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Original Research Article

Respiratory Muscle Training Exclusively for Patients with Chronic Obstructive Pulmonary Disease

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Abstract:

Background: Inspiratory muscle strength and endurance are diminished in patients with Chronic Obstructive Pulmonary Disease (COPD). Respiratory Muscle Training (RMT), which includes both Inspiratory Muscle Training (IMT) and Expiratory Muscle Training (EMT), is a component of pulmonary rehabilitation for these patients. IMT plays a particularly significant role within RMT. COPD patients experiencing dyspnea benefit from RMT, as strengthening the inspiratory muscles helps to reduce breathlessness. However, the effectiveness of IMT is debated, and its clinical application in COPD patients is limited. COPD patients often develop forward shoulder posture (FSP) and kyphosis, which negatively impact respiratory function. Individuals with kyphosis experience fatigue and have considerable difficulty with activities that require an upright posture or high exercise tolerance, such as walking, climbing stairs, housework, and reaching overhead. Consequently, basic activities of daily living are adversely affected by this spinal deformity. Correcting this posture can straighten the spine and enhance lung capacities. Kyphosis is characterized by excessive thoracic flexion, forward shoulders, and abducted scapulae. A thoracic supportive device, such as a postural brace, can be used to correct these postural abnormalities.

Aim: The aim of this study is to evaluate the effectiveness of respiratory muscle training as a sole intervention in improving respiratory function and overall health outcomes in patients with Chronic Obstructive Pulmonary Disease (COPD).

Material and Method: This prospective randomized controlled trial was conducted in the Department of Respiratory Medicine. Patients were randomly assigned to either a respiratory muscle training (RMT) group or an RMT with postural correction group using concealed envelopes. The study included male and female patients aged 40-70 years who were diagnosed with mild to moderate stable COPD by a physician and referred for pulmonary rehabilitation. After being briefed about the study, patients provided informed written consent. Demographic data were collected, and multiple outcome measures were evaluated. Assessments were conducted on day one before the intervention and eight weeks post-intervention, with a follow-up after three months. All subjects were referred from the Pulmonary and Medicine Outpatient Department (OPD) or as inpatients.

Results: Out of the initial 102 patients included in the study, 2 patients (one from each group) did not complete the intervention program. One patient in the control group dropped out due to prolonged exacerbations of respiratory disease, and one patient in the study group withdrew consent. Therefore, a total of 100 patients completed the study. The postural assessment, pulmonary function, and demographics of the two groups were well-matched, showing no significant differences between the groups for any variables. However, the 6-minute walk distance (6MWD) in the control group was significantly lower than in the study group.

Conclusion: From the present study it can be stated that postural correction along with respiratory muscle training is a meaningful addition to pulmonary rehabilitation programmes directed at COPD patients with inspiratory muscle weakness and faulty posture. It was also noted that few variables maintained the state of improvement even after 3 months of follow up in both the groups.

Keywords: COPD, Spirometry, Forward Shoulder Posture, Kyphosis and Plumbline.

Introduction

Chronic Obstructive Pulmonary Disease (COPD) is a major global health issue, characterized by persistent respiratory symptoms and airflow limitation due to airway and/or alveolar abnormalities. COPD typically arises from significant exposure to noxious particles or gases, most commonly from tobacco smoke, and it ranks as the third leading cause of death worldwide. [1] The disease imposes a substantial burden on patients, healthcare systems, and society, given its chronic nature and associated comorbidities, including cardiovascular diseases, osteoporosis, and metabolic syndrome. [2]

The pathophysiology of COPD involves chronic inflammation, increased mucus production, and structural changes in the lungs, which collectively impair gas exchange and lead to progressive airflow limitation. Patients with COPD experience symptoms such as chronic cough, sputum production, and dyspnea (shortness of breath), which significantly impair their quality of life and physical functioning. Exacerbations, defined as acute worsening of respiratory symptoms, further contribute to disease progression and morbidity.[3,4]

Standard COPD management includes pharmacological treatments (bronchodilators, corticosteroids), lifestyle modifications (smoking cessation, vaccination), and non-pharmacological interventions (pulmonary rehabilitation, oxygen therapy). [5] Pulmonary rehabilitation, a comprehensive intervention that includes exercise training, education, and behavioral change, is particularly effective in improving exercise capacity, reducing symptoms, and enhancing quality of life. However, access to pulmonary rehabilitation programs is often limited due to resource constraints, patient mobility issues, and other barriers. [6]

In recent years, Respiratory Muscle Training (RMT) has gained attention as a potential therapeutic approach for COPD patients. RMT involves exercises designed to strengthen the respiratory muscles, primarily the diaphragm and intercostal muscles, which are critical for effective breathing. The rationale behind RMT is based on the observation that respiratory muscle weakness is prevalent in COPD patients and contributes to dyspnea and exercise intolerance. [7]

There are two main types of RMT: inspiratory muscle training (IMT) and expiratory muscle training (EMT). IMT focuses on strengthening the muscles involved in inhalation, while EMT targets the muscles responsible for exhalation. Both types of training can be performed using specific devices that provide resistance during breathing exercises, thereby enhancing muscle strength and endurance over time. [8]

Previous studies have shown that RMT can lead to significant improvements in respiratory muscle strength, lung function, exercise capacity, and quality of life in COPD patients. For instance, IMT has been associated with increased maximal inspiratory pressure (MIP) and reduced dyspnea during physical activities. Despite these promising findings, RMT is often used as an adjunct to other treatments rather than as a standalone intervention. Consequently, the isolated effects of RMT on COPD management remain underexplored. [9]

This study aims to fill this gap by evaluating the effectiveness of RMT as a sole intervention for COPD patients. By isolating RMT from other treatment modalities, we can better understand its specific contributions to improving respiratory function and overall health outcomes. The primary objectives of this study are to assess changes in respiratory muscle strength, lung function, exercise capacity, and quality of life following a structured RMT program. [10,11]

Understanding the potential benefits of RMT as a standalone therapy is particularly important given the barriers to accessing comprehensive pulmonary rehabilitation.[12] If RMT proves to be effective on its own, it could offer a more accessible and cost-effective option for COPD patients who are unable to participate in full pulmonary rehabilitation programs. Moreover, RMT could be easily implemented in various settings, including outpatient clinics, home-based programs, and telehealth platforms, thereby reaching a broader patient population. [13]

The implications of this research are significant for clinical practice and COPD management guidelines. Demonstrating the efficacy of RMT as a sole intervention could lead to its integration into standard care protocols, offering an additional tool to manage COPD and improve patient outcomes. Furthermore, this study will contribute to the growing body of evidence supporting the role of non-pharmacological interventions in chronic disease management, highlighting the importance of personalized and multifaceted treatment approaches. [14,15]

Material and Methods

This prospective randomized controlled trial was conducted in the Department of Respiratory Medicine. Patients were randomly assigned to either a respiratory muscle training (RMT) group or an RMT with postural correction group using concealed envelopes.

The study included male and female patients aged 40-70 years who were diagnosed with mild to moderate stable COPD by a physician and referred for pulmonary rehabilitation. After being briefed about the study, patients provided informed written consent.

Demographic data were collected, and multiple outcome measures were evaluated. Assessments were conducted on day one before the intervention and eight weeks post-intervention, with a follow-up after three months. All subjects were referred from the Pulmonary and Medicine Outpatient Department (OPD) or as inpatients.

Inclusion Criteria

- Diagnosed with moderate to severe COPD (GOLD stage 2-4)
- Stable clinical condition
- Age between 40 and 75 years

Exclusion Criteria

- Recent COPD exacerbation
- Other significant respiratory diseases
- Cardiac or neuromuscular disorders

Statistical Analysis

All analyses within the groups were done using SPSS Version 16. Descriptive statistics are reported as means and SD (standard deviation). A repeated measures analysis of variance for each individual outcome measure time was performed to determine if there was any change in scores at three time periods within the groups.

The repeated measures of time were baseline, 8 weeks post-intervention, and 3 months post-intervention.

Result:

Of the initial 102 patients who were included in the study 2 patients (1 patient in each group) did not complete the intervention program.

One patient dropped out from the control group because of prolonged exacerbations of respiratory disease, and one patient in the study group withdrew consent. Hence a total of 100 patients completed the study. The baseline characteristics of the 100 patients (50 in each group) are shown in Table 1.

Table 1: Baseline characteristics of subjects

Variables	Control Group	Study Group
Subjects (n)	50	50
Gender		
Males	30 (60%)	40 (80%)
Females	20 (40%)	20 (30%)
Age in years	50.73 ± 2.54	44.10±2.38
Height in cms	155.02±3.23	157.10±2.30
Weight in Kgs	63.02±3.81	64.52±5.37
ISD in inches	4.33±0.68	4.26±0.63
KI (%)	9.13±0.88	9.25±0.77
PL in grades	1.22±0.62	1.32±0.60
6 MDW (mts)	239.0±5.21	243.04±8.31
Borg /dysp	2.10±0.86	2.15±1.07
FVC (liters)	1.13±0.20	1.14±0.17
FEV1 (liters)	1.24±0.12	1.21±0.10
FEV1/FVC (%)	50.7±3.11	49.25±3.36
PEF(L/Sec)	1.69±0.52	1.77±0.55
MVV (L/min)	33.04±4.08	32.04±5.23
PI Max (cm H_2O)	49.37±7.22	19.62±10.44

Patients with mild-to-moderate airflow obstruction, with a mean age of 50.73 ± 2.54 years in the control group and 44.10 ± 2.38 years in the study group, received intervention. In the control group, 30 (65%) males and 20 (35%) females volunteered for the study, while in the study group, 40 (70%) males and 10 (30%) females participated. Postural assessment, pulmonary function, and demographic characteristics were well-matched between the two groups, showing no significant differences for any variables. However, the 6-minute walk distance (6MWD) in the control group was significantly lower than in the study group, with mean scores of 239.0 ± 5.21 meters and 243.04 ± 8.31 meters, respectively. Additionally, peak expiratory flow (PEF) values were higher in the study group, with mean values of 1.69 ± 0.52 L/Sec for the control group and 1.77 ± 0.55 L/Sec for the study group.

Table 2: Within-group comparison of the control group at baseline, 8 weeks, and 3 months of follow-up

Outcome Measures	1	2	3
	Mean ± SD	**Mean ± SD**	**Mean ± SD**
	Baseline	**8 weeks**	**3 months**
ISD (inches)	4.26±0.66	4.26±0.66	4.26±0.66
KI (%)	9.14±0.88	9.14±0.88	9.14±0.88
PL	1.15±0.62	1.15±0.62	1.15±0.62
6 MWD (mts)	235.0±5.15	308.6±13.82	298.62±16.43

Borg Dyspnea	3.10±0.89	1.6±0.5	2.21±0.71
FVC (Liters)	1.25±0.26	3.04±0.29	1.13±0.23
FEV1(Liters)	1.30±0.13	1.18±0.24	1.70±0.17
FEV1/FVC (%)	50.7±3.11	62.54±1.37	58.66±3.22
PEF (L/sec)	1.72±0.51	1.91±0.62	1.3±0.44
MVV (L/min)	33.04±3.05	44.30±3.21	45.96±3.2
Pi MAX (cm H2O)	48.32±9.34	83.48±13.1	70.32±13.3

Within-group comparisons from baseline to 8 weeks and 3 months were conducted for both groups and are presented in Table 2. The means and standard deviations for Inspiratory Sternal Distance (ISD) in the control group at baseline, 8 weeks, and 3 months were 5.38 ± 0.78 inches, 5.38 ± 0.78 inches, and 5.38 ± 0.78 inches, respectively. Repeated measures of ISD (in inches) scores and Kyphosis Index (KI) scores in the control group showed no significant differences among the three time periods. The repeated measures of Postural Lordosis (PL) scores in the control group also revealed no significant difference among the three time periods.

However, repeated measures of the 6-minute walk distance (6MDW, in meters) and Borg scale of dyspnea in the control group showed significant differences among the three time periods. Additionally, repeated measures of Forced Vital Capacity (FVC, in liters), Forced Expiratory Volume in 1 second (FEV1, in liters), FEV1/FVC ratio (in percentage), Peak Expiratory Flow (PEF, in liters/second), and Maximum Voluntary Ventilation (MVV, in liters/minute) in the control group revealed significant differences among the three time periods.

Discussion

A total of 100 COPD patients participated in this study, receiving interventions over an 8-week period with a 3-month follow-up. Conducted in the outpatient department of Respiratory Medicine, patients diagnosed with COPD were randomly assigned to either the study group, receiving both postural correction and respiratory muscle training, or the control group, receiving only respiratory muscle training. This study aimed to compare the outcomes between the two groups. The key findings revealed that incorporating regular respiratory muscle training into pulmonary rehabilitation not only corrected posture but also resulted in additional improvements in inspiratory muscle strength, dyspnea scores, functional capacity, and pulmonary function among COPD patients. Notably, certain variables maintained their improved state even after the 3-month follow-up period.

Higgins et al.1977 [16] reported that 14% of adult men and 8% of adult women had chronic bronchitis, obstructive airway disease, or both. According to Kalpaj et al.2008 [17] the prevalence rate of COPD in India for men is 2% to 22% (median 5%) and1.2% to19% (median 2.7%) in women. In a significant multicentric study funded by the Indian Council of Medical Research (ICMR), COPD prevalence was estimated to be 5% among men and 3.2% among women. The study indicated a higher proportion of males diagnosed with COPD compared to females.

Wanke et al.1994 [18] did a study on patients with COPD with baseline mean age of 55±5years in one group and 57±6 years in other groups, the height of these subjects was 168±8 cms and 166± 8cms respectively, while the weight of these patients was 72.3±9.4 kg in one group and 70.8±10.6 kgs in the other group. They did this study to find the effects of combined inspiratory muscle and cycle ergometer training on exercise performance in patients with COPD. It was concluded with improvement in exercise performance following exercise training and inspiratory muscle training in mild to severe COPD patients.

Wanke et al. 1994 [18] reported and showed no improvement in exercise performance following exercise training and inspiratory muscle training in mild to severe COPD patients with baseline mean FVC of 3.03±0.89 liters in one group and 3.12±0.67 liters in the other group, the FEV1 of these subjects were 1.31±0.52 liters in one group and 1.34±0.44 liters in other group and the FEV/FVC% in group were 44±15 % and 43±14% in the other. In our study the mean values of the FVC and FEV1/FVC were slightly different at the baseline. The mean FVC at baseline for the control group was 2.27±0.26 liters and that of the study group was 2.24±0.23 liters. There was no significant difference between these groups at the baseline.

Putt et al.2008 [19] reported that hyperinflation and increased work of breathing in patients with COPD cause secondary postural deformities. Postural changes include elevated, protracted, or abducted scapulae with medially rotated humerus and kyphotic spinal deformity.

Hillegass et al.2001 [20] reported that patients with COPD tend to develop kyphosis and rounded shoulder posture with shortening of the pectoralis major muscle. In patients with chronic airflow limitation, the inspiratory muscles are required to overcome increased airway resistance and increased inspiratory elastance as functional residual capacity (FRC) increases. In addition to increasing the elastic load to breathing, this overinflation places the inspiratory muscles at a suboptimal length for generation of muscle tension and reduces the mechanical efficiency of the diaphragm and rib cage.' The inspiratory muscles, especially the diaphragm, may therefore be susceptible to fatigue as a result of increased loading and diminished "capacity" to produce inspiratory force. [21]

Gosselink et al.2000 [22] reported that respiratory muscle dysfunction is attributed to multiple factors related to the presence and severity of COPD. Indeed, intrinsic (muscular and metabolism mass) as well as extrinsic factors (changes in chest wall geometry diaphragm position, and systemic metabolic factors) may alter respiratory muscle function.

Ghanbari 2008 [23] reported that vital capacity (VC), forced vital capacity (FVC), and expiratory reserve volume (ERV) decreased as the degree of forward shoulder posture increased. Although patients with COPD have decreased respiratory values with bad posture and taking into consideration the ill effects of bad posture in the form of kyphosis and forward shoulder posture on respiratory values, the study group received an addition of postural correction with a brace.

Massushilta et al.1992 [24] reported the effect of dyspnea and inspiratory muscle function during exercise in severe chronic obstructive pulmonary disease (FEV1 0.61L +/- 0.15L). Here the relationship between respiratory muscle function and the sensation of dyspnea (Borg scale) during exercise was investigated in eight patients using EMG. With diaphragmatic fatigue, these patients were extremely dyspneic. Hence it has been concluded that there was a high correlation between respiratory muscle and dyspnea.

Conclusion:

Both groups exhibited enhanced respiratory muscle strength, with the study group, which received additional postural correction alongside respiratory muscle training, showing statistically and clinically significant improvements in inspiratory muscle strength and posture correction among COPD patients.

However, both groups experienced additional benefits, including reduced dyspnea scores, enhanced functional capacity, and improved pulmonary function. These outcomes underscored the considerable clinical impact of the study group compared to the control group. Furthermore, certain variables demonstrated sustained improvements even after the 3-month follow-up period in both groups. This study highlights the meaningful integration of postural correction with respiratory muscle training in pulmonary rehabilitation programs for COPD patients with inspiratory muscle weakness and postural abnormalities.

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