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Effectiveness of chest proprioceptive neuromuscular facilitation versus rib cage mobilization along with treadmill training on respiratory parameters among COPD subjects

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Abstract
Introduction: Chronic Obstructive Pulmonary Disease (COPD) is progressive disease and leading cause of morbidity and mortality world, especially in India. The abnormal inflammatory response develops an air flow limitation of the lungs which produces obstruction of mechanical function and the gas exchanging capability of the lungs. Various approaches like treadmill training, PNF techniques, rib cage mobilization have been employed to reduce dyspnea, increase chest expansion and expiratory flow rate.
Aim of the study: The aim of the study is to find out the effectiveness of treadmill training with chest Proprioceptive Neuromuscular facilitation versus treadmill training with rib cage mobilization on respiratory parameters among COPD subjects.
Methodology: 30 subjects were selected using convenient sampling method and randomly divided into two groups. Group A (n=15) received treadmill training with chest Proprioceptive Neuromuscular facilitation (PNF) and Group B (n=15) received treadmill training with rib cage mobilization for 3 days in a week for 2 months. The pre and post-test values were measured using Modified Borg's scale for dyspnea, Inch tape for Chest expansion, and Peak Flow Meter for Peak Expiratory Flow Rate (PEFR).
Result: The intra group analysis showed statistically significant improvement in decreasing dyspnea (t = 22.91), improves the chest expansion at axillary level (t = 14.36), xiphiod level (t = 20.99) and peak expiratory flow rate (t = 38.24) of treadmill training with rib cage mobilization group B than the treadmill training with chest Proprioceptive Neuromuscular facilitation group A at 5% level of significance. The inter group comparisons showed statistically significant differences in favour of group B.
Conclusion: Both the groups showed only minimal significant difference on comparison and they have been found to be effective. Therefore, the study concludes that participants who received treadmill training combined with rib cage mobilization is more efficient in helping COPD patients minimize dyspnea, enhance chest expansion, and increase peak expiratory flow rate.

Keywords: Chronic obstructive pulmonary disease (COPD), proprioceptive neuromuscular facilitation (PNF), Six-minute walk test (6MWT), peak expiratory flow rate (PEFR)

Introduction

COPD is defined as "a disease condition marked by airflow limitation that is not totally reversible" by the global initiative for chronic obstructive lung disease (GOLD). In most cases, the airflow restriction is progressive and accompanied by an abnormal inflammatory response of the lungs to noxious particles or gases [1, 2].
A progressive illness that is a major cause of morbidity and mortality worldwide, particularly in India, is chronic obstructive pulmonary disease (COPD) [3]. Around 251 million people worldwide had COPD in 2016 [4]. Prevalence rates in India range from 1.2 to 19% for women and 2 to 22% for men, with Northern states having higher prevalence rates than Southern states. [5] COPD was placed fourth in the remaining states and seventh in the north-eastern states. [6] The disease is the second leading cause of mortality in India and is estimated to have killed 3.17 million people worldwide in 2015. Almost 90% of COPD fatalities occurred in developing and middle-income countries. [7, 8] By 2030, it is predicted that COPD would be the cause of 4.5 million deaths. [9] It is anticipated that the burden of COPD would increase globally in the coming decades as a result of population ageing and continued exposure to COPD risk factors. Those over 40 years of age are most frequently affected with COPD [10, 11].
The leading cause of COPD risk in recent years is tobacco use. The majority of COPD research has mostly focused on smoking as a risk factor, however new studies have revealed that nonsmokers can significantly contribute to COPD. Both industrialized and developing nations have greater rates of COPD among nonsmokers [12, 13]. Occupational exposure, recurrent respiratory tract infections in early childhood, pulmonary tuberculosis, low socioeconomic status, long-standing asthma, environmental tobacco smoke, outdoor air pollution (from traffic and other sources), biomass smoke (wood, animal dung, gas used for cooking), genetic factors, and long-term asthma are all potential risk factors for COPD in nonsmokers.
The abnormal inflammatory response limits airflow in the lungs, impairing their ability to exchange gases as well as their ability to function mechanically. The signs & symptoms of COPD include a cough with expectoration, wheezing, worsening shortness of breath (SOB), weariness, tightness in the chest, and mood swings. These modifications lead to a decline in daily physical activity and health-related quality of life. [14, 15]

Aerobic Training

Aerobic exercise is defined as the sub maximal, rhythmic, repetitive exercise of large muscle group, during which the needed energy is supplied by inspired oxygen. [16] It is a training that improves the efficiency of the aerobic energy producing systems and improves cardio respiratory endurance. [17] Aerobic exercise is utilized as an evidence-based intervention for individuals with chronic respiratory disorders as it improves symptoms like dyspnea, exercise intolerance, and decreased quality of life that are frequent in COPD patients. It also raises aerobic parameters and functional capacity. [18, 19]

Proprioceptive Neuromuscular Facilitation (PNF) Technique

Proprioceptive Neuromuscular Facilitation is a form of stretching that aims to make muscles more flexible and increase range of motion. PNF is a gradual stretch that alternates between contracting and relaxing the muscles. PNF techniques combined with autogenic stretching helps to relax the respiratory muscles and enhance inspiration and expiration in the subsequent inspiration-expiration cycle. By actively initiating or engaging in greater respiration, inspiration-expiration is shown to improve. Due to contractions of a stretched muscle arc, it efficiently enhances chest expansion [20, 21].

The application of PNF techniques changes the pace and depth of breathing, altering the respiratory rate. It also improves the respiratory muscles' integrity and chest stability, which improves the diaphragm's breathing pattern and raises tidal volume. The airflow varies less slowly in COPD patients than in healthy individuals. So, compared to patients who actively initiate their breathing, COPD patients need to repeat the PNF stretch more frequently in order to see better results. [22]

Rig cage Mobilization Exercise

Mobilization is defined as the passive, skilled manual therapy techniques applied to joints and related soft tissues at varying speeds and amplitudes using physiological or accessory motion, for the therapeutic purposes. [23] Rig cage mobilization exercise is effective in all patients as it mobilize the chest wall, upper extremity and upper back. It produces a stretching to the chest wall that stretches the lungs also, as there is connection with chest wall between the parietal pleura and visceral pleura. This improves the air entry of the lung and it can be performed in warm up training also. Therefore, inexpensive, simple, accurate, and reproducible evaluation methods are required to assess chest wall mobility.

Six minute walk test (6MWT)

The six-minute walk test (6MWT) is a popular instrument for assessing functional capacity because it is straightforward, affordable, and accurately representing the activities of daily living (ADL) of people with COPD. [24] The American Thoracic Society and the European Respiratory Society (ATS/ERS) offer standardized instructions for performing the 6MWT on a 30-m track and recommend using the "Modified Borg scale" to assess dyspnea during the walk test. The scale is described as having a maximum of 10, which is "very, very severe (maximal)" dyspnea. [25]

Peak expiratory flow rate (PEFR)

The PEFR, which is given in liters per minute (L/min), is the maximum flow rate at which air is expelled out of the lungs. [26] Peak expiratory flow rate (PEFR) is a lung function test that is frequently used as it is simple, dependable, and reproducible. The PEFR is an extremely sensitive and precise measure of respiratory muscle strength and airway blockage. The usual range for males and females is 450–550 liters per minute (L/min) and 320–470 L/min, respectively. A number of variables are known to influence its value, including age, sex, height, and body surface area. [27]

Chest Expansion

In order to evaluate the effectiveness of various treatment modalities, chest expansion measurement has been employed in a variety of illness situations. [28, 29] Often, chest expansion is calculated as the difference between the thoracic girth measurements at the end of maximal inspiration and expiration. [30] The fourth intercostal space and fifth thoracic vertebrae are anatomical reference markers for chest expansion in the upper (axillary line), and the 10th thoracic vertebrae are anatomical reference markers for chest expansion in the lower (xiphoid process). [31–33] Between healthy and ill persons, chest expansion appears to be diverse and variable, ranging from 4 to 7 cm in healthy subjects. [34, 35] The typical range of chest expansion shrinks with age (50 to 60% between 15 and 75 years) and in males by 20% more than in women. [36]

In this study, treadmill exercises were performed using the exercise intensity set according to the individual capacity of the patients. Training programs were provided to COPD patients and expected that continuous exercise should increase the physical capacity and build the motivations to exercise regularly.

Materials and Method

30 subjects were selected through convenient sampling method based on the selection criteria at Sri Ramakrishna Institute of Paramedical Sciences. Inclusion criteria were subjects between 40 and 55 years of age, both male and female gender, Patients with mild, moderate airway obstruction based on GOLD criteria: GOLD 1 - (Mild) & GOLD 2 - (Moderate), Haemodynamically stable patients. Exclusion criteria includes patients with orthopedic problems, fracture of rib, history of cardiovascular problems, lung cancer, cardiac failure, neurological deficits affecting the respiratory muscles, patients with severe and very severe airway obstruction based on gold criteria.

Informed consent was obtained and clear explanation prior to their participation in the study was given. This was a Comparative study design in which the participants were randomly divided into two groups. Group - A were given treadmill training with chest Proprioceptive Neuromuscular facilitation (PNF) and Group - B were given treadmill training with rib cage mobilization for 50 minutes per day, 3 days in a week for 2 months. The patients were assessed with Modified Borg's scale for dyspnea, Inch tape for Chest expansion, and Peak Flow Meter for Peak Expiratory Flow Rate (PEFR). Pre - test evaluation was done on the first day prior to treatment and post - test evaluation was done on the last day of treatment.

Statistical Analysis & Results

The collected data were analyzed using paired t-test and unpaired t-test. The intragroup analysis for modified borg dyspnea scale demonstrated group A and B showed statistically significant improvement of t values 29.00, $p<0.05$ and $t = 22.91$, $p<0.05$ respectively. The intragroup analysis of chest expansion at axillary level demonstrated group A and B showed statistically significant improvement with t values 13.79 and 14.36 with $p<0.05$. The intragroup analysis of chest expansion at xiphoid level demonstrated group A and B showed statistically significant improvement with t values 14.07 and 20.99 with $p<0.05$. The intragroup analysis of peak expiratory flow rate demonstrated group A and B showed statistically significant improvement with t values 18.44 and 38.24 with $p<0.05$. The group B was more significant than the other. The inter group analysis of post test scores of group A and B showed statistically significant improvement with a t value of 2.11 for modified borg dyspnea scale, 3.98 for chest expansion at axillary level, 3.97 for chest expansion at xiphoid level and t value of 4.07 for peak expiratory flow rate at 28 degrees of freedom and 5% level of significance.

Table 1

Parameter	Post Mean Value		Mean Difference	Standard Deviation		Calculated t value	Table t value	Level of Significance
	Group A	Group B		Group A	Group B			
Modified Brog dyspnea Scale	1.53	1.10	0.43	0.52	0.60	2.11	2.048	P < 0.05
Chest expansion at axillary level	3.16	3.96	0.8	0.49	0.59	3.98	2.048	P < 0.05
Chest expansion at xhiphoid level	3.37	4.06	0.69	0.45	0.50	3.97	2.048	P < 0.05
Peak expiratory flow rate	353.33	381.33	28	17.99	19.59	4.07	2.048	P < 0.05

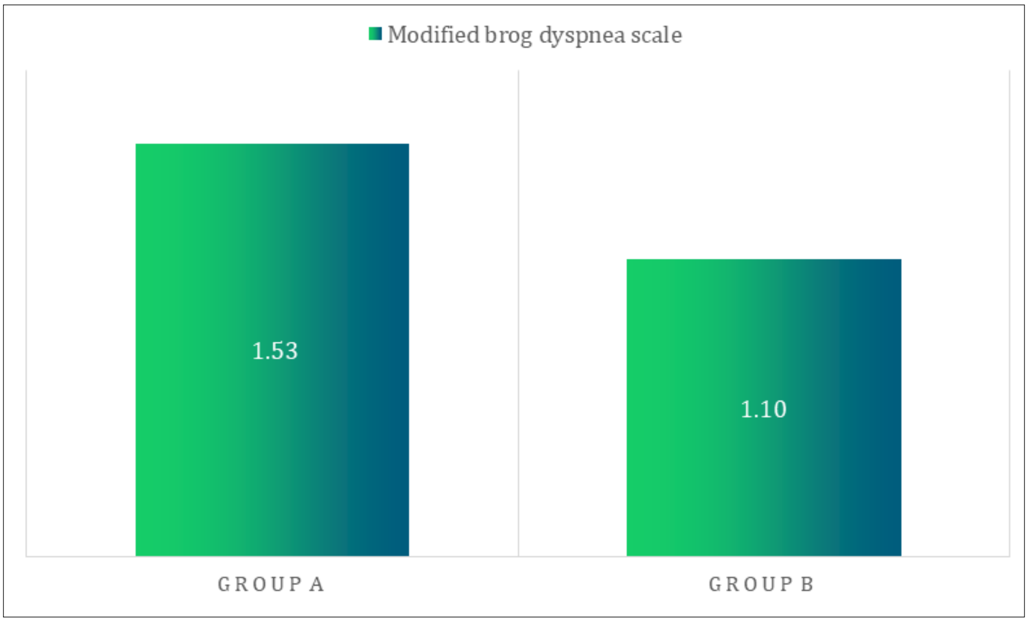

Fig 1

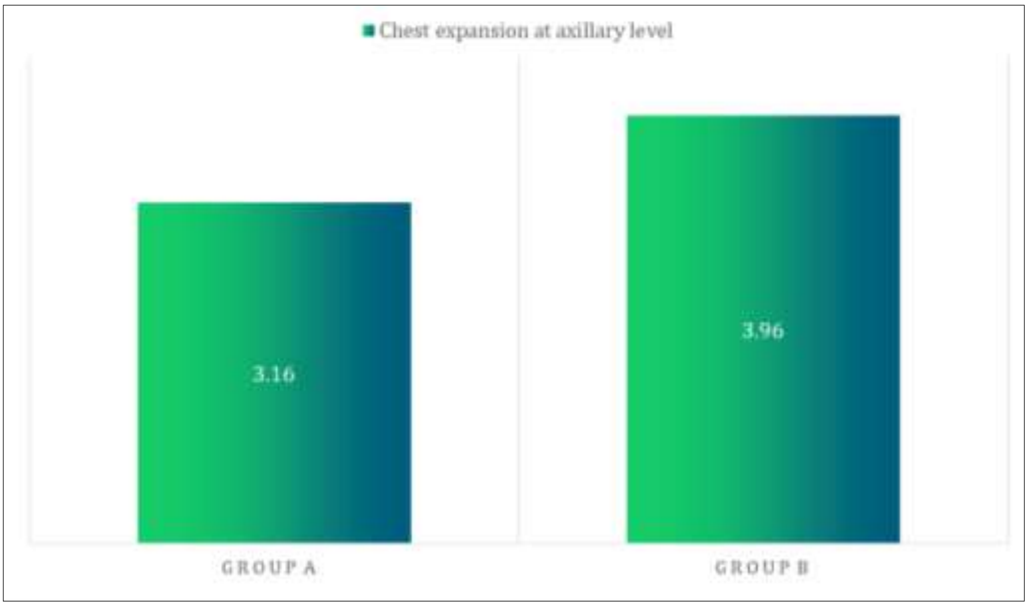

Fig 2

Fig 3

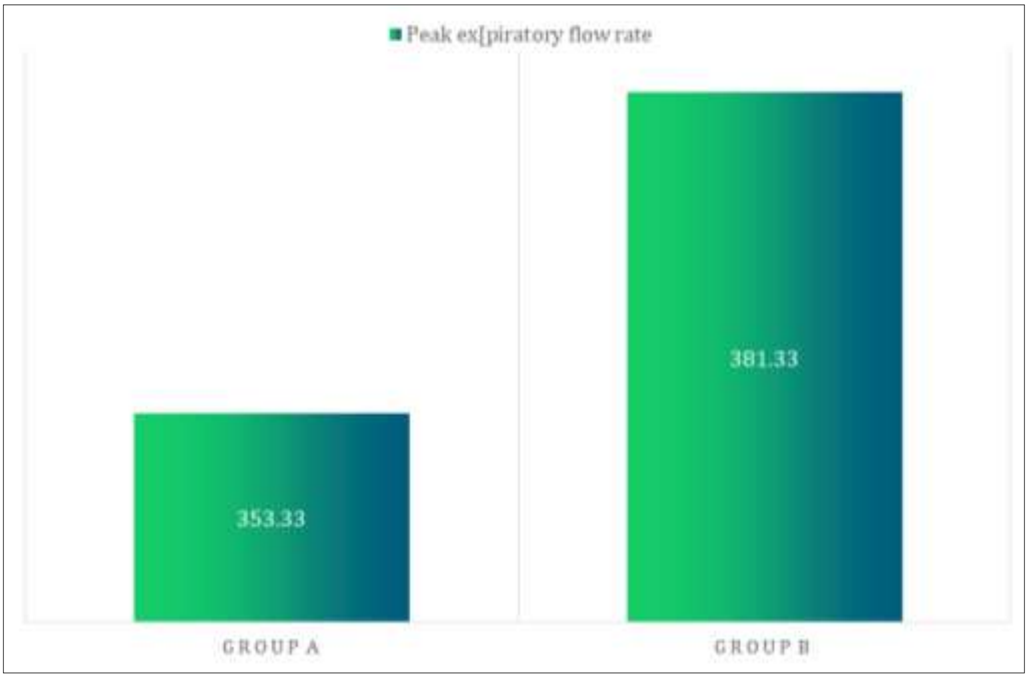

Fig 4

Discussion

The results of this study demonstrated that participants who underwent treadmill training with rib cage mobilization showed better outcomes on reduce dyspnea, improves the chest expansion and peak expiratory flow rate than the treadmill training with chest Proprioceptive Neuromuscular facilitation.

The mechanism underlying the significant improvement in Group A Chest PNF provide proprioceptive stimulus to the primary respiratory muscles and improve inspiration – expiration cycle by reflex stretching. It also increased the activity of the diaphragm & abdominal muscle, therefore resulting in increased chest wall mobility. Moreover, it modified the tidal volume, changed the rate and depth of breathing, and enhanced diaphragmatic breathing. According to studies by Shilpa Khatri *et al* also showed positive results. As COPD patients' airflow changes more slowly than other patients', they need to repeat the PNF stretch more frequently in order to see results than individuals who actively initiate their breathing.

Group B Rib cage mobilization affects ANS activity through activation of proximal ganglia of the thoracic sympathetic chain in the costo transverse joint and produced relaxation of skeletal muscles along with improved blood circulation enhancing pulmonary function. Hental *et al*. reinforced this by proposing that mobilization promotes autonomic activity, resulting in related vasodilation and smooth muscle relaxation, hence lowering dyspnea and improving chest mobility. Maximal pressures on inhalation and exhalation both increased with rib cage joint mobilization.

The treadmill is an exercise machine with regulated speed so the subjects should be able to maintain their balance and coordination during exercises. Treadmill training yields greater benefits in improving exercise performance, inspiratory muscle strength, dyspnea & health related quality of life. When combined with these approaches it also improved the respiratory parameters through increased oxygen consumption and thomas *et al*, also stated that volume of oxygen is usually improved in treadmill training.

Though chest PNF with treadmill training was found to be effective, rib cage mobilization with treadmill training showed statistically significant improvement among COPD patients as it mobilizes each intercostal space which helped in reducing dyspnea, improving chest expansion and peak expiratory flow rate. Chest PNF can be applied in patients who have difficulty in tolerating the quick manual pressure exerted in the intercostal spaces by rib cage mobilization.

Conclusion

The study concludes that participants who received treadmill training combined with rib cage mobilization is more efficient in helping COPD patients minimize dyspnea, enhance chest expansion, and increase peak expiratory flow rate.

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