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A study to evaluate and compare the effectiveness of upper limb exercise training programme in COPD: An experimental study

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Abstract

Background: COPD is a slowly progressive, inflammatory disease in the airways and lungs due to noxious particles or gases. COPD is amongst the leading cause of chronic diseases in India. WHO estimates suggest that 90% of COPD-related deaths occur in low and middle income population. Most patients of COPD are aged more than 40 years. The main risk factors are tobacco smoke in male and indoor biomass fuel exposure in female. The chronic airflow limitation leads to dyspnea and is associated with the development of limb muscle dysfunction. Spirometry is the gold standard for diagnosis of COPD. Unsupported upper limb exercise training programs can be used to reduce dyspnea in COPD patients by improving the breathing pattern by strengthening the accessory muscles of respiration.

Aims and Objectives: To measure and compare the association between lung function parameters and upper limb muscle strength and endurance.

Materials and Methods: The present study is a prospective, interventional single centered hospital based study conducted from February 2016 to February 2019 for a duration of 36 months in the Department of Pulmonary medicine, Gauhati Medical College and Hospital, Guwahati after getting approval from the Institutional Human Ethics committee. All patients diagnosed with COPD above 40 years of age irrespective of gender and giving proper written informed consent were included in this study.

Results: In the present study, a total of 100 patients diagnosed with COPD were included. Initially at first visit, the average hand grip muscle strength was found to be 39.75 ± 7.084 kg but it significantly increased after 8 weeks of continuous upper limb exercise training with hand held dynamometer to 46.41 ± 6.252 kg. On first visit, the mean FEV₁ value of all the patients was 62.3 ± 6.480 %, the mean MMRC grading of dyspnea was 2.65 ± 0.479 and the average distance covered on 6 minute walk test (6MWT) was 339.95 ± 34.7842 meters. On doing regular upper limb exercise with the hand held dynamometer for a duration of 8 weeks along with the prescribed bronchodilators and inhaled corticosteroids the mean FEV₁ value, the mean MMRC grading and the average distance covered on 6MWT significantly improved to 73 ± 5.853 %, 1.87 ± 0.338 and 408.54 ± 24.6016 meters respectively.

Conclusion: In the present study, it was observed that unsupported upper limb training with hand held dynamometer for patients with COPD improves upper limb exercise capacity, the lung volume and decreases dyspnea grading in a significant manner. So, upper limb exercise training program should be included in treatment regimen of COPD patients along with the pharmacotherapy in order to improve their quality of life, to reduce episodes of acute exacerbations, to reduce the rate of hospital admissions and finally mortality rate.

Keywords: upper limb exercise training program, hand held dynamometer, 6MWT, COPD

Introduction

According to GOLD 2019, Chronic Obstructive Pulmonary Disease (COPD) is a common, preventable and treatable disease that is characterized by persistent respiratory symptoms and airflow limitation that is due to airway and/or alveolar abnormalities usually caused by significant exposure to noxious particles or gases [1]. WHO estimates suggest that 90% of COPD-related deaths occur in low and middle income population [2]. COPD has been projected to rank third amongst all causes of death by 2020 [3]. COPD is amongst the leading cause of chronic disease in India [4]. There are roughly 30 million COPD cases in India [5].

India and China constitute 33% of the total human population and account for 66% of the global COPD mortality. Most patients of COPD are aged more than 40 years [6].

The main pathology is chronic inflammation leading to structural changes and narrowing of the small airways accompanied by airway hyper-responsiveness [7]. The important risk factors are- tobacco smoke (mainly in male), indoor biomass fuel (mainly in female), air pollution, noxious gases, chronic respiratory infections.

COPD patients report excessive symptoms during upper limb activities. The main reason behind this is the association between respiration and accessory muscles of respiration which are involved in upper limb movement. [8]

During unsupported upper limb exercises more load is being shifted to the diaphragm which in turn worsens dyspnea more in comparison to lower limb exercises. [9, 10] Proper upper limb exercise training programs can significantly reduce dyspnea during day to day upper limb activities like in case of upper arm elevation. [11-13] Martinez and his colleagues in their study strongly suggested that unsupported upper arm exercise training program should be preferred over ergometer training as an exercise modality as they mimic more accurately the activities of daily living [14].

Anxiety and depression are frequently associated with COPD thereby affecting its prognosis. These psychiatric disorders remain unevaluated and undiagnosed in COPD patients which throws a very negative impact on the patient's quality of life by increasing both healthcare and social costs [15].

Performance of regular upper limb exercises by patients with COPD is associated with an important reduction in the risk of both admission to hospital as well as mortality [16-18].

Aims and Objectives

- 1) To generate the knowledge regarding the feasibility, methodology, effects and evidence of upper limb exercise training program that could contribute to optimize the treatment including pharmacotherapy for patients with COPD.
- 2) To investigate the evidence for upper limb exercise training program being beneficial by comparing with relevant outcome measurement like exercise capacity, dyspnea grading in patients with COPD etc.

Materials and Methods

Study Site: The study has been conducted in the Department of Pulmonary Medicine, Gauhati Medical College and Hospital, Guwahati from February 2016 to Feb 2019 for a duration of 36 months. It is a tertiary care teaching hospital providing both specialized and superspecialized services. The study has been approved by the institutional human ethics committee.

Study design: A prospective, interventional single centered hospital based study

Study criteria

Inclusion criteria

1. Patients \geq 40 years of age diagnosed with COPD, of both gender.
2. Patients giving proper written informed consent

Exclusion criteria

1. Unstable angina

2. Intermittent claudication
3. Mobility limiting conditions (hemiplegia, hemiparesis, quadriplegia, quadriparesis)
4. Autoimmune disorders like rheumatoid arthritis, myasthenia gravis
5. Neuromuscular disorders.
6. Lung diseases other than COPD.
7. Uncooperative and comatose patients.
8. Patients unwilling to participate in the study.
9. Patients admitted in critical care units.

Follow Up

This is an intervention study with an intervention period of 8 weeks.

Investigations

Spirometry

➤ Spirometry is the gold standard for diagnosis of COPD. The highest value of FEV₁ and FVC were selected. Prior to testing, bronchodilators were withdrawn:- inhaled beta-2 agonist for at least 12 hours and oral bronchodilators for 24 hours. Inhaled steroids were just permitted if required. Spirometry was carried out again, 20 minutes after inhalation of 200 microgram salbutamol from a Metered Dose Inhaler (MDI) to assess bronchodilator responsiveness. Post bronchodilator values were taken for analysis. A spirometry showing FEV₁ to FVC ratio <0.70 indicates obstruction. A diagnosis of COPD should be considered in current or former smokers with spirometric evidence of irreversible airflow obstruction in which post-bronchodilator forced expiratory volume in 1 second (FEV₁) value is less than 80% of predicted value.

Pulse oximetry

In this study it was used to detect hypoventilation. In normal individuals SPO₂ should be above 92%. In COPD patients a level of 88-92% is considered normal. Any lower than that implies respiratory failure and warrants the use of supplemental oxygenation and further investigations and interventions.

Measurement of Dyspnea

The **MMRC Scale (Modified Medical Research Council Dyspnea Scale)** has staged dyspnea into the following grades-

Grade 0- 'I only get breathless with strenuous exercise'

Grade 1- 'I get short of breath when hurrying on the level or walking up a slight hill'

Grade 2- 'I walk slower than people of the same age on the level because of breathlessness or have to stop for breath when walking at my own pace on the level'

Grade 3- 'I stop for breath after walking about 100 yards or after a few minutes on the level'

Grade 4- 'I am too breathless to leave the house' or 'I am breathless when dressing'

Six-minute- walk-test

Patients performed the 6MWT after pulmonary function tests by spirometry. The 6MWT was conducted in accordance with the American Thoracic Society Guidelines [19]. None of the patients used a walking aid in daily life or during the test. The 6MWT was performed on a 30-meter indoor track by an experienced investigator using

standardized encouragement strateg ^[20]. Subjects were allowed to rest if needed. Measurements of SpO₂ were performed using a finger pulse oximetry. Dyspnea and leg fatigue were assessed after a resting period of 5 minutes immediately after the test.

Handgrip Strength

Handgrip-strength of the dominant hand was measured with the help of a hand held dynamometer. After explaining the procedure to the study subject and giving proper demonstration, they were asked to hold the handgrip dynamometer in the dominant hand in sitting position. The forearm was kept extended over a table and elbow was flexed at 90°. Subjects were asked to hold the dynamometer in such a way that the second phalanx was against the inner stir-up, and were asked to grip the dynamometer handle with as much force as possible. The handgrip muscle strength was then recorded in kilograms as indicated by the pointer on the dynamometer. Three recordings were taken with a gap of two minutes between each effort and the maximum value was recorded for the final analysis. ⁽²¹⁾

Statistical analysis

The descriptive statistical analysis of data has been done. The mean, standard deviation (SD) & P value of the study data were analyzed by Chi-square test, unpaired t test etc using Graph Pad Prism 5 (Graph Pad Software, San Diego, CA, USA). A P value of < 0.05 was considered statistically significant.

Results

In the present study, a total of 100 patients giving proper consent and diagnosed with COPD were included. Initially at first visit, the average hand grip muscle strength was found to be 39.75 ± 7.084 kg (lower 95% confidence limit was 38.342 and upper 95% confidence limit was 41.158) but it increased statistically significantly after 8 weeks of continuous upper limb exercise training with hand held dynamometer to 46.41 ± 6.252 kg (lower 95% confidence limit was 45.168 and upper 95% confidence limit was 47.652).

Hand grip muscle strength

First week visit	39.75 ± 7.084 kg	P value
8 th week visit	46.41 ± 6.252 kg	< 0.0001 (extremely significant)

During first week visit on recording FEV₁ value with the help of spirometer the average value came out to be 62.3 ± 6.48% (lower 95% confidence limit was 61.012 and upper 95% confidence limit was 63.588) but after 8th week visit it improved statistically significantly to an average value of 73 ± 5.853% (lower 95% confidence limit was 71.837 and upper 95% confidence limit was 74.163).

FEV₁ Value

First week visit	62.3 ± 6.480 %	P value
8th week visit	73 ± 5.853 %.	< 0.0001 (extremely significant)

The average MMRC grading of dyspnea on first week visit was found to be 2.65 ± 0.479 whereas on 8th week visit it improved statistically significantly to 1.87 ± 0.338.

MMRC grading of dyspnea

First week visit	2.65 ± 0.479	P value
8 th week visit	1.87 ± 0.338	< 0.0001 (extremely significant)

On performing the 6MWT following spirometry, the average distance covered was found to be 339.95 ± 34.7842 meters (lower 95% confidence limit was 333.04 and upper 95% confidence limit was 346.86) and the average distance covered after 8th week visit was found to be 408.54 ± 24.6016 meters (lower 95% confidence limit was 403.65 and upper 95% confidence limit was 413.43).

6MWT

First week visit	339.95 ± 34.7842 meters	P value
8 th week visit	408.54 ± 24.6016 meters	< 0.0001 (extremely significant)

Rate of hospital admission

	Formoterol/Budesonide	Salmeterol/Fluticasone
First week visit	17	23
8 th week visit	6	9

The study population was divided into two groups depending on pharmacotherapy, one group receiving Formoterol/Budesonide as treatment and another group receiving Salmeterol/Fluticasone as treatment.

In Formoterol/Budesonide treatment group, the rate of hospital admission has been reduced from 17 to 6 and in Salmeterol/Fluticasone treatment group the rate of hospital admission has been reduced from 23 to 9.

This indicates that there has been significant improvement in quality of life of COPD patients following upper limb exercise training program.

Discussion

In the present study, a total of 100 patients diagnosed with COPD were included. Initially at first visit, the average hand grip muscle strength was found to be 39.75 ± 7.084 kg but it significantly increased after 8 weeks of continuous upper limb exercise training with hand held dynamometer to 46.41 ± 6.252 kg. This finding was found to be quite comparable to another similar type of study done by Shah S *et al.* (P < 0.001) ^[22].

In the present study it has been observed that in Formoterol/Budesonide treatment group, the rate of hospital admission has been reduced from 17 to 6 and in Salmeterol/Fluticasone treatment group the rate of hospital admission has been reduced from 23 to 9 indicating a significant improvement in the quality of life of COPD patients. Similar type of observation was found in the study conducted by Mohammad A. *et al.* ^[23].

On first visit, the mean FEV₁ value of all the patients was 62.3±6.480 %, the mean MMRC grading of dyspnea was 2.65±0.479 and the average distance covered on 6 minute walk test (6MWT) was 339.95±34.7842 meters. On doing regular upper limb exercise with the hand held dynamometer for a duration of 8 weeks along with the prescribed bronchodilators and inhaled corticosteroids the mean FEV₁ value, the mean MMRC grading and the average distance covered on 6MWT significantly improved to 73±5.853%, 1.87±0.338 and 408.54 ±24.6016 meters respectively. Similar findings were found in study conducted by Garrod R *et al.* [24].

Limitations of the study

The results of this study cannot be extrapolated to the entire population of that region as it was conducted only in one tertiary care teaching hospital and did not include the patients visiting other tertiary care teaching hospitals of that region.

Conclusion

In the present study, it was observed that unsupported upper limb training with hand held dynamometer for patients with COPD improves upper limb exercise capacity, the lung volume and decreases dyspnea grading in a significant manner. Quality of life is impaired in patients with COPD and it deteriorates considerably with increasing severity of disease. Psychological assessment and psychiatric consultation are at times of dire necessity to improve the condition of severe COPD patients. There is now increasing evidence that non-pharmacological interventions may play a major role in treating COPD patients. Upper limb exercise training program should be included in treatment regimen of COPD patients along with the pharmacotherapy of bronchodilators in order to improve their quality of life, to reduce episodes of acute exacerbations, to reduce the rate of hospital admissions and finally mortality rate. Further research is required to determine the clinical significance of upper limb training for patients with COPD.

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