RESEARCH PAPER

# Effectiveness of Three Months Pulmonary Rehabilitation in Patients with Chronic Respiratory Diseases: A Prospective Interventional Study

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***ABSTRACT***

**INTRODUCTION:** Chronic respiratory diseases are associated with persistent dyspnoea, reduced exercise tolerance, impaired pulmonary function and poor health-related quality of life. Pulmonary rehabilitation (PR) is a comprehensive, multidisciplinary intervention aimed at improving physical capacity, symptom burden, and overall well-being in such patients.

**AIM OF THE STUDY:** To assess the effectiveness of three months of pulmonary rehabilitation in patients with chronic respiratory diseases.

**MATERIALS AND METHODS:** This is prospective interventional single center study conducted among patients above 18 years of age with chronic respiratory diseases like COPD, asthma, post-tuberculosis sequelae and interstitial lung disease. Baseline and post-rehabilitation assessments were done after completion of a structured three-month pulmonary rehabilitation programme. Outcome measures included modified Medical Research Council dyspnoea scale, Borg dyspnoea score, spirometric parameters, six-minute walk test distance, peak expiratory flow rate, exercise $SpO_2$ and Chronic Respiratory Questionnaire (CRQ) scores. Statistical analysis was performed using SPSS version 20, and $p < 0.05$ was considered statistically significant.

**Results:** The mean age of participants was 60.22 ± 10.81 years and 72.9% were males. COPD was the most common diagnosis (64.6%). Following pulmonary rehabilitation, significant improvement was observed in dyspnoea severity, exercise capacity, pulmonary function and quality of life. Mean mMRC score reduced from 2.95 ± 0.67 to 1.77 ± 0.72 ($p < 0.001$), while Borg dyspnoea score decreased from 4.89 ± 1.28 to 2.48 ± 1.22 ($p = 0.001$). Mean 6MWT distance improved from 250.83 ± 61.19 m to 293.44 ± 65.24 m. Significant improvements were also noted in $FEV_1$, FVC, $FEV_1$/FVC ratio, PEFR and exercise $SpO_2$ values. Mean CRQ score increased from 89.14 ± 14.75 to 109.05 ± 14.82 ($p < 0.001$).

**Conclusion:** A structured three-month pulmonary rehabilitation programme showed significant improvements in dyspnoea severity, exercise tolerance, pulmonary function, oxygenation during exertion and health-related quality of life in patients with chronic respiratory diseases. These findings reinforce pulmonary rehabilitation as an essential component of comprehensive management and support its wider implementation in routine clinical practice.

**Keywords:** Pulmonary rehabilitation, COPD, Asthma, Interstitial lung disease, ILD, Post-tuberculosis sequelae, Six-minute walk test, Spirometry, Chronic respiratory disease, Quality of life, mMRC, CRQ.

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## INTRODUCTION

Chronic respiratory diseases (CRDs) like chronic obstructive pulmonary disease (COPD), asthma, interstitial lung disease (ILD) and post-tuberculosis sequelae are major contributors to global morbidity, mortality and healthcare burden. These disease conditions are associated with persistent dyspnoea, reduced exercise tolerance, impaired pulmonary function, psychological distress and poor health-related quality of life. Pulmonary rehabilitation (PR) is a comprehensive, multidisciplinary interventional approach with detailed patient assessment. This includes structured exercise training, patient education, and behavior modification with the aim of improving both the physical and psychological well-being of individuals with chronic respiratory diseases and promoting adherence to healthy lifestyle practices. Pulmonary rehabilitation can effectively reduce respiratory symptoms and improve exercise capacity and quality of life.[1][2]

In patients with chronic respiratory diseases

reductions in exercise capacity, reduction in overall well-being and restricted participation in routine daily activities often exceed what would be expected based solely on the severity of pulmonary function impairment.[3] Meaningful gains in exercise capacity, symptom control, and overall well-being are typically achieved when pulmonary rehabilitation is integrated with standard pharmacological therapy in individuals with chronic respiratory diseases. Pulmonary rehabilitation in recent times has emerged as an important non-pharmacological intervention that is capable of reducing symptom burden, improving exercise capacity, enhancing functional independence, and promoting a better quality of life in patients with chronic respiratory diseases.[4] Comprehensive pulmonary rehabilitation programs are designed to address the behavioral and educational deficits that are commonly seen in patients, as well as the systemic effects of long-term lung disorders.[6] Even in the presence of irreversible structural abnormalities of the lungs, pulmonary rehabilitation has been shown to enhance overall well-being, reduce healthcare utilization, alleviate symptoms, and improve functional exercise performance in individuals with chronic respiratory diseases.[7] It should be considered as an integral component of routine care for all individuals with chronic pulmonary diseases who continue to experience persistent symptoms or functional impairment despite otherwise appropriate and adequate medical management.[8]

Although pulmonary rehabilitation is considered as an essential component of chronic respiratory disease management, important gaps still exist in the available literature. Most of the published literature have primarily focused on COPD alone, while evidence regarding the effectiveness of pulmonary rehabilitation across a heterogeneous population with chronic respiratory diseases remains limited, especially in the Indian setting.[9] Data regarding outpatient pulmonary rehabilitation programmes including patients with COPD, asthma, ILD, and post-tuberculosis sequelae within a single study group are scarce.

Furthermore, there is limited Indian literature assessing the short-term effectiveness of structured pulmonary rehabilitation programmes using clinical, functional and quality-of-life parameters. Variations in socioeconomic conditions, healthcare accessibility, environmental exposure and disease profile among Indian patients and this may influence rehabilitation outcomes differently when compared to the Western populations.[4] Hence, results from international studies may not be completely generalisable to the Indian population. Therefore a need for more region-specific evidence evaluating the effectiveness of pulmonary rehabilitation among Indian patients with chronic respiratory diseases. Studies conducted among patients with interstitial lung disease and post-tuberculosis lung disease have also shown encouraging outcomes with pulmonary rehabilitation, including better functional capacity and symptom control.[8,11]

The present study was done to assess the effectiveness of pulmonary rehabilitation programme in patients with chronic respiratory diseases like COPD, asthma, ILD, and post-tuberculosis sequelae. The study evaluated multiple outcome measures like dyspnoea severity, exercise tolerance, spirometric parameters, exercise oxygen saturation and health-related quality of life before and after three months of pulmonary rehabilitation. By including a heterogeneous group of patients with chronic respiratory diseases and assessing both objective and subjective outcome measures this study aims to provide comprehensive evidence regarding the clinical benefits of pulmonary rehabilitation in routine respiratory practice. The study was conducted to assess pulmonary function, degree of dyspnoea, exercise capacity, and health-related quality of life in patients with chronic respiratory diseases. The study also aimed to compare pulmonary status and health-related quality of life from the baseline and after three months of pulmonary rehabilitation. The findings of this study may help strengthen the evidence supporting wider implementation of pulmonary rehabilitation programme and encourage its integration into standard respiratory care protocols in India.

**AIM OF THE STUDY:**

To assess the effectiveness of three months of pulmonary rehabilitation in patients with chronic respiratory diseases.

**OBJECTIVES OF THE STUDY:**

- To assess pulmonary function test, degree of dyspnea, exercise capacity and health related quality of life in patients with chronic respiratory diseases.
- To compare between pulmonary status and health related quality of life from the baseline after three months of pulmonary rehabilitation

**Materials And Method:**

A total of 96 Patients with chronic respiratory diseases like COPD, interstitial lung disease, post-tuberculosis sequelae and asthma visiting the Department of Respiratory Medicine, B.L.D.E. (Deemed to be University) Shri B. M.Patil Medical College, Hospital and Research Centre, Vijayapura, Karnataka from March 2024 to December 2025were included in this study. Ethical approval for the study was obtained from the Institutional Ethics

Committee.
Patients with chronic respiratory diseases like COPD, interstitial lung disease, post-tuberculosis sequelae and asthma were included in the study.
INCLUSION CRITERIA:
Patients above 18 years of age, All patients with chronic respiratory diseases like COPD, interstitial lung disease, post-tuberculosis sequelae and asthma, Patients who are willing to give informed consent.

EXCLUSION CRITERIA:

Pregnant women, Patients with active pulmonary tuberculosis, Patients with life threatening disorders, Patients with orthopedic impairment that could interfere with therehabilitation program.

Eligible patients were included in this prospective interventional study following informed consent. All participants were adequately informed regarding the study objectives, possible risks, and their freedom to withdraw from the study at any stage without any consequences.

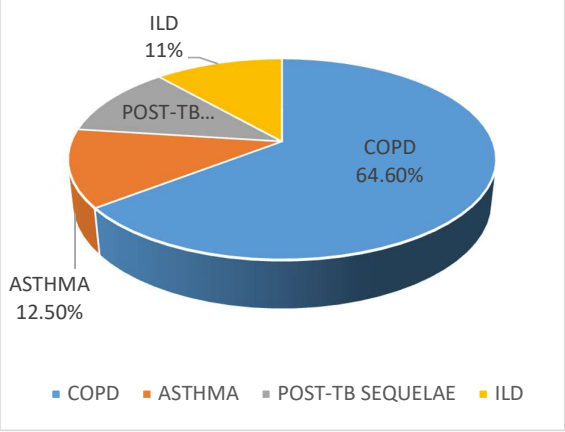
Evaluation of the study subjects: A comprehensive assessment of the patient was done before the start of the study which included clinical history and general physical examination. Patient's baseline degree of dyspnea was determined using mMRC (Modified Medical Research Council) Dyspnea Scale and Modified Borg Dyspnea Scale. Determining baseline exercise capacity using six minute walk test. To assess status of patient's current pulmonary function - SPO2 ,spirometry and PEFR was done. An individual's health related quality of life was documented with the help of Chronic Respiratory Questionnaire (CRQ). After thorough assessment, patients were included in the three monthpulmonary rehabilitation program.

Pulmonary rehabilitation program included**:** Pursed lip breathing exercises, Diaphragmatic breathing exercise, Upper extremity endurance training, Unsupported arm exercises- front arm raise and side arm raise exercises, Lower extremity endurance training, Daily walking on level ground for 30mins at his/her own pace with breaks in between whenever patient feels too breathless, Sit to stand exercise, alternate leg raise exercise and Incentive spirometry.

**Follow-up and Monitoring**
Participants were followed up at bi-weekly intervals through telephonic contacts to assess adherence to the rehabilitation programme, address patient-reported concerns, and provide motivation. A standardized checklist was used to record exercise compliance, duration of sessions, and any adverse events. Exercise techniques were additionally reviewed and during routine outpatient follow-up visits. At the end of three months, all participants underwent post-intervention assessment using the same clinical and functional parameters as recorded at baseline.
**Statistical analysis:**
The collected data was subjected to statistical analysis using the Statistical Package for the Social Sciences (SPSS), version 20. Pre- and post-rehabilitation comparisons were performed using paired t-tests for normally distributed variables and Wilcoxon signed-rank tests for non-normally distributed variables Categorical variables were analyzed using the Chi-square test or Fisher's exact test, as appropriate. When comparisons involved more than two groups, one-way analysis of variance (ANOVA) was applied for normally distributed data, while the Kruskal–Wallis H test was used for non-normally distributed variables. A $p$ value of less than 0.05 is considered statistically significant.

**Results:**
The study included 96 patients, 70 males and 26 females with chronic respiratory diseases like COPD, Asthma, Post tuberculosis sequelae and ILD. COPD was the most common diagnosis, accounting for 64.60% of the patients, Asthma 12.5%, Post-tuberculosis sequelae 11.50% and interstitial lung disease 11% as illustrated in Figure 1. Among the participants included in the study mean age group was 60.22 years with SD of 10.81. Most of the participants were of the age group of 60-69 years. Mean BMI of the patients included in the study is 23.18 ± 4.37 kg/m² with a median BMI of 22.90 kg/m².

**Figure 1: Diagnosis distribution**



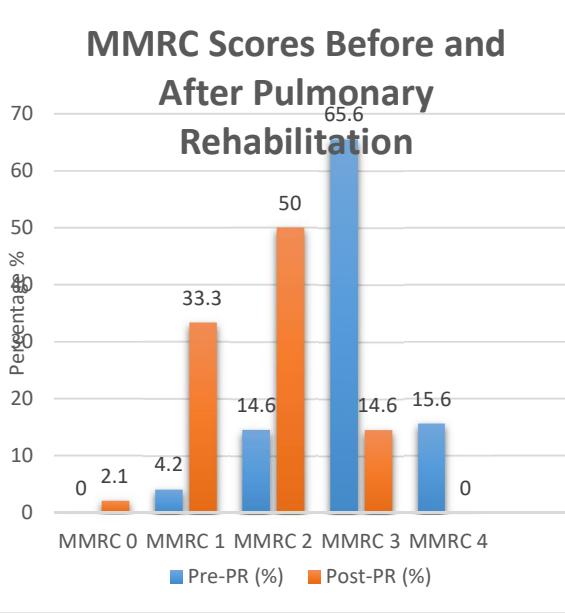

**DEGREE OF DYSPNOEA SCORES:**
In our study it was observed that majority of patients at baseline had degree of breathlessness of MMRC grade 3 accounting of 65.6% (n = 63) of the participants, followed by grade 4 in 15.6% (n = 15)**,** grade 2 in 14.6% (n = 14) of patients and 4.2% (n =

4) were grade 1.The mean MMRC score at baseline was 2.95 with a standard deviation of 0.67.

Following completion of the pulmonary rehabilitation program, a redistribution toward lower MMRC dyspnoea grades was observed. The largest proportion of patients had breathlessness of grade 2**,** 50.0% (n = 48) of the cohort. Followed by grade 1 in 33.3% (n = 32). A smaller proportion of patients, 14.6% (n = 14)**,** remained in grade 3, while no patients were categorized as grade 4**,** demonstrating the absence of severe dyspnoea following rehabilitation. Additionally, 2.1% (n = 2) of patients achieved MMRC grade 0**,** signifying complete resolution of dyspnoea during routine activities.

The mean post-rehabilitation MMRC score declined to 1.77 with a standard deviation of 0.72 signifying a reduction in dyspnoea severity after pulmonary rehabilitation as mentioned in figure 2. Comparative analysis of pre- and post-rehabilitation MMRC scores using the Wilcoxon signed-rank test demonstrated a highly statistically significant improvement in dyspnoea following pulmonary rehabilitation **(**$Z = -8.858$, $p < 0.001$**)**.

**FIGURE 2: Comparison of MMRC Dyspnoea Scores Before and After Pulmonary Rehabilitation**




**BORG dyspnoea score**

At baseline, higher Borg scores were observed across all diagnostic categories, indicating moderate to severe perceived dyspnea. The overall baseline mean score was 4.89 ± 1.28. At the end of the study a reduction in Borg dyspnoea scores was observed. The mean Borg score decreased from 4.89 ± 1.28 at baseline to 2.48 ± 1.22 post-rehabilitation. The difference between pre- and post-rehabilitation scores was analysed using the Wilcoxon Signed Ranks Test, which demonstrated a highly significant improvement ($Z = -8.714$, $p = 0.001$).

**Analysis of Lung Function ($FEV_1$/FVC)**

Patients with mild disease had a mean $FEV_1$/FVC ratio of 70.60 ± 10.23%. Participants with moderate disease 74.87 ± 23.81%, Patients with severe disease $FEV_1$/FVC of 55.96 ± 18.30%, The very severe group $FEV_1$/FVC of 46.71 ± 7.75%, Patients classified under the mixed category had intermediate values 68.14 ± 20.69%. Patients with mild disease showed an increase to 74.55 ± 8.86%. Those with moderate disease improved to 79.58 ± 22.82%. Importantly, patients with severe disease demonstrated a notable improvement from 55.96% to 61.77%. And those with very severe disease improved from 46.71% to 54.34%. The mixed group also showed improvement, with mean $FEV_1$/FVC increasing to 73.63 ± 20.31% as shown in table 1.

**Table 1 : Severity-wise comparison of $FEV_1$/FVC ratio before and after pulmonary rehabilitation**

| Severity | n | Pre-PR $FEV_1$/FVC (%) Mean ± SD | Post-PR $FEV_1$/FVC (%) Mean ± SD | p value |
|---|---|---|---|---|
| Mild | 23 | 70.60 ± 10.23 | 74.55 ± 8.86 | <0.001* |
| Moderate | 35 | 74.87 ± 23.81 | 79.58 ± 22.82 | <0.001* |
| Severe | 19 | 55.96 ± 18.30 | 61.77 ± 19.65 | <0.001* |
| Very Severe | 7 | 46.71 ± 7.75 | 54.34 ± 8.36 | <0.001* |
| Mixed | 12 | 68.14 ± 20.69 | 73.63 ± 20.31 | <0.001* |
| Total | 96 | 67.21 ± 20.61 | 72.27 ± 19.92 | <0.001* |

*p value refers to within-group comparison before and after pulmonary rehabilitation.

Abbreviations: PR – Pulmonary rehabilitation; SD – Standard deviation.

**FEV1**

Patients with mild disease had a mean $FEV_1$ of 71.04 ± 12.97%, moderate disease 60.49 ± 12.16%, severe disease 38.89 ± 10.59%, very severe disease 27.57 ± 5.47%, and mixed disease 56.50 ± 13.22%. Following pulmonary rehabilitation, improvement in $FEV_1$ was observed across all severity categories. Mean $FEV_1$ increased to 75.35 ± 11.71% in mild disease, 65.86 ± 12.27% in moderate disease, 46.79 ± 15.15% in severe disease, 33.57 ± 8.89% in very severe disease, and 61.25 ± 12.37% in mixed disease.

**Overall Comparison of $FEV_1$**

At baseline, the mean $FEV_1$ was 55.84 ± 17.76% predicted. Following pulmonary rehabilitation, mean $FEV_1$ increased to 61.43 ± 17.49% predicted. The improvement was statistically significant (Wilcoxon Signed Ranks Test, $Z = -7.822$, $p < 0.001$) as shown in Table 2.

**Table 2 : Comparison of $FEV_1$ Before and After Pulmonary Rehabilitation**

| Parameter | Pre-PR | Post-PR |
|---|---|---|
| Mean $FEV_1$ (% predicted) | 55.84 | 61.43 |
| Standard Deviation | 17.76 | 17.49 |
| Statistical Test | Wilcoxon Signed Ranks Test | |
| Z value | -7.822 | |
| P value | <0.001* | |

**FVC EVALUATION:** At baseline, the mean FVC was 67.69 ± 13.81% predicted, indicating reduced lung volumes in the study population. After pulmonary rehabilitation, mean FVC increased to 72.02 ± 13.51% predicted. The improvement was statistically highly significant ($Z = -7.064$, $p < 0.001$). Following pulmonary rehabilitation, improvement in FVC was observed across all severity categories**.**

**6 minute walk test Pre-PR vs Post-PR** At baseline, the mean 6MWT distance was 250.83 ± 61.19 metres, indicating reduced functional exercise capacity. Following pulmonary rehabilitation, the mean 6MWT distance increased to 293.44 ± 65.24 metres.

**PEFR Comparison PRE-PR and POST-PR**

Peak expiratory flow rate (PEFR) was done to evaluate changes in expiratory airflow. At baseline, the mean PEFR was 218.75 ± 54.00 L/min. Following pulmonary rehabilitation, the mean PEFR increased to 251.15 ± 56.71 L/min, demonstrating a clinically and statistically significant improvement in airway function illustrated in Table 4 and figure 3.

**Table 3 : Comparison of PEFR Before and After Pulmonary Rehabilitation**

| Parameter | Pre-PR | Post-PR |
|---|---|---|
| Mean PEFR (L/min) | 218.75 | 251.15 |
| Standard Deviation | 54.00 | 56.71 |
| Mean Change (L/min) | - | +32.40 |
| Statistical Test | Wilcoxon Signed Ranks Test | |
| P value | <0.001* | |

**6MWT SpO2 Comparison PRE-PR and POST-PR**

Oxygen saturation after the six-minute walk test was assessed before and after completion of study to evaluate changes in exercise-related oxygenation. At baseline, the mean 6MWT $SpO_2$ was 94.43 ± 1.52%. Following pulmonary rehabilitation, the mean $SpO_2$ increased to 95.93 ± 1.41%, indicating a clinically and statistically significant improvement in oxygen saturation during exercise.

**Chronic Respiratory Questionnaire (CRQ) Analysis**

Health-related quality of life was assessed using the Chronic Respiratory Questionnaire (CRQ) before and after completion of a structured pulmonary rehabilitation (PR) programme.

At baseline, the mean CRQ score was 89.14 ± 14.75**,** indicating impaired health-related quality of life among the study participants. Following pulmonary rehabilitation, the mean CRQ score increased to 109.05 ± 14.82, representing a mean improvement of 19.91 points. This change was highly statistically significant ($Z = -8.517$, $p < 0.001$), demonstrating a marked improvement in overall quality of life after pulmonary rehabilitation.

**Table 4: Comparison of CRQ Scores Before and After Pulmonary Rehabilitation**

| Parameter | Pre-PR | Post-PR |
|---|---|---|
| Mean CRQ Score | 89.14 | 109.05 |
| Standard Deviation | 14.75 | 14.82 |
| Mean Change | - | +19.91 |
| Statistical Test | Wilcoxon Signed Ranks Test | |
| P value | <0.001* | |

No deaths occurred among the study participants during the course of this study.

A total of 8 patients were loss to follow-up.

**DISCUSSION**

This prospective interventional study aimed to evaluate the effectiveness of a three-month pulmonary rehabilitation program in patients with COPD, asthma, post tuberculosis sequelae and ILD with the aim of improving physical and social functioning. COPD was the most common diagnosis among the study partcipants, accounting for 64.60% of the study population. In other studies like the one by Shi *et al.* involving individuals with chronic respiratory diseases, COPD was the most common diagnosis, accounting for 48.2% of cases, asthma patients (16.%) was comparable to the findings of our study (12.5%). However, Interstitial lung disease constituted a higher proportion in the Shi *et*

*al.* cohort (16.2%) compared to 11% in this study.[9] Among the participants included in the study mean age group was 60.22 years. The study results when compared with the Indian prospective study by Anjali G, Deepak Kumar R et al, on pulmonary rehabilitation in patients with COPD, the demographic characteristics are comparable with a Mean age of 57.17 years.[10]The mean body mass index (BMI) of the participants was 23.18 ± 4.37 kg/m², indicating an overall BMI distribution within the normal range. The majority of patients (43.6%) fell within the normal BMI category. A study on pulmonary rehabilitation in interstitial lung disease by Vivek et al., the baseline BMI of participants was reported as 23.8 ± 4.5 kg/m² in the rehabilitation group and 23.0 ± 2.7 kg/m² in the control group.Compared to this our study shows greater nutritional variability, likely reflecting differences in disease spectrum, socioeconomic background, and chronicity of illness.[11]

Dyspnoea is one of the most distressing symptoms in patients with chronic diseases. Following completion of the study, there was a clear and significant shift towards lower MMRC grades. Overall, 90 out of 96 patients showed improvement in dyspnoea, patients with MMRC grade 3 at baseline showed the most pronounced improvement with many improving to grade 2 or even grade 1 MMRC. These findings highlight that pulmonary rehabilitation plays a crucial role in reducing breathlessness, improving functional capacity and enhancing day-to-day comfort in the study subjects.[12] The overall mean Borg score at baseline was low, indicating significant perceived dyspnoea during exertion. Following completion of the study a clear and consistent reduction in Borg dyspnoea scores was noted across all the participants. The mean Borg score showed a reduction of 2.41 points at the end of the study. Sciriha et al. conducted a study on PR in patients with interstitial lung disease resulted in statistically significant reductions in Borg dyspnoea scores, reflecting improved exercise tolerance and reduced breathlessness.[13]These results are comparable with a study conducted by Priya N, et al. In patients with COPD undergoing a home-based pulmonary rehabilitation programme, the modified Borg dyspnoea score showed an improvement by an average of 3 points post-rehabilitation.[7] Also in our study it was observed that at baseline, the mean 6MWT distance was 250.83 ± 61.19m. After completion of the study, the mean distance increased to 293.44 ± 65.24 metres. This proves the effectiveness of pulmonary rehabilitation in improving functional performance. Following the completion of study, improvements were seen in all groups.

Improvements in exercise capacity by the end of this study may have occurred predominantly through peripheral muscle conditioning, enhanced ventilatory efficiency, and improved symptom control rather than changes in lung mechanics alone. These findings support the effectiveness of pulmonary rehabilitation in improving functional exercise capacity. PEFR increased corresponding to a mean improvement of 32.40 L/min was observed after the study suggests a uniform beneficial response across the study population. These findings support the role of pulmonary rehabilitation as an effective adjunct to pharmacological therapy in improving functional respiratory parameters.In a prospective study by Rejbi et al., PEFR showed significant post-rehabilitation improvement, particularly among patients with lower baseline airflow values. These findings align with the present findings, where a substantial PEFR gains were noted despite wide baseline variability, suggestive of patients with more pronounced airflow limitation may derive greater benefit from pulmonary rehabilitation.[14]

At baseline, the mean $FEV_1/FVC$ ratio for the entire study population was 67.21 ± 20.61%, after completion of this study $FEV_1/FVC$ ratio increased to 72.27 ± 19.92%, with the change being statistically significant. It was observed that patients with milder disease achieved higher absolute post study values, greater relative gains were observed in those with severe and very severe disease, suggesting that pulmonary rehabilitation may be particularly beneficial in improving lung mechanics in patients with marked baseline impairment. At the beginning of the study the baseline mean $FEV_1$ was 55.84 ± 17.76% predicted. After completion of the study, the mean $FEV_1$ increased to 61.43 ± 17.49% predicted which was statistically significant ($p < 0.001$), confirming a meaningful enhancement in lung function following rehabilitation. In this study it was observed that patients with asthma have shown measurable improvements in $FEV_1$, $FEV_1/FVC$**.** A study by Klimczak et al.**,** showed a significant post-intervention improvements in spirometry in asthma patients. The significant increase in $FEV_1/FVC$ ratio observed in the present study is consistent with this.[15]

Forced vital capacity (FVC) showed significant improvement in our study. At baseline, the mean FVC was 67.69 ± 13.81% predicted after completion of pulmonary rehabilitation, mean FVC increased to 72.02 ± 13.51% predicted. This improvement was found to be highly statistically significant using the Wilcoxon Signed Ranks Test ($Z = -7.064$, $p < 0.001$), confirming the beneficial impact of pulmonary rehabilitation on lung volumes. On Severity-wise analysis a progressive decline in baseline FVC with increasing disease severity, ranging from 79.22 ± 11.26% in mild disease to 48.14 ± 9.97% in very severe disease was noticed in this study.

Quality of the study subjects life was assessed using the Chronic Respiratory Questionnaire (CRQ). At start of the study the mean CRQ score of the study

population was 89.14 ± 14.75, indicating considerable impairment in quality of life. After completion of the pulmonary rehabilitation programme the mean score increased to 109.05 ± 14.82, a mean improvement of 19.91 points. This change was found to be highly statistically significant($p < 0.001$). Thus clearly demonstrating the positive impact of pulmonary rehabilitation on patient-reported outcomes. Importantly, patients with severe and very severe disease, who had the lowest baseline scores, demonstrated substantial gains of +21.42 and +20.86 points respectively, despite persisting lower absolute values.

The consistent improvement across all severity categories suggests that pulmonary rehabilitation effectively addresses not only physical limitations but also psychosocial aspects of chronic illnesses.

Cambach et al. reported significant improvements in CRQ dyspnea and fatigue domains following PR ($p < 0.05$), and Rejbi et al. demonstrated significant increases in total CRQ score and dyspnea domain ($p < 0.001$) alongside improvements in exercise capacity. Importantly, these studies emphasize that CRQ improvements occur even in the absence of major spirometric changes, highlighting the sensitivity of CRQ as a patient-centred outcome measure.[14][16]

Oxygen saturation measured during the 6MWT showed significant improvement following pulmonary rehabilitation. At baseline, the mean exercise $SpO_2$ was 94.43 ± 1.52%, indicating mild exercise-related desaturation among patients with chronic respiratory diseases. After completion of the pulmonary rehabilitation programme, the mean $SpO_2$ increased to 95.93 ± 1.41%, with a mean improvement of 1.50%. The absolute increase in $SpO_2$ is modest but it is clinically relevant, as even small improvements in exercise oxygen saturation can reduce breathlessness, delays fatigue, and improve confidence during daily activities. The consistent improvement observed across the study population suggests that this study helped patients tolerate physical activity with less oxygen desaturation. Overall the significant improvement in exercise $SpO_2$ highlights its role in improving functional oxygenation and supporting safer and more comfortable physical activity in patients with chronic respiratory diseases.

**Limitations of this study**

- Study was a single centre study with A heterogeneous patient population of only individuals COPD, asthma, post-tuberculosis sequelae, and interstitial lung disease were included in this study.
- The small sample size can limit the generalizability of the findings of this study to broader populations.
- The short duration of follow-up precluded assessment of the long-term sustainability of observed improvements.

**Conclusion**

This prospective interventional study showed that a structured three-month outpatient pulmonary rehabilitation program confers a significant and clinically meaningful benefit in individuals suffering from COPD, asthma, ILD and post-tuberculosis sequelae. Pulmonary rehabilitation resulted in reductions of dyspnea, a substantial improvement of functional exercise performance, and significant enhancement of overall health status and well-being. Improvements were observed across multiple objective and subjective outcome measures highlighting the multidimensional impact of rehabilitation beyond pharmacological therapy alone. The findings from this study signifies that pulmonary rehabilitation is an essential element of comprehensive respiratory care and its broader integration into routine clinical practice for patients with chronic respiratory diseases.

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