway disease is preventable, treatable but not curable lung disease with important extra-pulmonary (systemic) effects that may contribute to serious complications in some patients.[9]

The impairment in the lungs is characterized by airflow limitation which can be slightly reversible by a bronchodilator. The airflow limitation in people with COPD is caused by a combination of two inflammatory conditions: small airway disease (chronic bronchiolitis) and parenchymal destructions (emphysema).[9]

It is believed that the cellular mediators of inflammation present in the airways and alveolar walls spill over into the circulation and contribute to skeletal muscle dysfunction, cardiac failure, atherosclerosis and osteoporosis leading to poor quality of life and increased morbidity and mortality in COPD patients. It is, therefore, important to treat the systemic consequences also whenever possible to improve the quality of life and reduce mortality.[10]

Patients with chronic obstructive pulmonary disease (COPD) have altered respiratory mechanics and impaired gas exchange, which decreases physical ability and affects activities of daily living (ADL). Skeletal muscle dysfunction, including muscle weakness and atrophy, is a common systemic co-morbidity of COPD and is a better predictor of disease mortality than lung function. It contributes to exercise limitation leading to a poor quality of life and an increased need for medical assistance.[11-14]

Deconditioning has been traditionally suggested as the main reason for the presence of these peripheral muscle abnormalities in patients with COPD.[15]

Skeletal muscles are widely affected in COPD and several mechanisms have been postulated *viz*: *(i)* systemic hypoxia which causes a change in the muscle metabolic phenotype from oxidative metabolism to anaerobic metabolism as an adaptive process, and *(ii)* increased circulating levels of inflammatory mediators such as interleukin-6 (IL-6), tumor necrosis factor-α (TNF-α) and C-reactive protein (CRP).[16]

Importance of dysfunction of peripheral skeletal muscles on exercise capacity in patients with COPD was first suggested by Killian and coworkers in 1992.[17]

As a compensatory response in advanced stages of obstructive airway disease barrel chest and pursed lip breathing further reduces thoracic mobility and upper limb activity that may lead to tightening and stiffness around the muscle of upper quadrant increasing chest wall resistance and work of breathing.[9]

Patients with chronic obstructive pulmonary disease (COPD) have altered respiratory mechanics and impaired gas exchange, which decreases physical ability and affects activities of daily living (ADL).

Dyspnea is the primary activity-limiting symptom leading to reduced functional ability in patients with COPD. Patients with severe COPD report a marked increase in the sensation of dyspnea during routine tasks that require arm use, especially activities requiring unsupported arm elevation.[18]

Peak expiratory flow rate (PEFR) is the maximum flow rate generated during a forceful exhalation, starting from full lung inflation. Peak flow rate primarily reflects large airway flow and depends on the voluntary effort and muscular strength of the patient.

Maximal airflow occurs during the effort-dependent portion of the expiratory maneuver, so low values may be caused by a less than maximal effort rather than by airway obstruction. Nevertheless, the ease of measuring peak flow rate with an inexpensive small portable device has made it popular as a means of following the degree of airway obstruction in patients with asthma and other pulmonary conditions.

Most healthy adults equate exercise with strenuous workouts leading to increased physical fitness. However, the suggestion of an exercise program to patients with COPD is usually met with incredulity or scorn. For most individuals with moderate to severe COPD, even basic daily activities can be strenuous and daunting. Patients state they are too fatigued for even mild exercise and that any exercise makes them too short of breath and very uncomfortable.

Individuals with COPD typically have a slow, insidious decline in exercise ability. Patients consistently report lower levels of functional performance for ambulation, sleep and rest, and home management as well as recreation and other activities.[20-22] Patients with moderate or severe COPD report at least 15% impairment in each of these categories, while oxygen dependent patients report 25% to 40% impairment.[23] Exercise intolerance in patients with COPD results from a complex interaction between symptoms, impairment to ventilatory and respiratory mechanics impairment, gas exchange limitations, and peripheral muscle fatigue. Patients commonly cite dyspnea and leg fatigue as the main reasons for reducing or stopping exercise.[24] Intolerance to exercise is

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closely linked to impairment and disability and is a stronger predictor of poor quality of life and survival than either spirometry or oxygenation and thus contributes to progressively limited ADLs.[25]

According to Belman, functional loss in COPD patients is also related to gradual loss of muscle conditioning, leading to early anaerobiosis and associated dyspnea at increasingly lower effort levels.[26]

Exercise training is now considered as an essential component of pulmonary rehabilitation in patients with COPD. Although it does not change pulmonary function, exercise training improves exercise capacity and reduces dyspnea.[27-28]

Shigeki Yokoyama, PT, PhD (2011) and et all they investigated the effects of the Core Conditioning exercises (CC) using the Stretch Pole. They hypothesized that thoracic expansion difference is better improved by CC with the Stretch Pole than CC without it. They conclude that the Stretch Pole exercises are effective in increasing thoracic expansion in healthy, non-smoking middle-aged and elderly females.[29]

Syed Shakil-ur-Rehman(2013) and et all they concluded that rib cage mobilization had very effective role in increasing ribcage mobility and improve lung function in COPD patients.[30]

KriticaBoruah(2014) and et all they concluded that thoracic core conditioning exercises with stretch pole found to be more effective than without stretch pole in short term improving chest expansion, intensity of perceived exertion and functional performance in community elderly with moderate COPD.

Thoracic Core Conditioning training or Core instability strength training involves exercises that are given for both trunk muscles and postural control and may thus have the potential to induce benefits in trunk muscle strength, spinal mobility and balance performance.[31]

Thorax is easily extended or elevated in supine position on stretch pole, cylinder shaped tube made of materials similar to a special Styrofoam (Bolster) with a length of 98 cm and diameter of 15cm, and is therefore expected to improve thoracic mobility by core conditioning (figure no. 1).[29-30]

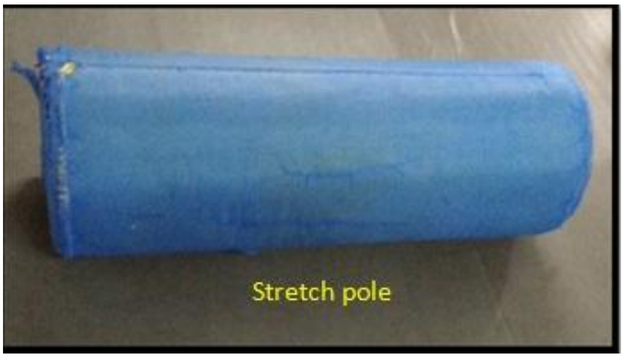

Figure 1

The study with research question is, "Does the immediate effect of thoracic core conditioning using stretch pole have an effect in obstructive airway disease?" Hence, the purpose of the study is to study &find the immediate effect of thoracic core conditioning using stretch pole in patients with obstructive airway disease.

2. Methodology

The ethical clearance was obtained from ethical committee of Institute and MUHS Research Board.

Total 77 patients were screened from the Chest OPD. 10 patients not meeting the inclusion criteria and 7 unwilling to participate were excluded from the study. 60 patients meeting the inclusion criteria were enrolled in the study after taking their informed consent. The basic personal information, anthropometric measures, vital parameters, recent PFT parameters, co-morbidities and information regarding current medication of the participant was taken.

Patients were randomly allocated using simple random sampling methodinto two groups, experimental (with stretch pole) and control group (without stretch pole) with 30 patients in each group. Patients in both the groups were explained about the intervention.

At baseline, thoracic expansion at 3^{rd}, 5^{th} and 10^{th} ICS, grading of breathlessness, functional capacity, and peak expiratory flow rate and oxygen saturation were assessed.

Thoracic Expansion

It was assessed by using inch tape at two levels of thorax, the axillary and the xiphisternal level before and after intervention. The patient was instructed to sit with the arms relaxed by the sides. The tape was placed around the circumference of the chest. To measure the upper thoracic excursion, tape was placed at the level 3rd intercostal space, 5^{th} intercostal space at midclavicular line. To measure the lower thoracic excursion, tape was placed at tip of xiphoid process at 10^{th}intercostals space. The measurements were taken at peak inhalation and an average of 3 trials was documented.[33]The reliability of this technique shows an interclass correlation coefficient of 0.81 to 0.91 proving it reliable in clinical setting.[34]
(Figure no. 2)

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Figure 2

Dyspnea (Rate of perceived exertion): It was measured by using the Borg Scale of dyspnea or Modified Borg Scale. The patient was given and explained clearly about the scale which consisted of grades from 0-10. They had accurately graded their breathlessness which they had felt before and after the intervention.[35]The scale showed a sensitivity of 75% and a specificity of 78%.[36-39]

Functional capacity (six minute walk distance): Six minute walk test (6 MWT) is the most common clinical and research tool for the evaluation of functional exercise capacity in chronic pulmonary disabled patients. It reflects the capacity of the individual to perform activities of daily living.[40]The patients made walk for six minute whatever he covers the distance and documented before and after the intervention. The platform for the test was 30 meter and added laps which covered the patient in particular time. (Figure no. 3)

Figure 3

Peak expiratory flow rate: Peak expiratory flow rate (PEFR) is the highest rate at which gas can be expelled from the lungs via an open mouth (Dougherty and Lister, 2004).The measurement of peak expiratory flow rate is a simple procedure in which an individual takes a full inspiration and blows out as forcibly as possible into an instrument called a peak flow meter, which measures the maximal gas flow during exhalation in liters per minute (Hinchcliffe et al, 1996). The patient instructed to take deep breath in and asked him or her to blow out forcefully in peak flow meter and best of three the value was documented pre and post intervention. The measurement of PEFR is one index of airway obstruction and may be an economical means of measuring the lung function/obstructive disease process both in the community and acute setting. It is also recommended by the British Thoracic Society (2004) as a useful tool in the diagnosis and management of asthma.[41]

Figure 3

Oxygen saturation: Pulse oximetry is a noninvasive method that enables rapid measurement of the oxygen saturation of hemoglobin in arterial blood.[42]It can rapidly detect changes in oxygen saturation, thus providing an early warning of dangerous hypoxemia.[43-44]The pulse oximetry was put on patient finger to get know the oxygen saturation and documented before and after intervention.

Figure 4

In both the groups, intervention includes single session of exercises lasting 30-45 minutes. Patients were instructed to perform the exercises with deep breathing.

In experimental group, the patients performed exercise on stretch pole which was placed longitudinally down the length of the spine, and in control group, patients performed same exercises without stretch pole, flat on the mat.

Each patient in experimental group performed total ten exercises consisting of three preliminary motions and seven main exercises in supine position on a stretch pole. Each patient in control group performed same exercises as

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experimental group except for swaying in supine position on a flat mat. The main exercises were repeated 8-10 times. Immediately after the treatment, reassessment of outcome measures was taken.

A. Preliminary Motions

1. Maintenance of shoulder abduction: Patients were instructed to take their arms away from the body with their elbow extended till a comfortable extent and maintained for about 60 seconds. The knees were flexed; figure 5 and 6

Figure 5: Experimental group

Figure 6: Control group

2. Maintenance of external rotation of hip joint: Patients were instructed to take their legs away from midline with the knees slightly flexed till a comfortable extent and maintained for about 60 seconds. Arms were placed beside the body; figure 7 and 8

Figure 7: Experimental group

Figure 8: Control Group

3. Unilateral shoulder abduction and contra lateral hip external rotation: Patients were instructed to take one arm away from the body with elbow extended and the opposite leg away from the midline with knee in slight flexion and were instructed to maintain this position for about 60 seconds. The same procedure was repeated with opposite arm and leg. The uninvolved arm was placed beside the body and the uninvolved leg was kept with knee in flexed position; figure 9 and 10

Figure 9: Experimental Group

Figure 10: Control group

B. Main Exercises

4. Floor polishing: Patients were instructed rotate hands to draw circles on the floor. The knees were in flexed position; figure 11 and 12

Figure 11: Experimental group

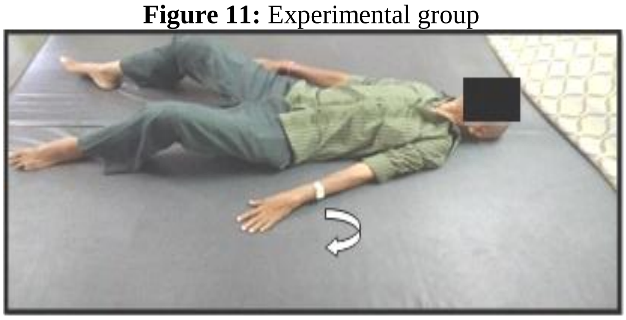

Figure 12: Control Group

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5. Scapular adduction and abduction: Patients were instructed with their knee in flexed position, to repeatedly extend both arms with hands reaching the ceiling with scapular abduction and then relaxing the scapulae while maintaining the arm in extension; figure 13 and 14

Figure 13: Experimental group

Figure 14: Control Group

6. Shoulder abduction and adduction: Patients with their knees flexed and instructed to repeatedly abduct and adduct both shoulders with both forearms sliding on the floor; figure 15 and 16

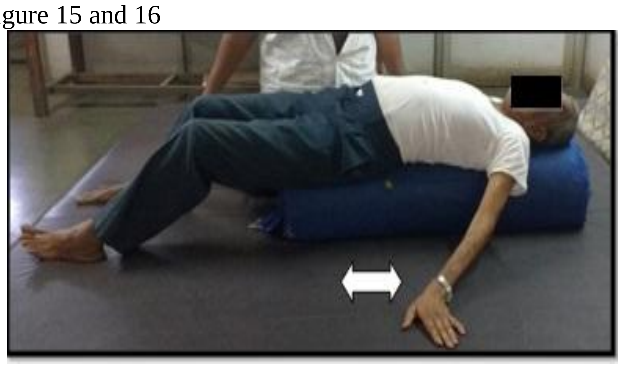

Figure 15: Experimental group

Figure 16: Control Group

7. Internal and external rotation of hips: Patients were instructed to repeat hip external and internal rotation with both hips in extension and knees in slight flexion; figure 17 and 18

Figure 17: Experimental group

Figure 18: Control Group

8. Slight knee extension: Patients were instructed to repeat hip abduction in extension and external rotation with knees in slight flexion; figure 19 and 20

Figure 19: Experimental group

Figure 20: Control Group

9. Swaying: Patients were instructed to slide the trunk repeatedly on the stretch pole in lateral directions; figure 21

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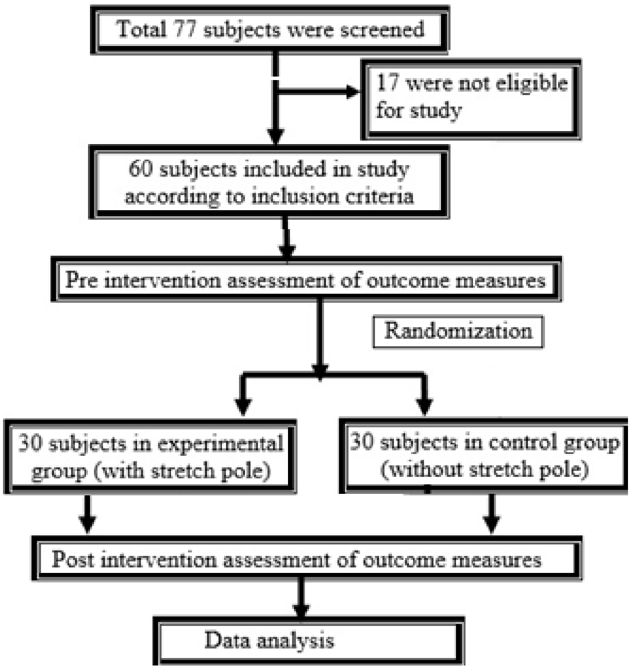
Figure 21: Control Group

10. Abdominal breathing: Patients were instructed to puff out the abdomen during inspiration and drawing it in during expirations; figure 22 and 23

Figure 22: Experimental group

Figure 23: Control Group

FLOW CHART



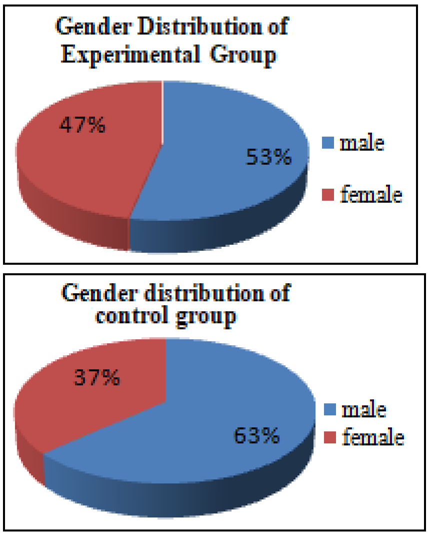
3. Result

The results were obtained by using the SPSS 16version software. Data was tested for normality using the Shapiro Wilk test. Then Parametric test like paired t-test and unpaired t-test were used for the data passing the normality test whereas nonparametric test like Wilcoxon Signed Rank test and Mann Whitney U test were used for the data not passing the normality test. Level of significance was set at 5%. At baseline, unpaired t-test was used to compare Age, BMI, PEFR, 6MWD between experimental and control group and Mann Whitney U was used to compare Gender, thoracic expansion at 3rd, 5th and 10thintercostals space, dyspnea (RPE), SPO2 between the groups. In experimental group, for within group analysis, paired t-test was used for PEFR and 6MWD whereas Wilcoxon Signed Rank test was used for thoracic expansion at 3rd, 5th and 10th ICS level, RPE, and SPO2. In control group, for within group analysis, paired t-test was used for PEFR and 6MWD and while Wilcoxon Signed Rank testwas thoracic expansion 3rd 5th and 10th ICS, RPE and SPO2. Comparison of differences in thoracic expansion 3rd,5th and 10th ICS, PEFR, 6MWD, RPE and SPO2, between experimental group and control group had tested using Mann Whitney U test.

Demographic Data

Table 1: Gender distribution in experimental group and control group

	Experimental Group	Control Group
Male	16(54%)	19(63%)
Female	14(46%)	11(37%)
Total	30(100%)	30(100%)



Graph 1: Gender distribution of experimental group and control group

The table 1 and graph 1 shows the gender distribution in the groups. In the experimental group, the number of patients was 30, of which 54% were males and 46% were females. In the control group, the number of patients was 30, of which 63% were males and 37% were females.

I: BASELINE COMPARISON BETWEEN THE GROUPS

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Table 2: Baseline characteristics in both groups

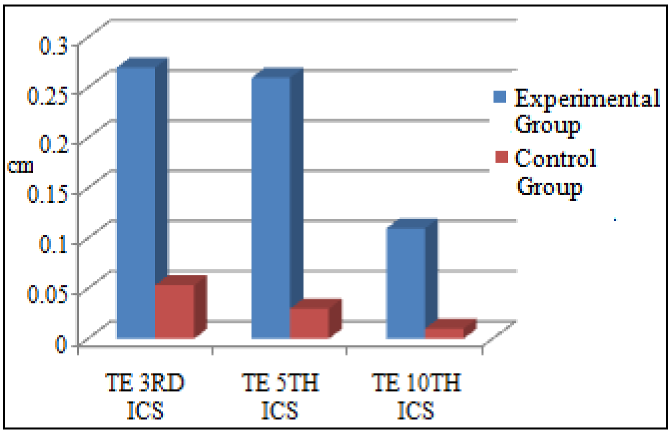
Outcome measures	Mean		Median		Std deviation		Std error		Confidence interval	
	Exp	Con	Exp	Con	Exp	Con	Exp	Con	Exp	Con
AGE	49.43	52.36	48.50	51.00	8.93919	8.18528	1.63207	1.49442	46.09 to 52.77	49.31 to 55.42
BMI	20.4587	21.3766	20.4300	21.7200	3.67625	2.92138	0.67119	0.53337	19.08 to 21.83	20.28 to 22.46
TE at 3rd ICS	0.9833	1.0833	1.0000	1.0000	0.24507	0.18952	0.4474	0.03460	0.89 to 1.07	1.01 to 1.15
TE at 5thICS	1.1333	1.1667	1.0000	1.0000	0.26042	0.31768	0.04755	0.05800	1.03 to 1.23	1.04 to 1.28
TE at 10th ICS	1.1000	1.1567	1.0000	1.1000	0.21814	0.39973	0.03983	0.07298	1.01 to 1.18	1.00 to 1.30
PEFR	1.6360E2	1.7633E2	1.5700E2	1.7750E2	2.66595E1	4.06476E1	4.86734	7.42121	1.53E2 to 1.73E2	1.61E2 to 1.91E2
6MWD	2.9955E2	2.9393E2	3.0000E2	2.9800E2	4.5564E1	5.49896E1	8.31885	10.03968	2.82E2 to 3.16E2	2.73E2 to 3.14E2
RPE	0.3500	0.3333	0.5000	0.2500	0.35111	0.37905	0.06410	0.06410	0.21 to 0.448	0.19 to 0.47
SPO2	96.1833	96.4333	96.0000	96.5000	0.86546	1.27802	0.15801	0.2333	95.86 to 96.50	95.95 to 96.91

The table 2 shows the baseline characteristics of age, BMI, thoracic expansion at three levels, peak expiratory flow rate, six minute walk distance, rate of perceived exertion and oxygen saturation in both experimental and control group.

Table 12: Comparison of both the groups

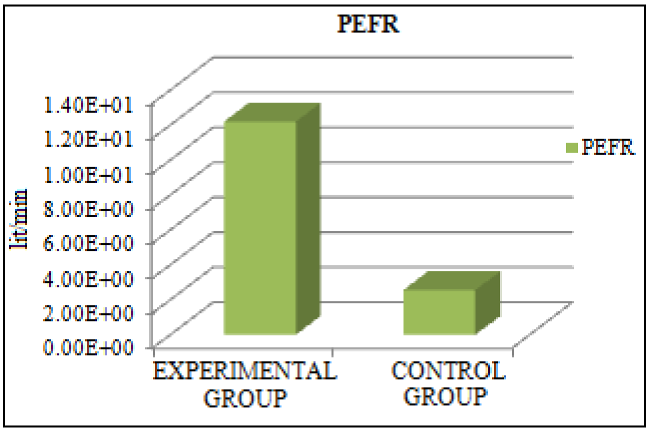
	Group	N	Mean Rank	Sum of Ranks	z	Asymp sig (2 tailed)
TE 3RD ICS	With Stretch Pole	30	41.75	1252.5		
	Without Stetch Pole	30	19.25	577.5	-5.255	0
	Total	60				
TE 5TH ICS	With Stretch Pole	30	44.05	1321.5		
	Without Stetch Pole	30	16.95	508.5	-6.358	0
	Total	60				
TE 10TH ICS	With Stretch Pole	30	40.67	1220		
	Without Stetch Pole	30	20.33	610	-5.194	0
	Total	60				
6MWD	With Stretch Pole	30	45.5	1365		
	Without Stetch Pole	30	15.5	465	-6.677	0
	Total	60				
PEFR	With Stretch Pole	30	45.27	1358	-6.701	0
	Without Stetch Pole	30	15.73	472		
	Total	60				
RPE	With Stretch Pole	30	31	930	-0.257	0.797
	Without Stetch Pole	30	30	900		
	Total	60				
SPO2	With Stretch Pole	30	41.1	1233		
	Without Stetch Pole	30	19.9	597	-5.063	0
	Total	60				

The table 12 shows the analysis was done by using Mann Whitney U test. It shows that there was a statistically significant increase in thoracic expansion at 3rd, 5th and 10th ICS, six minute walk distance, peak expiratory flow rate and oxygen saturation and there was reduction in rate of perceived exertion in experimental group (with stretch pole) compared to control group (without stretch pole).



Graph 12: Comparison difference of thoracic expansion at three levels in both groups

The table 12 and Graph 12 shows there was statistically significant improvement in thoracic expansion at three levels in experimental group compared to control group ($p<0.05$).



Graph 13: Comparison difference of peak expiratory flow rate (litter per minute) in both groups

The table 12 and graph 13 shows there was a statistically significant improvement in peak expiratory flow rate ($p<0.05$) in experimental group this indicates the thoracic core conditioning by using stretch pole helps in the PEFR in obstructive airway disease patients compared to control group.

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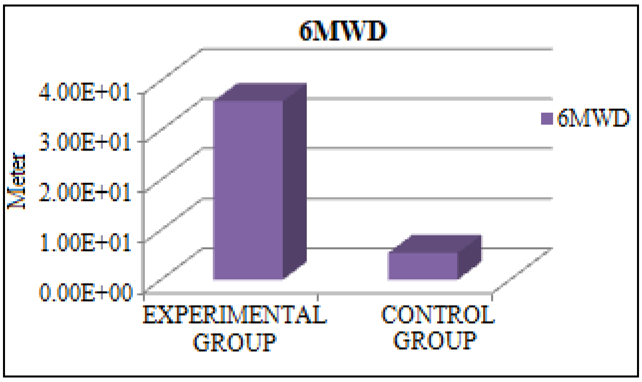
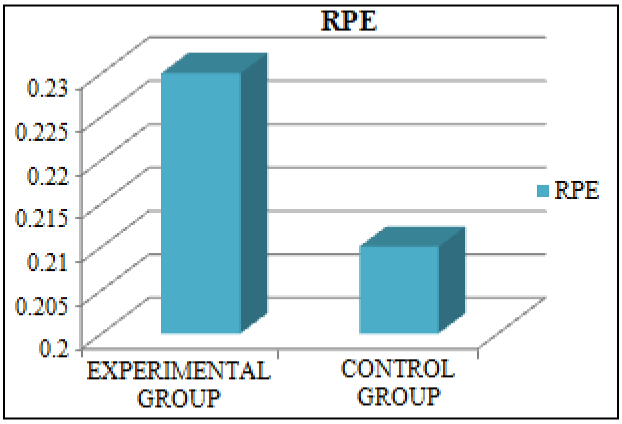


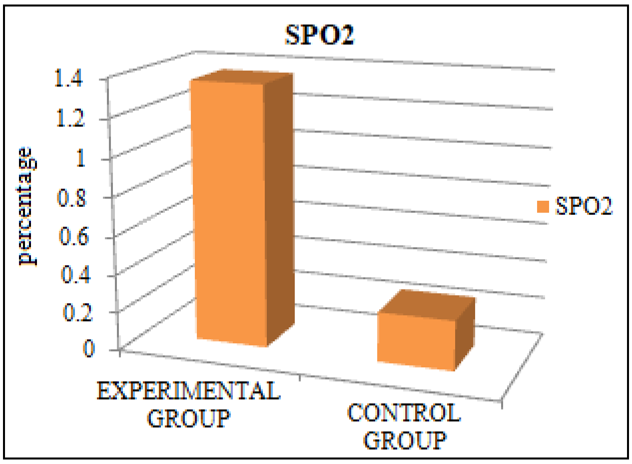
Graph 14: Comparison differences of six min walk distance (meter) in both groups.

The table 12 and graph 14 shows there was a statistically significant improvement in six minute walk distance (functional capacity) in experimental group this indicates the thoracic core conditioning by using stretch pole helps in the improving functional capacity in patients with obstructive airway disease compared to control group.



Graph 15: Comparison difference of rate of perceived exertion (Borg's score) in both groups.

The table 12 and graph 15 shows there was an improvement in Borg's score post intervention in experimental group this indicates the thoracic core conditioning by using stretch pole helps in reducing rate of perceived exertion in patients with obstructive airway disease compared to control group.



Graph 16: Comparison difference of oxygen saturation (percentage) in both groups

The table 12 and graph 16 shows there was a statistically significant improvement ($p<0.05$) in oxygen saturation in experimental group this indicates the thoracic core conditioning by using stretch pole helps in the improving oxygen saturation in patients with obstructive airway disease compared to control group.

4. Discussion

The aim and objectives of the study were to find out an immediate effect of thoracic core conditioning by using stretch pole on patients with obstructive airway disease.

60 patients with obstructive airway diseases were recruited from the chest OPD of tertiary health care hospital. Patients were randomly allocated using simple random sampling method into two groups, experimental (with stretch pole) and control group (without stretch pole) with 30 patients in each group. The objectives of the study to find out immediate effect on thoracic expansion at different three levels 3rd, 5th, and 10thintercostals space, peak expiratory flow rate, six minute walk distance, rate of perceived exertion and oxygen saturation were collected at baseline and at post intervention was statistically analyzed by using SPSS 16.0.

The table1 and graph 1 show gender distribution in experimental group (with stretch pole) and control group (without stretch pole). The percentage of male was 54% and 63% and the percentage of female was 46% and 37% in experimental group and control group respectively.

The table 2 shows baseline characteristics of both the groups. In experimental group, the mean and standard deviation of age was 49.43 years ± 8.93 (95% CI 46.09 - 52.77), BMI was 20.45 kg/m^2 ± 3.67 (95%CI 19.08 - 21.83), thoracic expansion at 3rd ICS was 0.98 cm ± 0.44 (95% CI, 0.89 -1.07), 5th ICS was 1.13 cm ± 0.26 (95% CI, 1.03 – 1.23), 10th ICS was 1.1cm ± 0.21 (95% CI 1.01 – 1.18), PEFR was 163 lit/m ± 2.66 (95% CI, 153 - 173), 6MWD was 299.5m ± 4.55 (95%CI, 282 - 316), RPE was 0.35 ± 0.35 (95% CI, 0.21 – 0.44), SPO2 was 96.18%± 0.86 (95% CI, 95.86 – 96.50).

In control group, the mean and standard deviation of age was 52.36 years ± 8.18 (95% CI 49.31 - 55.42), BMI was 21.37 kg/m^2 ± 2.92 (95%CI 20.28 – 22.46), thoracic expansion at 3rd ICS was 1.08 cm ± 0.03 (95% CI, 1.01 - 1.15), 5th ICS was 1.16 cm ± 0.31 (95% CI, 1.04 – 1.28), 10th ICS was 1.15cm ± 0.39 (95% CI 1.00 – 1.30), PEFR was 176 lit/m ± 4.06 (95% CI, 161 - 191), 6MWD was 293m ±5.49 (95%CI, 273 - 314), RPE was 0.33 ± 0.37 (95% CI, 0.19 – 0.47), SPO2 was 96.50%± 1.27 (95% CI, 95.95 – 96.91).

The table3 shows the normality tests of both groups shows unpaired t- test analysis of differences in age (p=0.190), BMI (p=0.289), PEFR (p=0.157), 6MWD (p=0.668) in both the groups. There was no statistically significant difference in age, BMI, PEFR and 6MWD in both the groups.

The table 4 shows non parametric Mann Whitney U- test analysis of the differences in thoracic expansion at 3rd, 5th

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and 10th ICS, rate of perceived exertion and oxygen saturation in both the groups. There was no statistically significant difference in thoracic expansion 3rd ICS (p=0.090), 5th ICS (p=0.569), 10th ICS (p=0.318), RPE (p=0.778) and oxygen saturation (p= 0.345) in both the groups.

From Table 3 and 4, it was seen that there was no statistically significant difference between the groups at baseline. This suggests that both the groups were homogenous with respect to age, BMI, thoracic expansion at 3rd, 5th and 10th ICS, PEFR, 6MWD, RPE and oxygen saturation at the baseline.

The table 5 shows descriptive statistics of pre and post intervention within experimental group, in this group PEFR and 6MWD passes the normality for them statistically paired t-test was used and for other outcome measures Wilcoxon signed rank test was used that was with stretch pole. Pre intervention the mean and standard deviation of thoracic expansion at 3rd ICS was 0.98 cm ± 0.24 (95% CI, 0.89 - 1.07), 5th ICS was 1.13 cm ± 0.26 (95% CI, 1.03 – 1.23), 10th ICS was 1.1cm ± 0.21 (95% CI 1.01 – 1.18), PEFR was 163 lit/m ± 2.66 (95% CI, 153 - 173), 6MWD was 299.5m ± 4.55 (95%CI, 282 - 316), RPE was 0.35 ± 0.35 (95% CI, 0.21 – 0.48), SPO2 was 96.18% ± 0.86 (95% CI, 95.86 – 96.50).

Post intervention the mean and standard deviation of thoracic expansion at 3rd ICS was 1.25 cm ± 0.17 (95% CI, 1.18 -1.32), 5th ICS was 1.39 cm ± 0.22 (95% CI, 1.31 – 1.48), 10th ICS was 1.21cm ± 0.21 (95% CI 1.13 – 1.28), PEFR was 175 lit/m ± 2.72 (95% CI, 165 - 185), 6MWD was 339m ± 4.62 (95%CI, 321 - 356), RPE was 0.10 ± 0.20 (95% CI, 0.02 – 0.17) and SPO2 was 97.55% ± 0.96 (95% CI, 97.18 – 97.91).

The table 6 and 7 showed that there was a statistically significant increase in thoracic expansion 3rd ICS (p=0.000), 5th ICS (p=0.000) and 10th ICS (p=0.000), PEFR (p=0.000), 6MWD (p=0.000), RPE (p=0.000) and oxygen saturation (p= 0.000) in experimental group that was with stretch pole.

This suggest that the immediate effect of thoracic core conditioning by using stretch pole in experimental group on thoracic expansion, peak expiratory flow rate , six minute walk distance, rate of perceived exertion and oxygen saturation there was a statistically significant increase in all outcome measures.

The table 8 shows descriptive statistics of pre and post intervention within control group, in this group PEFR and 6MWD passes the normality for them statistically test paired t-test was used and for other outcome measures Wilcoxon signed rank test was used that was without stretch pole. Pre intervention the mean and standard deviation of thoracic expansion at 3rd ICS was 1.08 cm ± 0.18 (95% CI, 1.01 - 1.15), 5th ICS was 1.16 cm ± 0.31 (95% CI, 1.09 – 1.28), 10th ICS was 1.15cm ± 0.39 (95% CI 1.00 – 1.30), PEFR was 176 lit/m ± 4.06 (95% CI, 161 - 191), 6MWD was 293.9m ± 5.49 (95%CI, 273 - 314), RPE was 0.33 ± 0.37 (95% CI, 0.19 – 0.47) and SPO2 was 96.43% ± 1.27 (95% CI, 95.95 – 96.91).

Post intervention the mean and standard deviation of thoracic expansion at 3rd ICS was 1.1 cm ± 0.21 (95% CI, 1.02 -1.18), 5th ICS was 1.17 cm ± 0.31 (95% CI, 1.05 – 1.29), 10th ICS was 1.16cm ± 0.40 (95% CI 1.01 – 1.31), PEFR was 178 lit/m ± 4.12 (95% CI, 163 - 194), 6MWD was 293m ± 5.49 (95%CI, 273 - 314), RPE was 0.31 ± 0.24 (95% CI, 0.22 – 0.40) and SPO2 was 96.70% ± 1.20 (95% CI, 96.24– 97.15).

The table 9 and 10, showed that statistically there was no significant improvement in thoracic expansion 3rd ICS (p=0.416), 5th ICS (p=0.705), 10th ICS (p=0.317), PEFR (p=0.000), 6MWD (p=0.000), RPE (p=0.782), and oxygen saturation (p= 0.063) in control group that was without stretch pole.

This suggest that there was no significant immediate effect of thoracic core conditioning without using stretch pole in control group on thoracic expansion, rate of perceived exertion and oxygen saturation. There was no statistically significant increase in all outcome measures but mild improvement in PEFR .There was no difference in 6MWD.

The table 11 showed descriptive characteristics of differences between the experimental group and control group at the end of intervention.

Post intervention difference of experimental group, the mean and standard deviation of thoracic expansion at 3rd ICS was 0.27 cm ± 0.14 (95% CI, 0.21 -0.32), 5th ICS was 0.26 cm ± 0.09 (95% CI, 0.22 – 0.29), 10th ICS was 0.11cm ± 0.08 (95% CI 0.07 – 0.14), PEFR was 12.2 lit/m ± 3.31 (95% CI, 10.9 – 13.4), 6MWD was 35.8m ± 7.1 (95%CI, 33.1 – 38.4), RPE was 0.23 ± 0.25 (95% CI, 0.13 – 0.32) and SPO2 was 1.36% ± 0.8 (95% CI, 1.04 – 1.69).

Post intervention difference of control group of outcome measures, the mean and standard deviation of thoracic expansion at 3rd ICS was 0.05 cm ± 0.13 (95% CI, 0.00 - 0.10), 5th ICS was 0.03 cm ± 0.07 (95% CI, 0.00 – 0.05), 10th ICS was 0.01cm ± 0.05 (95% CI -0.01 – 0.03), PEFR was 2.56 lit/m ± 2.41 (95% CI, 0.12 – 0.31), 6MWD was 5.36m ± 3.89 (95%CI, 3.91 – 6.81), RPE was 0.21 ± 0.25 (95% CI, 0.12 – 0.31) and SPO2 was 0.26% ± 0.78 (95% CI, -0.02 – 0.55).

The table 12 showed there was a statistically significant increase in thoracic expansion at 3rd ICS (p=0.000), 5th ICS (p=0.000) and 10th ICS (p=0.000), PEFR (p=0.000), 6MWD (p=0.000) RPE (p=0.797), oxygen saturation (p= 0.000) in experimental group.

This suggests that there were significant improvement in thoracic expansion at 3rd ,5th and 10th ICS , peak expiratory flow rate, six minute walk distance, rate perceived exertion and oxygen saturation in experimental group (with stretch pole) compared to control group (without stretch pole).

The outcome measures in this study were thoracic expansion at 3rd, 5th and 10th ICS, peak expiratory flow rate; six min walk distance, rate of perceived exertion and oxygen saturation. This study showed that the immediate effect of

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thoracic core conditioning were more effective by using stretch pole.

Thus, our study supports the hypothesis that there was significant immediate effect of thoracic core conditioning by using stretch pole on patients with obstructive airway disease.

Thoracic expansion

In experimental group, the graph 2 shows that there was an improvement in thoracic expansion at 3rd, 5th and 10th which was statistically significant (p=0.00<0.05) improvement in thoracic expansion.

In control group, the graph 7 shows that there was no significant improvement in thoracic expansion at three levels.

Shigeki Yokoyama, PT, PhD, et all *(2011) They investigated the effects of the Core Conditioning exercises (CC) using the Stretch Pole. They hypothesized that thoracic expansion difference was better improved by CC with the Stretch Pole than CC without it. Participants were 14 healthy middle-aged and elderly females. Participants were randomly allocated to CC with the stretch pole (SP group) or CC without it (control [C] group). The protocol for both groups consisted of 10 exercises aiming to relax the thoracic and lumbar muscles. The exercises were regularly performed twice a day for one week. Thoracic mobility was measured at the axillary and the 10th rib levels and the thoracic elevation difference was calculated. They concluded that post-intervention values of the SP group were higher than the C group at both the axillary and 10th rib levels. These results indicate that core conditioning using the Stretch Pole improves thoracic mobility.[29]

Hightower et al. (1999) tested the effects of rib cage mobilization and respiratory muscle stretching on vital capacity and chest wall expansion in fourteen elderly adults aged 58 to 83. Although the results indicated that the experimental group showed an improvement in xiphoid and axillary chest wall expansion measurements following manual stretching and rib mobilization compared to a control group.[45]

Peak expiratory flow rate

In experimental group, the graph 3 shows significant improvement in peak expiratory flow rate that post intervention statistically significant (p=0.00<0.05).

In control group, the graph 8 shows mild improvement in peak expiratory flow rate compared to pre intervention.

Minehiko Yamada et al. studied benefits of Respiratory Muscle Stretch Gymnastics in COPD patients. The study results suggested that RMSG immediately reduced dyspnea at rest, and improved spirometric variables including forced vital capacity (FVC) and PEFR in patients with severe COPD. In our study also they found an improvement in PEFR and decrease in Borg's score after RMSG training.[46] PEFR was a measure of maximum expiratory flow rate sustained by a subject for at least 10 ms starting from the level of maximum lung inflation expressed in liters/minute (L/min).[47] It was an important parameter of pulmonary function test and it reflects mainly the caliber of the bronchi and larger bronchioles, which were subjected to reflex bronco constriction. It was a good indicator of respiratory efficiency as it denotes the expiratory flow rate during the peak of FVC. Thus, the flow rate was a function of lung volume rather than the effort exerted, which was why it is 'effort – independent flow' and was significantly increased in our study. GulderenSahin et al reported that the stretch receptor reflex decreased the tracheal smooth muscle tone.[48] This in turn leads to decreased airway resistance and increase airway calibre, increasing the PEFR. It has been reported that elderly people have lower chest wall compliance than younger people. Although the chest wall compliance was not measured in the present study, it seems reasonable to assume that the elderly people in the present study had stiff chest walls, including the respiratory muscles.

Six minute walk distance

In experimental group, the graph 4 shows that there was a significant improvement in six min walk distance and it was statistically significant (p=0.00<0.05).

In control group, the graph 9 shows there was no any difference in functional capacity compared to pre intervention and that was statistically significant.

A walking test can be a good measure of "functional exercise capacity", defined as patient's ability to undertake physically taxing activities encountered in everyday life. Hideko Mineguchi et al conducted a study on "Cross-over comparison between respiratory muscle stretch gymnastics and inspiratory muscle training" and reported a significant improvement in the 6MWD and reduction of functional residual capacity (FRC) in patients with chronic obstructive pulmonary disease (COPD) after RMSG training of 4 weeks. The resultant hyperinflation thus increases the metabolic cost of breathing.[49] Some studies have reported that an increased FRC is likely to be associated with increased dyspnea intensity during exercise.[50-53]

Victor Z. et al (2006) investigated the influence of thoracic and upper limb muscle function on 6 min walk distance in COPD patients. This study showed the importance of skeletal musculature of the thorax and upper limbs in submaximal exercise tolerance and could open new perspectives for training programs designed to improve functional activity in COPD patients.[54]

Dyspnea (Rate of Perceived Exertion)

In experimental group, the graph 5 shows that there was an improvement in Borg's score post intervention which was highly significant statistically (p=0.00<0.05), suggesting that there was a reduction in their RPE.

In control group, the graph 10 shows there was mild reduction in rate of perceived exertion and that was not statistically significant.

Donrawee L et al (2009) studied acute benefits of chest wall stretching exercise on expired tidal volume, dyspnea and chest expansion in a patient with COPD. The results showed a significant clinical improvement of expired tidal volume, reduction in dyspnea level and increase in chest expansion.[55]

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In other Studies have reported that the "In phase vibration" (IPV), or alternating vibration applied to the contracting intercostal muscles, decreases dyspnea.[56,57] This effect has been suggested to be physiologic, since out-of-phase vibration, or alternating vibration applied to the non contracting intercostal muscles, increases dyspnea.[58] The dyspnea-decreasing effect of IPV is probably mediated by vibration-elicited afferent activity from chest wall respiratory muscle receptors to supraspinal centers. These afferents could be from muscle spindles, since vibration is a powerful stimulus of the muscle spindles.[59]

Similarly, stretching also stimulates muscle spindles and the sensitivity of muscle spindles is increased during contraction.[60] Thus, RMSG may increase afferent activity from the contracting chest wall respiratory muscle spindles to the supraspinal centers in a manner similar to IPV. This powerful stimulus from the stretching of contracting respiratory muscles and the reduced FRC may have resulted in reduced RPE post RMSG training.

Oxygen saturation (SPO2)

In experimental group, the graph 6 shows that there was a significant improvement in oxygen saturation that was statistically significant.

In control group, the graph 11 shows that there was mild improvement in oxygen saturation but not statistically significant.

Ciro Casanova MD, Ma Concepcio´n Herna´ndez MD et al, they prospectively studied 88 patients with stable COPD (forced expiratory volume in the first second [FEV1] < 80% of predicted, ratio of FEV1 to forced vital capacity < 70% of predicted, and PaO2 60 –70 mm Hg) with 24 hours of ambulatory oximetry. Desaturators were defined as those who spent > 30% of the time with SpO2 < 90%. Patients engaged in their usual activities of daily living. They correlated these desaturations with the following variables, measured immediately before the 24 hours of oximetry: body mass index, dyspnea (measured with the modified Medical Research Council dyspnea scale), gas exchange, pulmonary function, quality of life (measured with the Saint George's respiratory questionnaire), and comorbidity (measured with the Charlson index). In result, Thirty-three (38%) of the patients were desaturators: 50% nocturnal and 22% diurnal. They also measured daytime arterial blood gas values from arterial blood samples and found that the desaturators had higher PaCO2 (p 0.001) and lower PaO2 (p 0.007) than the non desaturators. There were no differences in the other variables. The correlation between nocturnal and diurnal time with SpO2 < 90% was r 20.67, and the concordance was low (Cohen's kappa 0.43, p < 0.001).They concluded that Patients with stable COPD and moderate hypoxemia have frequent and potentially important desaturations during activities of daily living and at night. In addition, there was a big difference in the profile and degree of nocturnal and diurnal desaturations. Twenty-four hours of oximetry provides valuable information for comprehensive evaluation of patients with COPD.[61]

In the comparison of both groups experimental and control, the graph 12 shows the thoracic expansion at 3rd, 5th and 10th ICS in experimental group was more beneficial and most effective and has an immediate effect of thoracic core condition on thoracic expansion at three levels, the improvements in thoracic expansion from pre to post intervention could be because of the thoracic core conditioning exercises using stretch pole. Following exercises using stretch pole thoracic spine extension range of motion increases. Simply lying supine with one's spine on the stretch pole is thought to reduce hyper nutation of sacrum and if combined with core conditioning exercises realigns spine and respiration related muscle particularly thorax is easily extended in supine on stretch pole that improve thoracic mobility.[29]

The core conditioning exercises helps to stretch the respiratory muscles which reduces the muscle tension resulting in relaxation of the muscles of the respiration. Watanabe N et al., stated that core conditioning exercises are designed to relax the trunk muscles which might enhance thoracic expansion.[62]

In comparison of both groups, the graph 13 showed the peak expiratory flow rate was more improved in experimental group than control group. Studies have reported that if the respiratory muscles are stretched to their full extent, the respiratory apparatus is able to work to their maximal capacity.[63-66]The increase in PEFR might also be explained by this mechanism.

In comparison of both groups, the six minute walk distance was more improved in experimental group than control group that shown in graph 14.

In experimental group, the rate of perceived exertion much reduced compared to control group that shows graph 15 Perceived intensity of exertion dyspnea is attributed to decreased frequency of breathing as a result of increased dead space ventilation following core conditioning exercises. The elderly in study performed the exercises with deep breathing on stretch pole which might have added to the improvement due to use of proper breathing pattern thereby reducing tightness, chest wall resistance and work of breathing resulting in the reduction of dyspnea and improving thoracic mobility. Janos P et al in their study stated that reduction in breathing frequency through exercise training reduces and delays the development of dynamic hyperinflation.[67]While performing the stretch pole exercises thorax is observed to expand on the pole. These exercises are subjected to be more comfortable in supine on the stretch pole with reduced strain or pressure and a better feeling of relaxation of the whole body that influence the relieve tension in respiratory muscle and reducing dyspnea.[29]

Oxygen saturation was improved in experimental group compared to control group shown in graph 16 and that was statistically significant.

Based on the finding in experimental group, thoracic core conditioning with stretch pole exercises were found clinically and statistically have significant effect on effective in increasing thoracic expansion at 3rd, 5th and 10th ICS, peak expiatory flow rate, functional capacity (6MWD), dyspnea (RPE) and oxygen saturation., it signifies that the thoracic core conditioning exercises with or without stretch pole on

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improving chest expansion, PEFR, 6MWD, RPE and oxygen saturation however greater effect were found by using stretch pole. Hence, the present study supports the hypothesis.

5. Conclusion

Immediate effect of thoracic core conditioning in experimental group by using stretch pole on patients with obstructive airway disease were most effective and improving in thoracic expansion at three levels, peak expiratory flow rate, six minute walk distance, rate of perceived exertion and oxygen saturation compared with control group that was without stretch pole.

6. Limitations

1) Small sample size.
2) All the samples collected were from one institution, the results cannot be generalized for the entire population.

However, in spite of these limitations, the study presents thoracic core conditioning exercises using stretch pole which may be an initial step towards future treatments. This program may represent yet another valuable tool in rehabilitation.

7. Suggestions

a) A large multi centric study should be conducted so that the results can be generalized to population.
b) Large sample size can be studied.
c) Long term effects can be studied.

8. Clinical Implication

The immediate effect of thoracic core conditioning by using stretch pole proves to be an effective method to improve the thoracic expansion at 3rd , 5th and 10th ICS, Peak Expiratory Flow Rate, functional capacity (6MWD), dyspnea (Rate of Perceived Exertion), and oxygen saturation can be employed as a novel method for stretching chest wall muscles in patients. Thus thoracic core conditioning can be used as an effective modality of treatment in patients with obstructive airway disease.

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