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Impact of Pulmonary Rehabilitation (PR) on Functional Exercise Capacity among Chronic Obstructive Pulmonary Disease (COPD) Patients: Pilot Study

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Abstract **Introduction:** Chronic Obstructive Pulmonary Disease (COPD) is a complex lung disorder marked by persistent respiratory symptoms such as breathlessness, cough and sputum production due to airway and/or alveolar damage. **Methods:** A quasi-experimental pretest-posttest design was employed, assessing 10% of the projected sample size (n = 200) using convenience sampling at Saveetha Medical College and Hospitals, Chennai. The experimental group received a three-month intensive PR program in addition to standard medical care per GOLD guidelines, while the control group received only standard care. The intervention included education on COPD management, breathing exercises, physical training and psychological support. Outcomes were measured at just before starting the study, 6th week and 12th week using 6-Minute Walk Test (6MWT). **Results:** Both the groups were comparable at just before the study initiation regarding clinical and demographic characteristics. The experimental group showed a significant increase in 6MWT distance over 12 weeks (from 320±45 m to 400±48 m; $F = 42.18$, $p<0.001$), whereas the control group exhibited only minimal improvement. **Conclusions:** A comprehensive pulmonary rehabilitation program significantly improved the exercise capacity in COPD patients regardless of demographic or clinical variables, highlighting its importance as an adjunct to standard medical treatment.

Key Words Pulmonary Rehabilitation, Chronic Obstructive Pulmonary Disease, 6 Minute Walk Test, Exercise Training

INTRODUCTION

The 2023 GOLD guidelines define COPD as a diverse lung condition with chronic symptoms (e.g., dyspnea, cough, mucus production) caused by airway and/or alveolar abnormalities, leading to persistent airflow obstruction [1]. Cigarette smoking and passive smoking are identified as the highest risk factors compared to other non-smoking causes [1-3]. A study from an Asian country found that the mortality rate from COPD ranked third lowest from 2002 to 2022 [4]. The GOLD (2023) guidelines and recent recommendations suggest step-by-step algorithms for pharmacological therapy in COPD patients [1,5]. A thorough evaluation in 2020 found that Pulmonary Rehabilitation (PR) is the most effective approach to improving muscular function, reducing dyspnea and increasing physical activity endurance in individuals diagnosed with COPD [6,7].

A comprehensive systematic review and component network meta-analysis of 337 Randomized Controlled Trials (RCTs) involving over 19,000 individuals with COPD found that in-person supervised Pulmonary Rehabilitation (PR) components and delivery modalities provided the most significant benefits [8]. A holistic PR program improved adherence and outcomes physically, mentally and socially for COPD patients [9]. Components of pulmonary rehabilitation often include exercise training, education and self-management, psychological and nutritional support, behavioral modification, physical activity promotion, as well as oxygen therapy and ventilatory support to enhance results [10]. Pulmonary rehabilitation has been shown to improve exercise capacity, reduce dyspnea, promote functional independence and support psychological well-being [11].
The fundamental component encompasses aerobic activities (such as walking and cycling) and resistance training to enhance skeletal muscle performance and exercise endurance. Interval training and exercises for the upper and lower limbs are frequently employed [9-11]. Post- hospital discharge PR for COPD exacerbation leads to decreased hospital readmissions and enhancements in exercise capacity, health-related quality of life and dyspnoea [12]. Hence, the study focused to assess the effectiveness of Pulmonary Rehabilitation (PR) on functional exercise capacity among patients with COPD.

METHODS

A quasi-experimental pre-test and post-test study method was employed. The samples were categorised into two groups: one the experimental and the control, each including 10 samples using convenience sampling method. The Inclusion criteria comprised individuals aged 40 years old and above, encompassing both male and female patients, those exhibiting diminished exercise tolerance, individuals experiencing exertional dyspnoea or fatigue, patients utilising oxygen support or not, individuals diagnosed according to GOLD criteria grades 2-4, patients with hyperinflation, mild to moderate impairment in activities of daily living, participants willing to engage in the study and individuals capable of reading, writing or speaking Tamil, English or Hindi. The exclusion criteria encompass patients who are bedridden and those who have undergone significant procedures, such as CABG, within the past six months. Patients with comorbidities such as liver disease, dialysis-dependent renal disease, musculoskeletal restrictions, cardiac or respiratory failure, ischaemic heart disease and other debilitating diseases that may impede testing, as well as those participating in other research projects.

Ethical Approval

The Institutional Ethics Committee approved the research project on October 1, 2024 and the reference number (002/10/2024/IEC/SMCH) was received to proceed with the pilot study.

Intervention

The experimental group received intense Pulmonary Rehabilitation (PR) for a duration of three months. It comprises breathing exercises, physical training, psychoeducation, social activities, emotional reinforcement and dietary instruction. Nevertheless, the Exercise Training program mostly focused on observing changes in the result aspect. Both the control and experimental groups got standard medical care as per the Global-initiative Obstructive Lung Disease (GOLD) guidelines, whereas the experimental group additionally involved in Pulmonary Rehabilitation (PR) program. The study group received a planned educational teaching on COPD and its management. Furthermore, the participants engaged in breathing exercises such as deep breathing, pursed lip breathing, controlled coughing, diaphragmatic breathing and singing. Intensive exercise training included a warm-up (3-5 minutes), strength and endurance training (10-15 minutes based on tolerance) and cooldown exercises (2-3 minutes). Psychoeducation, emotional fortification through counselling as needed and nutritional education were provided over a three-month period, twice weekly for both inpatients and outpatients. Outcomes were assessed three times during the study: prior to the intervention, one and a half months post-intervention and at the conclusion of the intervention program. The demographic characteristics and 6-minute walk test for both the control and study groups were conducted at the scheduled assessment time.

Data Analysis

Section A: Demographic and Clinical Variables of the Experimental and the Control Group: The experimental and control groups were demographically similar. In the experimental group, 50% were aged 51-60 years and 70% were male, while the control group had 40% aged 51-60 years and 60% male. Most participants in both groups were Hindus (60% experimental, 70% control). Educational and occupational distributions were similar, with 30% graduates and most working in industrial settings. The majority earned ₹27,883-₹69,534 monthly and resided in urban areas (50% experimental, 60% control).

Both groups had similar clinical profiles. COPD duration was 1-3 years for 50% (experimental) and 40% (control). Smoking rates were 60% in the experimental and 50% in the control group, with a higher frequency of productive cough in the experimental group (70% vs. 60%). Comorbidities included hypertension (40% experimental, 30% control) and diabetes (30% in both). Most used bronchodilators (80% experimental, 70% control) and practiced breathing exercises (70% experimental, 60% control). Protein intake was slightly higher in the experimental group (1.2±0.3 g/kg/day).

Section B: Effect of Pulmonary Rehabilitation on 6Minute walk Test (6MWT) among the Experimental and Control Group

Table 1 portrays that the effect of Pulmonary Rehabilitation on functional exercise capacity, assessed by the 6MWT, is presented in Table 1. At baseline, the mean 6MWT distance was similar between groups (320±45 m in the experimental group and 325±40 m in the control group). Following six weeks, participants in the experimental group demonstrated a notable improvement in mean walking distance to 360±50 m, whereas the control group elicited a modest hike to 335±42 m. By 12 weeks, the experimental group exhibited a further increase to 400±48 m, indicating a substantial enhancement in exercise capacity, while the control group improved only slightly to 340±43 m. These findings suggest that pulmonary rehabilitation significantly enhanced functional exercise performance over the 12-week period in the experimental group compared to standard care in the control group.

Figure 1 shows the significant increase in walking distance in the Experimental Group suggests the intervention was effective in improving functional exercise capacity. The Control Group showed minimal improvement, indicating the changes in the Experimental Group were likely due to the intervention rather than natural progression or practice effect.

Table 1: 6Minute Walk Test (6MWT) Distance at Pretest, 6 Weeks and 12 Weeks

Time Point	Experimental Group (n = 10) Mean±SD (m)	Control Group (n = 10) Mean±SD (m)
Pretest	320±45	325±40
6th Week	360±50	335±42
12th Week	400±48	340±43

Table 2: Within-Group Comparison of 6MWT Distance Using Repeated Measures ANOVA

Group	Time Point	Mean±SD (m)	Change from Previous Time Point (m)	F-value	p-value
Experimental (n = 10)	Pretest	320±45	-	42.18	<0.001*
	6th Week	360±50	+40	-	-
	12th Week	400±48	+40	-	-
Control (n = 10)	Pretest	325±40	-	2.12	0.15
	6th Week	335±42	+10	-	-
	12th Week	340±43	+5	-	-

p<0.05-Significant

Table 3: Between-Group Comparison of 6MWT Distance Using Mann-Whitney U Test

Time Point	Experimental (m)	Control (m)	U-value	p-value
Pretest	320±45	325±40	45.0	0.62
6th Week	360±50	335±42	22.0	0.03
12th Week	400±48	340±43	18.0	0.01

Table 4: Association of Demographic and Clinical Variables with Post-test 6MWT Distance in Experimental Group (n = 10)

Variable	Category	n	Post-test 6MWT Mean±SD (m)	p-value
Age (years)	40-50	3	410±45	0.58
	51-60	5	395±50	
	≥61	2	400±48	
Gender	Male	7	398±48	0.72
	Female	3	405±50	
Religion	Hindu	6	400±45	0.85
	Christian	2	395±50	
	Muslim	2	410±55	
Educational Status	Professional degree	1	420	0.91
	Graduate	3	400±45	
	Diploma/Intermediate	2	395±50	
	High School	2	390±48	
	Primary	1	380	
	Illiterate	1	405	
Nature of Workplace	Industrial	6	400±45	0.68
	Non-industrial	4	395±50	
Area of Residence	Urban	5	398±48	0.80
	Semi-urban	3	400±45	
	Rural	2	405±50	
History of COPD (years)	<1	2	410±50	0.77
	1-3	5	398±48	
	4-6	2	395±45	
	>6	1	400	
Habit of Smoking	Yes	6	398±50	0.88
	No	4	400±45	
Comorbid Illness	Present	7	397±48	0.70
	Absent	3	405±50	

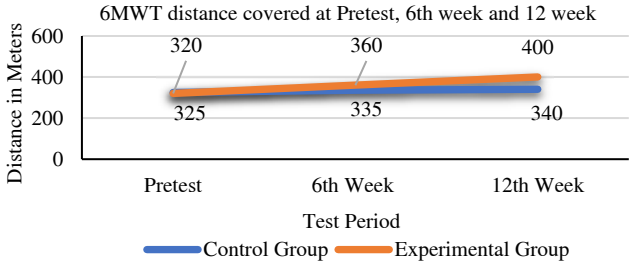

Figure 1: 6MWT distance covered at Pretest, 6th week and 12th week

Within-group analysis (Table 2) using repeated measures ANOVA showed that the experimental group experienced a significant improvement in 6MWT distance over 12 weeks ($F = 42.18$, $p<0.001$), increasing from 320±45 m at pretest to 400±48 m at 12th week. The control group showed a minimal, non-significant increase ($F = 2.12$, $p = 0.15$). Whereas Between-group analysis (Table 3) using the Mann-Whitney U-test demonstrated no significant difference at baseline ($U = 45.0$, $p = 0.62$), confirming comparability. However, at the 6th week ($U = 22.0$, $p = 0.03$) and 12th week ($U = 18.0$, $p = 0.01$), the experimental group showed significantly higher 6MWT distances than the control group. These results indicate that pulmonary rehabilitation significantly improved functional exercise capacity compared with standard care.

Section C: Association of Demographic Variables with Post-test 6MWT Distance in the Experimental Group

Table 4 presents the association of the demographic and the clinical variables with post-test 6MWT distance in the experimental group. No significant associations were observed for age ($p = 0.58$), gender ($p = 0.72$), religion ($p = 0.85$), educational status ($p = 0.91$), nature of workplace ($p = 0.68$), area of residence ($p = 0.80$), history of COPD

(p = 0.77), smoking habit (p = 0.88) and comorbid illness (p = 0.70). These findings indicate that improvements in functional exercise capacity following pulmonary rehabilitation were consistent across demographic and clinical subgroups.

DISCUSSION

The findings of this study provide strong evidence that Pulmonary Rehabilitation (PR) significantly improves functional exercise capacity, as measured by the 6-Minute Walk Test (6MWT). Specifically, the experimental group demonstrated a substantial improvement in walking distance, increasing from a baseline average of 320±45 m to 400±48 m by week 12. In comparison, the control group experienced only a modest increase, from 325±40 m to 340±43 m during the same period. These differences highlight the effectiveness of PR programs in enhancing physical performance among individuals with chronic respiratory conditions [13,14].

The significant within-group improvements in the experimental group ($F = 42.18$, $p<0.001$) contrasted with the non-significant changes in the control group ($F = 2.12$, $p = 0.15$), further support the robustness of PR effects. These findings align with previous studies that have consistently demonstrated improvements in exercise capacity and quality of life through PR. For example, a systematic review found that structured PR is critical in achieving clinically meaningful improvements in the 6MWT for patients with Chronic Obstructive Pulmonary Disease (COPD), reinforcing the validity of the present study's outcomes [15,16].

Additionally, the results of the between-group analyses further underscore the effectiveness of PR, with significant differences in walking distance observed at both 6 weeks and 12 weeks, with U-values of 22.0 (p = 0.03) and 18.0 (p = 0.01), respectively. These findings are consistent with previous studies suggesting that PR leads to meaningful improvements compared to standard care [17,18]. A meta-analysis also emphasized that rehabilitation patients not only showed greater exercise capacity but also improvements in related symptoms such as dyspnea and fatigue, indicating broader benefits beyond walking distance alone [19,20].

Moreover, the result indicating that 50% of participants achieved Minimal Clinically Important Differences (MCID) in the 6MWT is consistent with prior research documenting similar trends [21,22]. These findings underscore the importance of incorporating PR as a core component of treatment for chronic respiratory diseases, suggesting that it enhances exercise capacity and acts as a catalyst for broader improvements in overall health metrics when compared to usual care [23,24].

In conclusion, this study reinforces the crucial role of pulmonary rehabilitation in the management of chronic respiratory diseases, with significant implications for clinical practice. Future research should continue to explore the long-term sustainability of these improvements and investigate the integration of innovative delivery methods, such as tele-rehabilitation, which have shown promise in improving adherence and access to rehabilitation programs [25].

CONCLUSIONS

The pilot study revealed that pulmonary rehabilitation significantly enhanced exercise tolerance among individuals with chronic obstructive pulmonary disease, as evidenced by improved 6-minute walk test performance after a 12-week program. Compared with standard care, the comprehensive rehabilitation approach-encompassing exercise, breathing training, education and psychological support-effectively improved functional capacity across diverse patient profiles, highlighting its vital role in boosting physical endurance and overall quality of life.

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