

Effects Of Lower Limb Muscle Training Strategies To Improve The Exercise Endurance Of Moderate Copd Patients

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ABSTRACT

Background: Chronic Obstructive Pulmonary Disease (COPD) is a progressive lung disease characterized by airflow limitation and skeletal muscle dysfunction, particularly in the lower limbs, contributing to reduced exercise tolerance. Pulmonary rehabilitation, including lower limb muscle training, has been shown to enhance physical endurance in COPD patients. **Objective:** This study aimed to evaluate the effectiveness of lower limb muscle training strategies, alongside conventional chest physiotherapy, in improving exercise endurance and quality of life in patients with moderate COPD. **Methods:** A total of 60 patients with moderate COPD, aged 45–65 years, were enrolled and randomly divided into two groups (n=30 each). Group A (Experimental) received lower limb training using a cycle ergometer three times per week for 12 weeks, along with conventional chest physiotherapy and breathing exercises. Group B (Control) received only conventional chest physiotherapy. Exercise endurance and quality of life were assessed using the 6-Minute Walk Test (6MWT), Five-Repetition Sit-to-Stand Test (5STS), and Clinical COPD Questionnaire (CCQ), measured at baseline, 4th, 8th, and 12th weeks. Paired and unpaired t-tests were used for statistical analysis. **Results:** Group A showed a statistically significant improvement in 6MWT distance and 5STS time compared to Group B ($p < 0.05$). CCQ scores also demonstrated marked enhancement in quality of life in the experimental group. These findings suggest that lower limb muscle training improves functional capacity and reduces symptoms in moderate COPD patients. **Conclusion:** Lower limb muscle training as part of a structured pulmonary rehabilitation program significantly enhances exercise endurance and quality of life in patients with moderate COPD. Incorporating such training into standard physiotherapy practices may improve clinical outcomes.

Keywords: COPD, lower limb training, pulmonary rehabilitation, exercise tolerance, 6MWT, 5STS, CCQ.. ..

1. INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a common disease characterized by progressive airflow limitation and tissue destruction. It is associated with lung changes due to chronic airway inflammation from prolonged exposure to noxious particles or gases mostly cigarette smoke. Chronic airway inflammation leads to airway narrowing and reduced lung recoil. The disease mostly presents with symptoms of cough, dyspnea, and sputum production. Symptoms may range from being asymptomatic to respiratory failure.

The predisposing factor for COPD is due to prolonged exposure to harmful particles or gases. Cigarette smoking is the common cause of COPD globally. Other etiological factors may include second-hand smoke, environmental and occupational exposures, and alpha-1 antitrypsin deficiency (AATD).

COPD is primarily present in smoking population and those greater than age 40. Prevalence increases with age and it is currently the third most common cause of morbidity and mortality globally. In 2015, the prevalence of COPD was 174 million and there were approximately 3.2 million deaths due to COPD worldwide. According to the WHO's estimates, nearly 65 million people have moderate to severe COPD that accounts for 5% of deaths (41.9 deaths per 100 000 individuals) globally. The number of COPD cases in India was 55.3 million in 2016.

COPD is a chronic condition involving the airways, lung parenchyma, and pulmonary vasculature. The process is due to involvement of oxidative stress and protease-antiprotease imbalances. Emphysema may cause structural changes in COPD where there is destruction of the alveolar air sacs (gas-exchanging surfaces of the lungs) leading to obstructive physiology

mechanisms. Neutrophils and macrophages are recruited and release multiple inflammatory mediators. The protease-mediated destruction of elastin causes loss of elastic recoil and leads to airway collapse during exhalation.

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COPD will typically present in adulthood and often during the winter months. The clinical features may include chronic and progressive dyspnea, cough with copious amount of sputum production, wheezing and chest tightness. While a smoking history is present in most cases, there are many patients affected without history of smoking. They should be asked questions on exposure to second-hand smoke, occupational and environmental exposures, and family history. Patients with a confirmed diagnosis of COPD should be asked about previous exacerbations, nighttime awakenings, inhaler usage, and the impact of the disease on activity level. Patients should be questioned on their past medical history for other diseases such as asthma, allergies, and childhood respiratory infections.

Patients with COPD may have the following physical findings:

Respiratory distress in acute exacerbations

Skeletal muscle dysfunction, atrophy and muscle wasting

Accessory respiratory muscle usage

Prolonged expiration

Wheezing

Pursed-lip breathing

Increased antero-posterior chest wall diameter (barrel chest)

Central cyanosis when arterial oxygenation is low

Clubbing in the fingers

Lower limb edema in right heart failure

COPD patients often experience peripheral muscle weakness due to skeletal muscle weakness and muscle atrophy that affects exercise endurance.

The diagnosis of COPD is based on history and occurrence of symptoms. Pulmonary function test is the gold standard method of diagnosis. Other investigations may also include a 6-minute walk test, laboratory testing, and radiographic imaging.

Pulmonary function testing (PFT) is important to make diagnosis, to stage the severity of the disease and to monitor the disease. Spirometry is performed before and after bronchodilator inhalation. A ratio of the forced expiratory volume in one second to forced vital capacity (FEV1/FVC) less than 70% percent confirms the diagnosis of COPD. Patients with a severe reduction of FEV1 and signs of dyspnea should be assessed for oxygenation with pulse-oximetry or arterial blood gas analysis.

The Global Initiative for Chronic Obstructive Lung Disease (GOLD) is a disease prevention program initiated by the World Health Organization (WHO) and the National Heart, Lung, and Blood Institute (NHLBI). The program is recognized globally for providing updated and detailed reports on the recommendations for the diagnosis and management of COPD. The GOLD recommendations are often used to assess the severity of the disease and choice of therapy.

Symptom severity is evaluated using the modified British Medical Research Council (mMRC) questionnaire and the COPD Assessment Test (CAT). The mMRC questionnaire assesses the degree of breathlessness on a scale of 0-4 with 4 being the most severe. The COPD Assessment Test (CAT) provides a score on eight functional parameters to assess the impact of the disease on a patient's activities of daily living.

A 6-minute walk test is performed to assess the sub-maximal functional capacity of a patient. This test is performed indoors on a flat and straight surface. The length of the hallway is 100 feet and the test measures the distance that the patient walks over a period of 6 minutes.

Laboratory testing includes a complete blood count to assess the infection, anemia, and polycythemia. Radiographic imaging is used to find out the abnormal changes in the lung. Chest x-rays may show hyperinflation of the lung, flattening of the diaphragm, and increased anterior-posterior diameter. Computed tomography imaging is useful in patients with bronchiectasis, malignancy, or to plan surgical procedures. CT is significant to visualize centrilobular emphysema and to detect bullae in the subpleural region.

The primary aims of treatment are to control the symptoms, to improve the quality of life, and to reduce exacerbations and mortality. The main elements of COPD management are appropriate pharmacotherapy, smoking cessation, pulmonary rehabilitation and regular follow-up to monitor the disease severity.

Based on clinical evidence, it has been found that inhaled beta₂ agonists, inhaled anticholinergics and orally administered corticosteroids are beneficial in the management of stable COPD patients

Annual influenza vaccination is widely suggested in all patients with COPD. The PPSV23 is recommended for those aged 64 and younger with significant comorbidities (e.g., diabetes mellitus, chronic heart disease, and chronic lung disease)

Severe COPD cases may require surgical management including bullectomy, lung volume reduction surgery, or lung transplantation. Surgical intervention is indicated in severe conditions where symptoms are not controlled with medical therapy alone and may improve quality of life.

Pulmonary rehabilitation is a multi disciplinary treatment program that includes physician, physiotherapist and respiratory therapist etc. It is indicated in all stages of COPD. It is a comprehensive plan tailored individually and may involve therapies such as exercise training, education, and behavioral changes. Its core aim is to improve a patient's physical function and psychological condition.

Pulmonary rehabilitation may be provided in home care settings and also in hospital settings. There may be merits and demerits based on the patient participation and availability of resources in both home care and hospital based pulmonary rehabilitation programs

Skeletal muscle dysfunction in later stages of COPD leads to reduced exercise tolerance and endurance. Lack of appropriate nutrition and psychological factors also lead to reduced exercise tolerance and exercise performance. Skeletal muscle dysfunction in COPD is the result of reduction in muscle mass and strength, atrophy of Type I (slow twitch oxidative endurance), Type IIa muscle fibers, reduction in capillarization and oxidative enzyme capacity and also decreased exercise endurance.

The resting and exercise muscle metabolism gets affected and patients develop acidosis i.e (lactic acidosis) at lower exercise intensity than healthy individuals. This may cause an increased ventilator requirement and early onset of fatigue. Low muscle mass is a strong indicator of mortality in COPD. Muscle dysfunction in COPD is caused by many co-existing factors and it includes airway inflammation, low anabolic hormonal levels, deconditioning, and nutritional impairments, aging and hypoxia. Steroid induced myopathy also play a crucial role to decrease the muscle mass in COPD patients

Since exercise limitation begins with difficulty in ambulation, most of the clinical trials emphasized exercise training in COPD should be focused on training the lower limb muscles alone or in combination with training the muscles of arm or muscles of respiration. All the clinical trials conducted over the last 30-40 years had concluded that lower limb training improves the exercise endurance of COPD patients. Lower limb training of several types such as treadmill running, cycling, walking, stair climbing conducted in various study settings increases exercise tolerance of COPD patients.

In this study we evaluated the effects of lower limb muscle training strategies to improve the exercise endurance of moderate and severe COPD patients

2. METHODOLOGY

A) Sample Design

Non probability randomized sampling.

B) Sample Size

Totally 60 Patients are included in the study and randomly assigned to Group A and Group B. **Selection criteria**

A) Inclusion Criteria:

Patients with age group of 45 to 65 years.

Both male and female

Moderate COPD patients based on GOLD criteria

Patients with Manual muscle power grading of 3+ and above for quadriceps and hamstring muscles.

Baseline Modified Medical Research Council (MMRC) dyspnoea grade 3 or 4.

No participant had been previously enrolled in a pulmonary rehabilitation program.

B) Exclusion Criteria:

Unstable cardiac disease

Patient with long-term use of supplemental oxygen

Patients with lower limb surgery within preceding 3 months

Exacerbation within preceding 4weeks

Malignant disease.

Musculoskeletal disorders.

Assessment parameters:

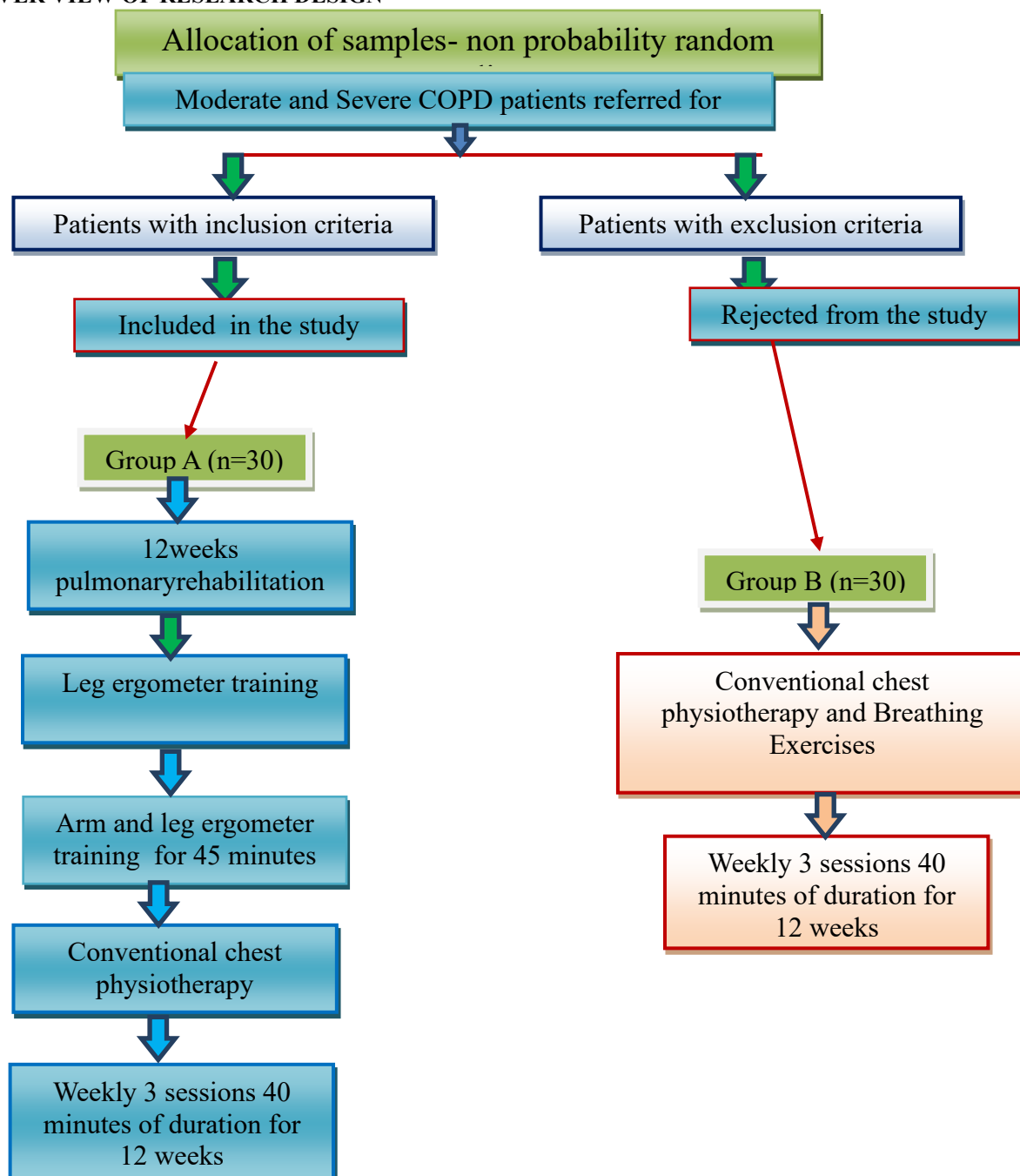
6MWTdistance in meters

5STS test time in seconds

Clinical COPD Questionnaire for measuring Quality of Life

The parameters are measured at baseline, 4th week, 8th week and at 12th week.

3. OVER VIEW OF RESEARCH DESIGN



TECHNIQUE

Group A: (EXPERIMENTAL GROUP)

Patients underwent lower limb muscle training and conventional chest physiotherapy and breathing exercises

Group B : (CONTROL GROUP)

Patients underwent conventional chest physiotherapy and breathing exercises

Study protocol

Group A: (EXPERIMENTAL GROUP)

Pulmonary rehabilitation programs are beneficial to patients with COPD and lower extremity strength training is considered a fundamental component of pulmonary rehabilitation.

Training protocol:

30 moderate COPD patients were assessed regarding pulmonary function, exercise capacity, quality of life. Patients were allocated to experimental group (n=30) was assigned to a protocol of exercise sessions on a cycle ergometer with training intensity based on age predicted maximum heart rate ($220 - \text{age}$) and dyspnoea score. Patients were instructed to pedal at a rate of 60 revolutions per minute (rpm) and they were encouraged to push themselves to the limits of their dyspnoea, without exceeding a heart rate equal to 80% of the predicted maximal heart rate. Patients should use pulse oxymeters to monitor heart rate and they kept a log of training that included the duration, work rate, and highest heart rate for each training session.

Method:

Bicycle ergometer training

12 weeks

3 days/ week

40 minutes/ session.

Conventional chest physiotherapy

Conventional chest physiotherapy is referred to as a combination of postural drainage, airway clearance techniques such as percussion, vibration, shaking in severe COPD patients to improve breathing and exercise tolerance.

GROUP B: (CONTROL GROUP)

30 patients with moderate COPD were receiving conventional chest physiotherapy (CCPT). This includes any combination of the following:

Postural drainage

Chest Percussion

Chest shaking

Huffing

Directed coughing

Relaxation techniques

Free exercises for lower limb

DATA PRESENTATION AND ANALYSIS

Paired t test is used to measure the changes within the group and unpaired t test is used to measure the changes between the group

6 minute walk distance test

5 sit to stand test

Clinical COPD questionnaire

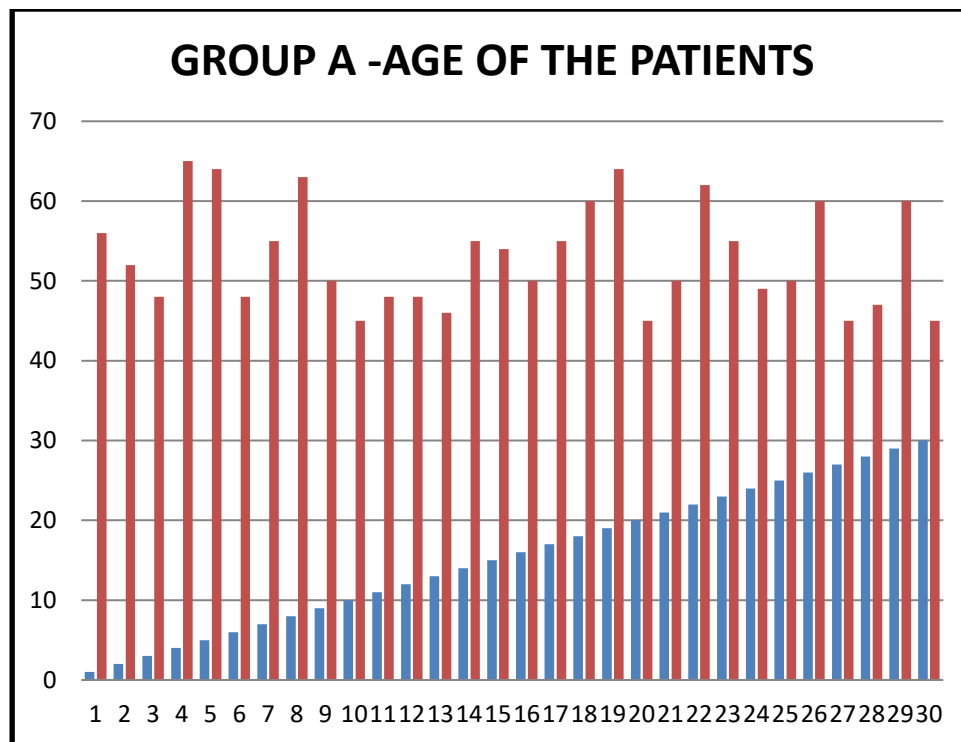


Figure 1- Age of the patients

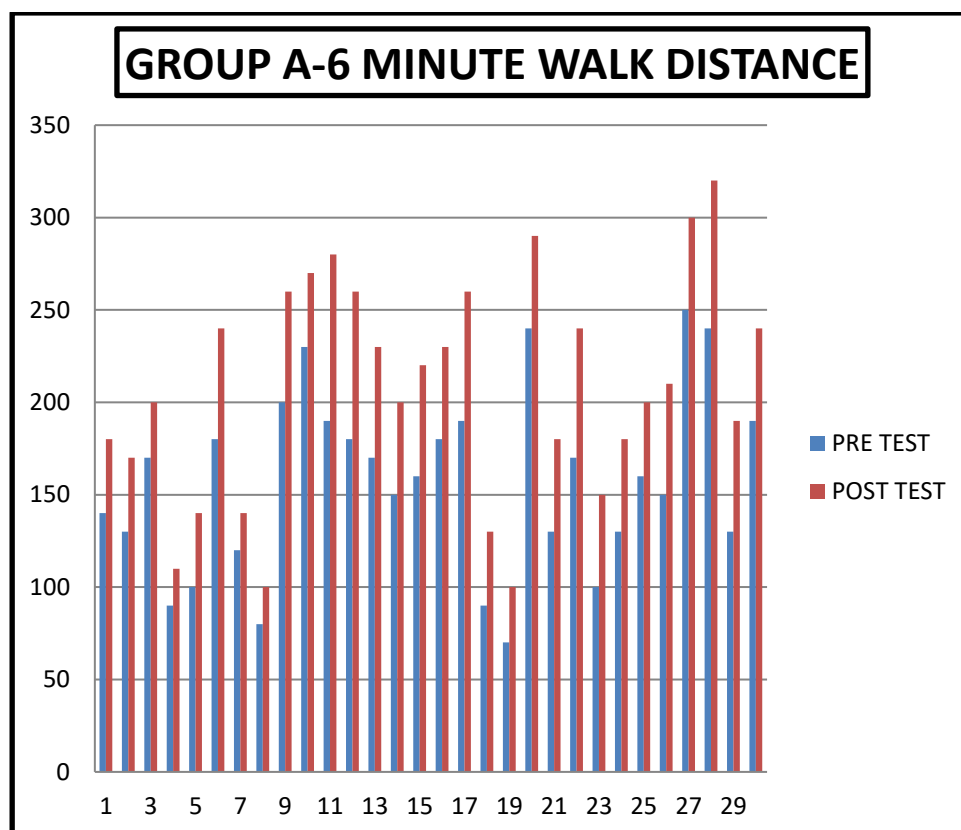


Figure 2- 6MWD in meters

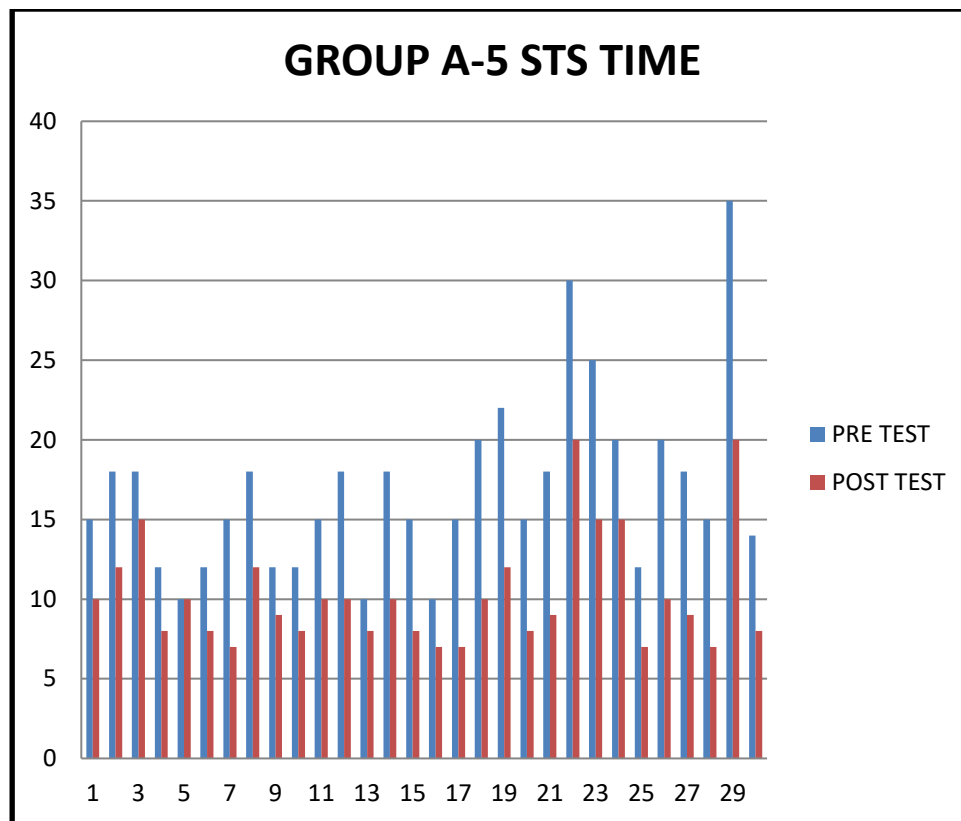


Figure 3-5STS time in seconds

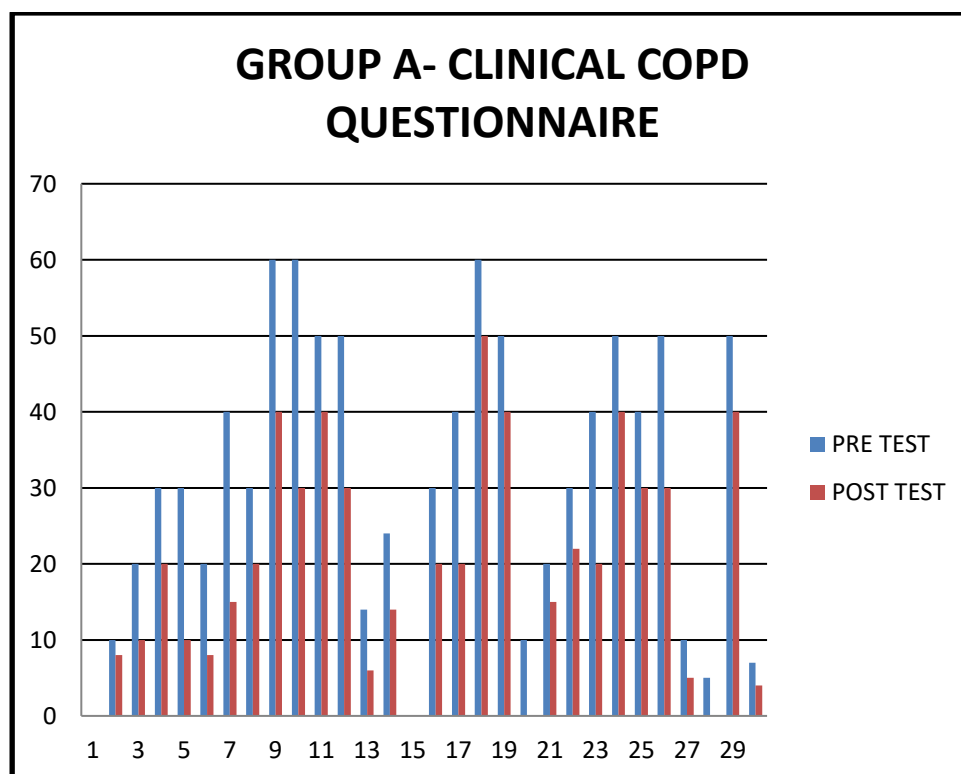


Figure 4-CCQ scores

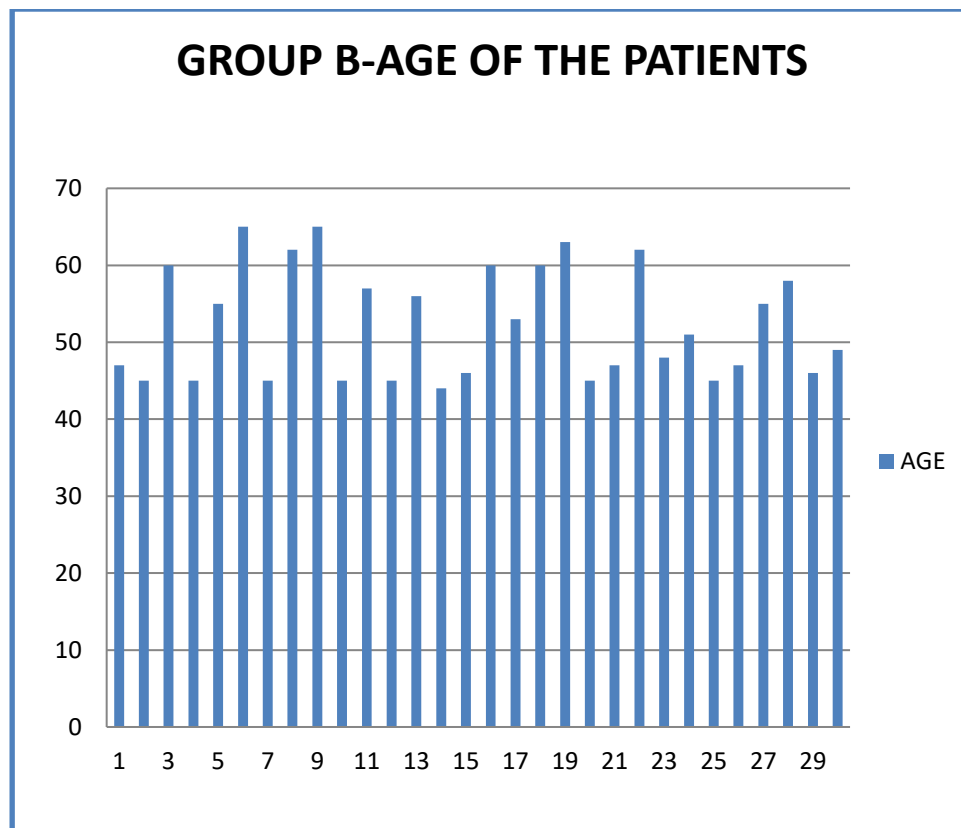


Figure 4- Age of the patients

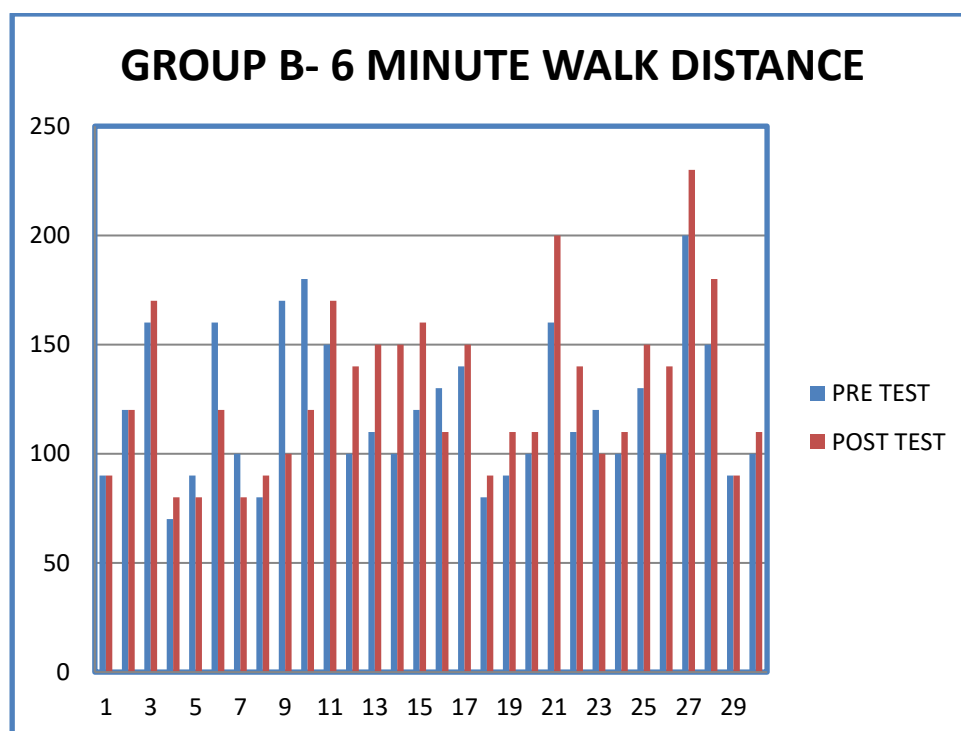


Figure 5- 6MWD in meters

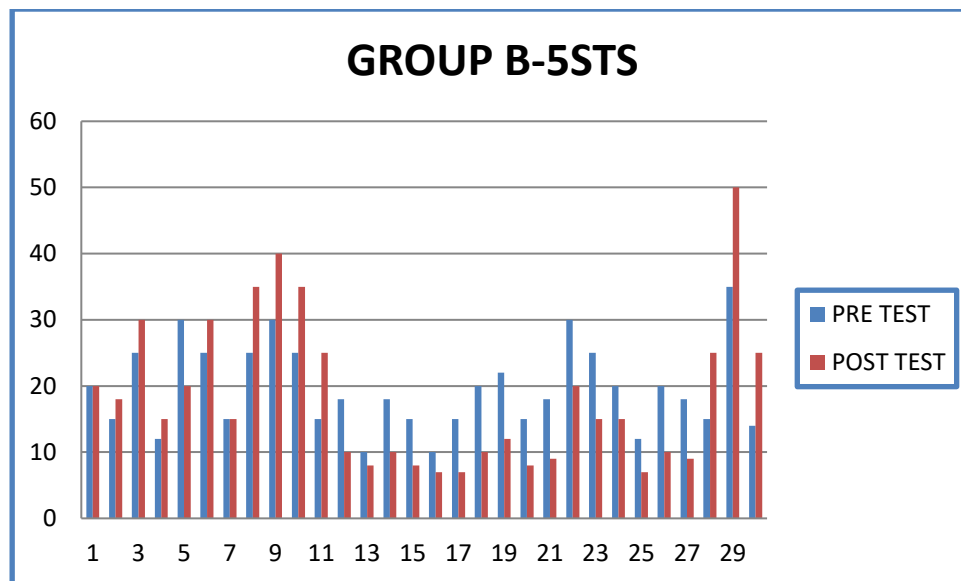


Figure 6-5 STS time in seconds

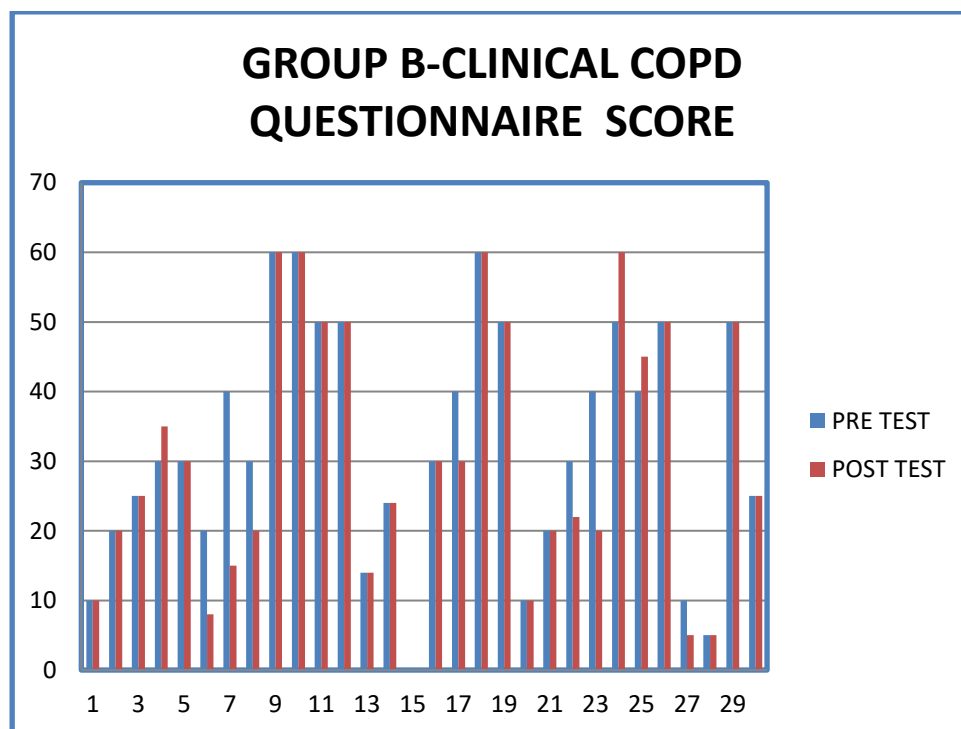


Figure 7- CCQ scores

4. DISCUSSION

There are several causes of exercise intolerance in COPD. Skeletal muscle dysfunction plays an important role in the symptoms and impairments in strength, endurance, and maximal exercise capacity experienced by COPD patients. **Oga, Nishimura C et al (2003)** analysed the factors related to mortality in chronic obstructive pulmonary disease and the role of exercise training and its impact on health status and concluded that exercise training for patients with COPD improves exercise capacity by optimizing muscle function and significant gains are typically made in exercise training in spite of irreversible abnormalities in lung function

Gosselink R et al (2013) showed that Peripheral muscle weakness contributes to exercise limitation in COPD and the resultant inactivity leads to progressive deconditioning that further increases the sense of respiratory effort related to airflow obstruction, the structural, metabolic, and physiologic skeletal muscle abnormalities can be improved or reversed by exercise training and they concluded that PR can restore the patient to the highest level of functioning.

Carolyn L. Rochester et al (2010) conducted a study on exercise training in chronic obstructive pulmonary disease and they found that exercise limitation usually begins with difficulty in Ambulating, thus exercise training have focused on training the muscles of the lower limbs, alone or in combination with training the arms or respiratory muscles.²⁹

This study was done with an objective to determine the efficacy of pulmonary rehabilitation programme vs. high frequency neuromuscular electrical stimulation emphasizing lower limb muscle training to improve the efficiency of 5 sit to stand test time and six minute walk distance in severe COPD patients.

The study involved 60 patients and they were randomly allotted into 2 groups as follows, Group A, and Group B. Pre test values taken during the commencement of the study and post test values were taken at 4th, 8th, 12th weeks of training program. The improvement of the patients following the treatment was evaluated by 6MWT, 5STS, CCQ..

5. CONCLUSION

The outcome of data collection reveals that HF-NMES and lower limb strength training plays a vital role in the reduction of peripheral muscle weakness in patients with severe COPD. The recordable change shows in Six minute walk test, five sit to stand test(5STS) and clinical COPD questionnaire (CCQ). It has been concluded that “There is significant improvement in 5STS time and 6MWT distance following 12 weeks of lower limb muscle training in pulmonary rehabilitation program for moderate COPD patients.

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