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# EFFECT OF PULMONARY REHABILITATION ON QUALITY OF LIFE AND EXERCISE CAPACITY IN PATIENTS WITH CHRONIC OBSTRUCTIVE PULMONARY DISEASE: A LONGITUDINAL STUDY

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## ABSTRACT

**Background:** Chronic obstructive pulmonary disease (COPD) is a major cause of morbidity and mortality worldwide, characterised by persistent airflow limitation, physical deconditioning, and impaired health-related quality of life (HRQoL). Pulmonary rehabilitation (PR) is a comprehensive, evidence-based, multidisciplinary intervention that is now regarded as the most effective non-pharmacological therapy for improving exercise capacity and HRQoL in COPD, yet its implementation remains limited in resource-constrained settings. **Aim and Objectives:** To study the effect of pulmonary rehabilitation in COPD, with the specific objective of determining its impact on quality of life and exercise capacity among COPD patients.

**Materials and Methods:** This longitudinal study was conducted over 18 months in the Department of Respiratory Medicine, Kanachur Institute of Medical Sciences and Research Hospital, Mangalore. Forty-two stable COPD patients aged 20–85 years, diagnosed by GOLD/ATS-ERS spirometric criteria, underwent a structured 6-week PR program comprising physical training (breathing exercises, limb exercises, Nordic walking) and self-management education (smoking cessation, treatment adherence, inhaler technique), with follow-up at 2, 4, and 6 weeks. Pre- and post-rehabilitation assessments included spirometry (FEV1, FVC, FEV1/FVC), 6-minute walk distance (6MWD), sit-to-stand test, stair climbing test, treatment adherence, inhaler technique, and quality of life using the St George's Respiratory Questionnaire-COPD (SGRQ-C). Data were analysed using SPSS version 27, with paired t-tests and $p<0.05$ considered significant.

**Results:** Participants were predominantly male (73.8%), aged 51–60 years (31.0%), skilled workers (35.7%), and non-smokers (64.3%). Following PR, FEV1 improved from 1.1±0.13 L to 1.4±0.14 L and FEV1/FVC from 51.12±2.78% to 59.21±3.97% ($p<0.001$ for both). Exercise capacity improved significantly: 6MWD increased from 297.14±29.66 m to 375.48±46.76 m, sit-to-stand repetitions from 9.5±1.21 to 13.45±1.81, and stair-climbing performance from 40.95±4.45 to 52.79±5.91 steps/min ($p<0.001$ for all). Treatment adherence rose from 67.93±3.23% to 88.57±3.95% ($p<0.001$), and SGRQ-C scores fell from 63.79±3.02 to 42.5±4.1 ($p<0.001$), indicating improved quality of life. Inhaler technique improved from 0% correct or mostly correct at baseline to 100% post-rehabilitation.

**Conclusion:** A structured 6-week pulmonary rehabilitation program produced statistically and clinically significant improvements in pulmonary function, exercise capacity, treatment adherence, inhaler technique, and quality of life in

patients with stable COPD. These findings support the integration of PR as a standard component of COPD management, particularly in resource-limited settings.
**Keywords:** Pulmonary rehabilitation; chronic obstructive pulmonary disease; quality of life; exercise capacity; six-minute walk test; SGRQ-C.

## INTRODUCTION

The Global Initiative for Chronic Obstructive Lung Disease (GOLD) defines chronic obstructive pulmonary disease (COPD) as a heterogeneous lung condition characterised by chronic respiratory symptoms—dyspnoea, cough, sputum production, and/or exacerbations—due to abnormalities of the airways and/or alveoli that cause persistent, often progressive airflow obstruction. COPD is a major cause of morbidity and mortality worldwide and carries a high socioeconomic burden.1 COPD develops through complex, cumulative interactions between genetic factors and environmental exposures over an individual's lifetime, leading to lung damage and disrupted lung development and ageing.[1]

Beyond airway inflammation and emphysema, pulmonary vascular pathology has emerged as a third major component of COPD, contributing significantly to its associated morbidity and mortality; pulmonary vascular involvement raises pulmonary vascular resistance and pulmonary artery pressure, increasing right ventricular afterload, with pulmonary hypertension typically representing a late complication of advanced disease.[2] Globally, COPD causes an estimated 3 million deaths annually and is projected to become the third leading cause of death, with the South-East Asian region expected to bear a disproportionate share of this rising mortality.[3] Recent Global Burden of Disease estimates place the worldwide prevalence of COPD at around 2.7%, affecting approximately 213 million people of all ages,[4] and India alone is estimated to have around 30 million affected individuals, recording one of the highest COPD mortality burdens worldwide and highlighting the need for a dedicated national prevention and control strategy.[5]

For many years, COPD was viewed primarily as a disorder of progressive breathlessness caused by tobacco smoking. However, the disease also drives physical inactivity, which in turn accelerates loss of muscle mass and further decline in exercise capacity, creating a self-perpetuating cycle of deconditioning that extends beyond the lungs themselves.[6] Pulmonary rehabilitation (PR) is a comprehensive intervention based on thorough patient assessment followed by patient-tailored therapies—including but not limited to exercise training, education, and behaviour change—designed to improve the physical and psychological condition of people with chronic respiratory disease and to promote long-term adherence to health-enhancing behaviours.[7] PR is now recognised as the most effective non-pharmacological intervention for improving health status in COPD and has become integral to the lifelong management of symptomatic patients, rather than being reserved for severe illness alone.

Exercise intolerance is a common and disabling complaint in COPD, closely linked to reduced quality of life and survival, and can be assessed through walking- or cycling-based protocols.[8] The six-minute walk test (6MWT) remains the most widely used field test to evaluate functional exercise capacity in COPD because it is simple, inexpensive, and clinically well validated, even though cycle-based endurance testing may offer greater sensitivity to change in some contexts.[9]

Health-related quality of life (HRQoL)—the extent to which a patient's health status affects their own assessment of satisfaction and overall well-being—is an important prognostic indicator in COPD, with reduced HRQoL associated with increased hospitalisation and mortality.[10] The present study was undertaken to evaluate the effect of pulmonary rehabilitation on quality of life and exercise capacity among patients with COPD.

**Aims and Objectives**

**Aim:** To study the effect of pulmonary rehabilitation in chronic obstructive pulmonary disease.

**Objective:** To determine the impact of pulmonary rehabilitation on quality of life and exercise capacity among COPD patients.

## MATERIALS AND METHODS

**Study Setting and Design**

This longitudinal study was conducted in the Department of Respiratory Medicine, Kanachur Institute of Medical Sciences and Research Hospital, Deralakatte, Mangalore, Karnataka, India, over a period of 18 months from the time of Institutional Ethics Committee approval.

**Study Population**

The study population comprised patients attending the outpatient department of Respiratory Medicine diagnosed with COPD according to standard spirometric criteria (GOLD/ATS-ERS definition).1

**Sample Size**

A total of 42 stable COPD patients meeting the inclusion and exclusion criteria were enrolled. Sample size was calculated using $n = (Z\alpha+Z\beta)^2\sigma^2/d^2$, with $Z\alpha=1.645$ (90% confidence interval), $Z\beta=0.84$ (80% statistical power), an expected improvement in 6-minute walk test distance from a baseline of 255 m, a standard deviation ($\sigma$) of 52 m, and an expected

difference (d) of 20 m, yielding a total sample size of 42.

**Inclusion Criteria**

Stable COPD patients aged 20 to 85 years who provided informed consent to participate were included.

**Exclusion Criteria**

Patients with acute exacerbation of COPD, acute pulmonary tuberculosis, bronchial asthma, severe rheumatoid arthritis, gangrenous foot, cardiovascular disease, inability to walk, or age outside the 20–85 year range were excluded.

**Methods of Data Collection**

Eligible patients were identified and screened using spirometry. Participants received structured training in pulmonary rehabilitation, comprising physical training exercises—breathing exercises (deep breathing, diaphragmatic breathing), lower limb exercise, upper limb exercise, and Nordic walking—together with self-management education covering smoking cessation, treatment adherence, and inhaler technique. Follow-up evaluations were carried out at 2, 4, and 6 weeks to assess adherence and provide counselling.

Pre- and post-rehabilitation assessments included: 6-minute walk distance, stair-climbing test, sit-to-stand test, spirometry (FEV1, FVC, FEV1/FVC), and the St George's Respiratory Questionnaire-COPD (SGRQ-C) to assess quality of life.

**Statistical Analysis**

All data were compiled in Microsoft Excel and analysed using SPSS version 27. Continuous variables were expressed as mean and standard deviation, and categorical variables as frequencies and percentages. The chi-square test was used to assess normality, and paired t-tests were used to compare pre- and post-intervention values. A p-value of less than 0.05 was considered statistically significant.

## RESULTS

A total of 42 stable COPD patients completed the 6-week pulmonary rehabilitation programme and pre- and post-intervention assessments.

**Table 1: Demographic and Baseline Characteristics of Study Participants (n=42)**

| Characteristic | Category | Frequency (%) |
|---|---|---|
| Age group | 51–60 years | 13 (31.0) |
| | 31–40 years / ≥61 years | 9 each (21.4) |
| | 41–50 years | 8 (19.1) |
| | 21–30 years | 3 (7.1) |
| Gender | Male | 31 (73.8) |
| | Female | 11 (26.2) |
| Smoking history | Non-smoker | 27 (64.3) |
| | Smoker | 15 (35.7) |
| Occupation | Skilled worker | 15 (35.7) |
| | Semi-skilled worker | 10 (23.8) |
| | Professional | 9 (21.4) |
| | Unemployed | 8 (19.1) |

Middle-aged and elderly individuals formed the largest proportion of participants, with a male predominance and a majority engaged in skilled or semi-skilled manual occupations. Non-smokers (64.3%) outnumbered smokers, suggesting a substantial contribution of non-tobacco risk factors such as occupational and environmental exposure in this cohort.

**Table 2: Effect of Pulmonary Rehabilitation on Pulmonary Function**

| Parameter | Before PR (Mean±SD) | After PR (Mean±SD) | p value |
|---|---|---|---|
| FEV1 (L) | 1.1 ± 0.13 | 1.4 ± 0.14 | <0.001 |
| FEV1/FVC (%) | 51.12 ± 2.78 | 59.21 ± 3.97 | <0.001 |

**Table 3: Effect of Pulmonary Rehabilitation on Exercise Capacity**

| Parameter | Before PR (Mean±SD) | After PR (Mean±SD) | p value |
|---|---|---|---|
| 6-Minute Walk Distance (m) | 297.14 ± 29.66 | 375.48 ± 46.76 | <0.001 |
| Sit-to-Stand Test (reps/30s) | 9.5 ± 1.21 | 13.45 ± 1.81 | <0.001 |
| Stair Climbing Test (steps/min) | 40.95 ± 4.45 | 52.79 ± 5.91 | <0.001 |

**Table 4: Effect of Pulmonary Rehabilitation on Treatment Adherence and Quality of Life**

| Parameter | Before PR (Mean±SD) | After PR (Mean±SD) | p value |
|---|---|---|---|
| Adherence to treatment (%) | 67.93 ± 3.23 | 88.57 ± 3.95 | <0.001 |
| Quality of Life (SGRQ-C score) | 63.79 ± 3.02 | 42.5 ± 4.1 | <0.001 |

Since lower SGRQ-C scores indicate better health status, the 21-point reduction reflects a clinically meaningful improvement in patients' well-being and daily functioning.

**Table 5: Improvement in Inhaler Technique Following Pulmonary Rehabilitation**

| Category | Before PR, n (%) | After PR, n (%) |
|---|---|---|
| Correct | 0 (0) | 21 (50) |
| Mostly correct | 0 (0) | 21 (50) |
| Partially correct | 16 (38.10) | 0 (0) |
| Partially incorrect | 3 (7.14) | 0 (0) |
| Incorrect | 23 (54.76) | 0 (0) |

Before intervention, the majority of participants demonstrated incorrect inhaler usage (54.76%), while none demonstrated fully correct technique. After pulmonary rehabilitation, all participants (100%) achieved correct or mostly correct inhaler technique, with no incorrect or partially incorrect usage remaining.

## DISCUSSION

This study evaluated the effect of a structured 6-week pulmonary rehabilitation programme on pulmonary function, exercise capacity, treatment adherence, inhaler technique, and quality of life among 42 stable COPD patients. The cohort was predominantly male (73.8%), middle-aged (51–60 years, 31.0%), employed in skilled occupations (35.7%), and largely non-smokers (64.3%), reflecting a population in which occupational and environmental exposures, rather than tobacco alone, likely contribute substantially to disease burden.

The demographic profile observed—predominance of the 51–60 year age group with a substantial proportion of elderly participants—is consistent with prior PR cohorts, including those of Orooj et al. in asthma-COPD overlap syndrome,[11] Blervaque et al. in a long-term PR maintenance cohort,[12] Jayasheela and Sivabalan, whose participants were similarly concentrated in the 55–64 year range,[13] and Sharma et al., whose mean age was 64–65 years14, together confirming that middle-aged to elderly patients form the predominant demographic seeking pulmonary rehabilitation.

Male predominance (73.8%) in the present cohort aligns with the male-skewed distributions reported by Blervaque et al,[12] and Ali et al. in AECOPD patients undergoing PR,[15] although it contrasts with the female-predominant cohorts of Jayasheela and Sivabalan,[13] and Chacko et al,[16] likely reflecting differing local patterns of smoking and occupational exposure between study populations.

Although only 35.7% of participants in this study were smokers, the large non-smoking majority (64.3%) parallels the substantial non-smoking COPD burden described by Jayasheela and Sivabalan, whose cohort showed high rates of passive smoke and biomass exposure,[13] and by Tiwari et al., who documented biomass exposure in 13.8% of a large Indian COPD cohort, predominantly among women,[17] reinforcing that non-tobacco environmental and occupational exposures are important, and likely under-recognised, contributors to COPD in Indian populations.

The predominance of skilled and semi-skilled manual occupations (59.5% combined) among participants suggests a contribution of occupational dust and fume exposure to disease burden in this cohort, in keeping with occupational exposure patterns described in other Indian COPD populations,[17] although this pattern contrasts with the predominance of agricultural workers reported in some rural Indian cohorts,[13] likely reflecting the more urban-industrial catchment of the present study population.

Pulmonary rehabilitation produced a marked improvement in pulmonary function, with FEV1 rising from 1.1±0.13 L to 1.4±0.14 L and FEV1/FVC from 51.12±2.78% to 59.21±3.97% ($p<0.001$ for both). This magnitude of improvement exceeds the more modest FEV1 gains reported with home-based PR by Priya et al,[18] and with short-term PR in AECOPD by Ali et al,[15] and contrasts with the lack of significant pulmonary function change reported after short-term PR in asthma-COPD overlap syndrome by Orooj et al,[11] suggesting that a supervised, structured programme of the type used here can produce measurable gains in airflow parameters beyond those typically expected from PR, which classically targets extrapulmonary rather than purely pulmonary mechanisms.

Exercise capacity improved substantially across all three measures, with a 78 m (26%) gain in 6MWD, consistent with the magnitude of improvement reported by Ali et al. in AECOPD15 and exceeding the smaller gains reported by Jayasheela and Sivabalan,[13] and by home-based regimens such as that of Priya et al., where 6MWD change was not significant.[18] These findings are consistent with the broader literature confirming that supervised exercise training, including endurance and strength components, reliably improves functional exercise capacity in COPD,[8] and align with the Cochrane systematic review by McCarthy et al., which confirmed significant 6MWT improvement across pooled randomised trials of PR.[19]

Treatment adherence improved markedly, from 67.93±3.23% to 88.57±3.95% ($p<0.001$). This finding is particularly notable given that poor awareness and financial burden have been identified as major barriers to adherence in large Indian COPD cohorts,[17] and given that predictors of PR success and failure include patient motivation and engagement with structured education.[20] The magnitude of improvement in adherence observed here exceeds that implied by comparable Indian PR studies,[13] and is consistent with the good adherence

and completion achieved in a comparable short, structured outpatient PR programme delivered in a resource-limited setting,[21] supporting the central role of structured education within a supervised PR programme in overcoming barriers to compliance.

Quality of life, assessed by SGRQ-C, improved by 21 points (63.79±3.02 to 42.5±4.1; $p<0.001$), a magnitude exceeding the SGRQ improvements reported by Jayasheela and Sivabalan,[13] but consistent with the substantial multi-domain gains described by Orooj et al. in ACOS,[11] and by Chacko et al. across multiple validated quality-of-life instruments.[16] This improvement parallels the strong correlation between exercise capacity gains and quality-of-life improvement described by Kerti et al,[22] and is consistent with longer-term data from Blervaque et al. showing that HRQoL gains from PR can be sustained over several years with appropriate maintenance.[12] These findings are also consistent with the recognised impact of psychological and symptom burden on HRQoL in COPD more broadly.[23]

Inhaler technique showed a complete transformation, from 0% correct or mostly correct at baseline to 100% following rehabilitation, with elimination of incorrect and partially incorrect technique. This finding directly addresses a documented gap in Indian COPD care, where poor inhaler technique knowledge has been shown to significantly influence treatment adherence,[17] and underscores the critical role of structured, supervised education—an established core component of comprehensive PR programmes—in optimising pharmacotherapy delivery.[6,7]

Taken together, these findings reaffirm pulmonary rehabilitation as the most effective non-pharmacological intervention for improving exercise capacity and quality of life in COPD, consistent with long-term outpatient rehabilitation data,[24] and pooled evidence from randomised controlled trials.[19] In the Indian context, where COPD affects working-age adults through diverse aetiologies including occupational and biomass exposure, this study highlights the adaptability and effectiveness of a structured, supervised PR programme even within a resource-limited, single-centre setting.

**Limitations**

This study has certain limitations. It was conducted at a single tertiary care centre with a modest sample size of 42 patients, which may limit the generalisability of the findings. The absence of a control group precludes distinguishing the specific contribution of pulmonary rehabilitation from the natural course of stable COPD or from non-specific effects of increased clinical attention. Follow-up was limited to the immediate post-rehabilitation period, and the durability of the observed improvements in exercise capacity, adherence, and quality of life beyond six weeks was not assessed. Treatment adherence and inhaler technique were assessed by clinician evaluation and self-report, which may be subject to observer and reporting bias. Finally, potential confounders such as concurrent pharmacotherapy changes and comorbidities were not adjusted for in the analysis.

## CONCLUSION

This study demonstrates that a structured 6-week pulmonary rehabilitation programme, combining physical training and self-management education, produces statistically and clinically significant improvements in pulmonary function, exercise capacity, treatment adherence, inhaler technique, and quality of life in patients with stable COPD. These improvements were consistent across all measured domains and were achieved with complete participant retention, supporting the feasibility of comprehensive PR delivery even in a resource-limited Indian tertiary care setting. Given the predominance of occupational and non-tobacco risk factors in this cohort, these findings support the integration of pulmonary rehabilitation into routine COPD care, particularly for patients with occupational pollutant exposure. Larger, multicentre, randomised controlled trials with extended follow-up are needed to confirm the durability of these benefits and to establish the cost-effectiveness and scalability of PR, including home-based and hybrid delivery models, in similar resource-constrained settings.

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