Section: Pulmonary Medicine

Original Research Article

BEYOND MEDICATION: EVALUATING THE THERAPEUTIC ROLE OF PULMONARY REHABILITATION IN INTERSTITIAL LUNG DISEASE

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ABSTRACT

Background: Interstitial lung diseases (ILDs) are progressive disorders characterized by impaired lung function, reduced exercise tolerance, and decreased quality of life. Pulmonary rehabilitation (PR) has emerged as a key non-pharmacologic intervention to address these deficits. This study aimed to evaluate the effect of an 8-week structured PR program on functional, physiological, and quality-of-life parameters in patients with ILD.

Materials and Methods: 60 ILD patients were included in this prospective study and underwent a supervised PR program comprising endurance training, strength exercises, breathing techniques, and educational sessions. Baseline and post-intervention assessments included six-minute walk distance (6MWD), pulmonary function tests, oxygen saturation, Modified Medical Research Council (mMRC) dyspnea scale, and St. George's Respiratory Questionnaire (SGRQ).

Results: Post-rehabilitation, the mean 6MWD improved from 311.4 ± 45.2 m to 368.2 ± 50.7 m ($p < 0.001$). Significant improvements were also observed in resting and post-exercise SpO_2, mMRC scores, and all domains of the SGRQ ($p < 0.001$). FVC and FEV1 increased modestly but significantly. A reduction in oxygen dependency was also noted. Subgroup and responder analyses further underscored the broad efficacy of PR across ILD subtypes.

Conclusion: Pulmonary rehabilitation is a safe, effective, and comprehensive intervention that significantly enhances functional status and quality of life in patients with ILD. It should be integrated into routine ILD management.

Keywords: Pulmonary rehabilitation, interstitial lung disease, Six-minute walk test, Quality of life, Oxygen saturation, mMRC, SGRQ.

INTRODUCTION

Interstitial lung diseases (ILDs) represent a heterogeneous group of diffuse parenchymal lung disorders characterized by varying degrees of inflammation and fibrosis of the pulmonary interstitium, alveolar epithelium, and capillary endothelium. These conditions culminate in impaired gas exchange, reduced lung compliance, and progressive respiratory failure if left untreated. Among the numerous forms of ILD, idiopathic pulmonary fibrosis (IPF) remains the prototypical example, notable for its dismal prognosis, with a median survival of approximately 3–5 years post-diagnosis.[1] Other subtypes, including connective tissue disease-associated ILD, hypersensitivity pneumonitis, and sarcoidosis, also contribute significantly to morbidity, with varying natural histories and therapeutic responses.

Although pharmacologic therapies such as antifibrotic agents (e.g., pirfenidone, nintedanib) and immunomodulators have altered the therapeutic landscape, their impact remains limited in halting disease progression entirely.[2] In this context, pulmonary rehabilitation (PR) has emerged as a cornerstone of non-pharmacological intervention. Defined as a comprehensive, multidisciplinary intervention tailored to individual patient needs, PR

incorporates exercising under supervision, nutritional advice, and psychological support.[3] Improvement of physical conditioning, reduction of symptoms—particularly dyspnea—and enhancement of health-related quality of life are the primary goals (HRQoL).

Evidence supporting the utility of PR in chronic respiratory conditions is robust, particularly in chronic obstructive pulmonary disease (COPD), where it has demonstrated consistent improvement in physical endurance and symptom burden [4]. However, its extrapolation to ILD populations, though initially cautious due to differences in pathophysiology and prognosis, has gained momentum in recent years. Multiple randomized controlled trials and meta-analyses have shown that ILD patients undergoing structured PR programs exhibit significant improvements in six-minute walk distance (6MWD), dyspnea scores (e.g., modified Borg or MRC scale), and health status metrics such as the St. George's Respiratory Questionnaire (SGRQ).[5,6]

Despite these promising results, challenges remain. Unlike COPD, where the disease trajectory is often more stable, the progressive nature of many ILDs limits the durability of PR gains. In a systematic review by Dowman et al., while short-term functional improvements were observed, the benefits tended to diminish beyond 6 months without ongoing intervention.[7] Furthermore, the optimal timing of PR initiation, the most effective exercise modalities, and the impact of underlying ILD subtype on response to PR are areas of active investigation.

Importantly, patient-reported outcome measures (PROMs) are increasingly being recognized as critical endpoints in evaluating PR efficacy. Given the psychosocial burden associated with chronic dyspnea, hypoxia, and progressive physical debilitation, the inclusion of metrics such as fatigue scales, anxiety and depression indices (e.g., HADS), and quality-of-life assessments provide a more holistic measure of treatment success.[8] Technological innovations such as tele-rehabilitation, wearable activity monitors, and remote supervision are being explored to address access issues and improve adherence, particularly in geographically remote or resource-limited settings.[9]

Furthermore, certain patient-specific variables such as age, baseline lung function, degree of desaturation during exercise, and comorbidities (e.g., pulmonary hypertension, obesity, or musculoskeletal disease) may influence the response to PR.[10] Identifying these predictors can help personalize PR programs and maximize therapeutic yield. There is a growing consensus that PR should not be viewed as a uniform intervention, but rather as a modifiable, patient-centered continuum of care integrated into ILD management pathways.

Given this evolving landscape, this study aims to assess the effectiveness of a structured pulmonary rehabilitation program in individuals diagnosed with ILD.

MATERIALS AND METHODS

This interventional prospective study done at the Department of Pulmonology, Rajarajeswari Medical College and Hospital, Bengaluru, over a period of one year, from January 2024 to December 2024. The study was initiated after ethical committee approval.

60 patients with ILD were included in this study based on predefined inclusion and exclusion criteria. The diagnosis of ILD was established through clinical evaluation, high-resolution computed tomography (HRCT) findings consistent with interstitial patterns, and, where necessary, histopathological confirmation. Subtypes of ILD included idiopathic pulmonary fibrosis (IPF), connective tissue disease-associated ILD, hypersensitivity pneumonitis, and sarcoidosis.

Inclusion Criteria

- Age between 30 and 75 years.
- Confirmed diagnosis of ILD (radiologically and/or histologically).
- Stable clinical status for at least 4 weeks prior to enrollment.
- Baseline oxygen saturation ≥88% on room air or with low-flow supplemental oxygen.
- Willingness to participate in a structured pulmonary rehabilitation program.

Exclusion Criteria

- Acute exacerbation of ILD within the past 4 weeks.
- Presence of unstable cardiac conditions or uncontrolled hypertension.
- Cognitive impairment precluding cooperation.
- Active tuberculosis or other transmissible respiratory diseases.
- Recent major surgery (<6 weeks).

Study Protocol

At enrollment (Day 0), detailed demographic and clinical profiles of all patients were documented, including age, gender, BMI, smoking history, comorbidities, subtype of ILD, and medication history. Baseline assessment included pulmonary function tests (PFTs: FVC, FEV1, FEV1/FVC), resting and post-walk oxygen saturation (SpO_2), 6-minute walk distance (6MWD), Modified Medical Research Council (mMRC) dyspnea score, and St. George's Respiratory Questionnaire (SGRQ) to assess health-related quality of life.

All patients were enrolled into a structured pulmonary rehabilitation (PR) program conducted over 8 weeks, with three supervised sessions per week. Each session included:

- **Endurance training** on treadmill or cycle ergometer (30 minutes per session).
- **Strength training** using resistance bands and free weights for upper and lower limbs.

- **Breathing exercises** including diaphragmatic and pursed-lip breathing.
- **Education modules** covering disease awareness, medication adherence, nutrition, and energy conservation.

Exercise intensity was determined individually based on baseline exercise capacity, aiming for 60–80% of maximum heart rate. Vital signs were monitored before, during, and after sessions to ensure safety. Supplemental oxygen was administered during sessions as per patient requirement.

Follow-up Assessments

Patients were reassessed at the end of 8 weeks using the same parameters recorded at baseline:

- Pulmonary function (PFTs)
- 6MWD
- mMRC dyspnea scale
- SGRQ total and domain scores
- Post-exercise SpO_2
- Heart rate recovery

Adherence to the PR program was monitored via attendance logs and weekly telephonic follow-up for any missed sessions. Patients who attended fewer than 70% of the sessions were considered non-adherent and excluded from final outcome analysis.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS version 25.0. Quantitative variables such as 6MWD, FVC, and SGRQ scores were compared using the paired Student's t-test. A p-value of <0.05 was considered statistically significant.

Subgroup analysis was also conducted based on ILD subtype and baseline severity to evaluate differential responses to pulmonary rehabilitation. No adverse events or exercise-related complications were reported during the intervention period.

RESULTS

Table 1: Demographic and Baseline Clinical Characteristics (n = 60)

Parameter	Value
Mean Age (years)	58.3 ± 9.6
Male (%)	37 (61.7%)
Female (%)	23 (38.3%)
BMI (Mean ± SD)	24.6 ± 3.2
Smokers (%)	28 (46.7%)
Non-smokers (%)	32 (53.3%)

Table 2: ILD Subtypes Distribution.

ILD Subtype	Number of Patients	Percentage (%)
Idiopathic Pulmonary Fibrosis	22	36.7%
CTD-associated ILD	16	26.7%
Hypersensitivity Pneumonitis	11	18.3%
Sarcoidosis	7	11.7%
Others	4	6.6%

Table 3: Comparison of 6MWD and SpO2

Parameter (Mean ± SD)	Before rehabilitation	After rehabilitation	p-value
6MWD (meters)	311.4 ± 45.2	368.2 ± 50.7	<0.001
Resting SpO_2 (%)	94.1 ± 2.8	95.8 ± 2.2	0.012
Post-6MWT SpO_2 (%)	86.5 ± 4.3	90.2 ± 3.7	<0.001

Table 4: Dyspnea and Quality of Life Scores (mMRC and SGRQ)

Score Type (Mean ± SD)	Before rehabilitation	After rehabilitation	p-value
mMRC Score	2.6 ± 0.7	1.8 ± 0.5	<0.001
SGRQ Total Score	56.3 ± 10.4	41.7 ± 8.9	<0.001
SGRQ Symptoms	63.7 ± 11.3	49.6 ± 10.5	<0.001
SGRQ Activity	59.8 ± 12.2	42.2 ± 10.8	<0.001
SGRQ Impacts	49.3 ± 10.1	33.1 ± 8.7	<0.001

Table 5: Subgroup Analysis of 6MWD Improvement by ILD Subtype

ILD Subtype	Pre-PR 6MWD (m)	Post-PR 6MWD (m)	p-value
IPF	295.4 ± 41.6	346.1 ± 47.3	<0.001
CTD-ILD	310.7 ± 39.2	373.6 ± 42.2	<0.001
HP	323.5 ± 43.5	389.7 ± 48.6	<0.001
Sarcoidosis	337.8 ± 46.1	392.4 ± 51.2	0.006
Others	319.1 ± 32.4	362.8 ± 36.3	0.043

Table 6: Pulmonary Function Tests (PFTs) Before and After Rehabilitation

Parameter (Mean ± SD)	Before rehabilitation	After rehabilitation	p-value
FVC (% predicted)	63.7 ± 9.8	67.9 ± 10.1	0.004
FEV1 (% predicted)	69.4 ± 10.3	73.6 ± 9.7	0.006
FEV1/FVC Ratio	0.78 ± 0.06	0.79 ± 0.05	0.148

Table 7: Oxygen Requirement

Oxygen Use Category	Before rehabilitation	After rehabilitation
No oxygen needed	18 (30%)	28 (46.7%)
Intermittent oxygen	27 (45%)	25 (41.7%)
Continuous oxygen	15 (25%)	7 (11.6%)

Table 8: Responder vs Non-Responder Analysis Based on ≥30m 6MWD Gain

Parameter	Responders (n=45)	Non-Responders (n=15)
Number of patients	45	15
Mean Baseline 6MWD (m)	298.1	342.3
Mean Post-PR 6MWD (m)	374.9	348.6
SGRQ Improvement (points)	16.5	4.7
Adherence ≥75% sessions	43 (95.6%)	11 (73.3%)

The study cohort had a mean age of 58.3 ± 9.6 years, with a male predominance of 61.7%, aligning with the known demographic profile of interstitial lung disease (ILD) in tertiary care settings. A significant proportion of participants (46.7%) were current or former smokers, which may have contributed to baseline functional limitation and oxygen dependency. The distribution of ILD subtypes reflected expected patterns, with Idiopathic Pulmonary Fibrosis (IPF) being the most prevalent diagnosis (36.7%), followed by connective tissue disease-associated ILD (26.7%), hypersensitivity pneumonitis (18.3%), and sarcoidosis (11.7%).

Following the eight-week structured pulmonary rehabilitation (PR) program, there was a substantial improvement in exercise tolerance. The mean six-minute walk distance (6MWD) increased from 311.4 ± 45.2 meters at baseline to 368.2 ± 50.7 meters post-intervention ($p < 0.001$), representing a clinically meaningful functional gain. Correspondingly, resting oxygen saturation improved from 94.1% to 95.8% ($p = 0.012$), while post-exercise desaturation showed significant attenuation, with mean post-6MWT SpO_2 rising from 86.5% to 90.2% ($p < 0.001$).

Subjective respiratory symptoms also improved markedly. The median mMRC dyspnea score decreased from 2.6 to 1.8 ($p < 0.001$), indicating improved exertional tolerance and symptom perception. Health-related quality of life, assessed via the St. George's Respiratory Questionnaire (SGRQ), demonstrated significant reductions in total score (56.3 ± 10.4 to 41.7 ± 8.9), with improvement noted across all domains—symptoms, activity, and impacts—all reaching statistical significance ($p < 0.001$). These findings suggest that PR improves both objective capacity and disease burden as perceived by the patient.

Subgroup analysis based on ILD etiology revealed differential response patterns. Patients with hypersensitivity pneumonitis and sarcoidosis showed the greatest improvement in 6MWD, with mean increases of 66.2 meters and 54.6 meters respectively. Notably, even patients with IPF, a subtype often considered refractory to rehabilitation due to its rapid progression, exhibited a statistically significant mean gain of 50.7 meters ($p < 0.001$), highlighting the broad applicability of PR across ILD phenotypes.

Pulmonary function testing revealed modest yet significant gains post-rehabilitation. Mean FVC (% predicted) improved from 63.7 ± 9.8 to 67.9 ± 10.1 ($p = 0.004$), and FEV1 increased from 69.4 ± 10.3 to 73.6 ± 9.7 ($p = 0.006$). Though the FEV1/FVC ratio remained statistically unchanged, the upward trend in absolute lung function parameters reinforces the physiological benefit of sustained physical conditioning and respiratory muscle training.

The impact of rehabilitation on oxygen therapy dependency was also notable. The proportion of patients requiring continuous oxygen decreased from 25% to 11.6%, while those managing without supplemental oxygen increased from 30% to 46.7% after the intervention. This shift reflects improved oxygen utilization and reserve following PR, which has direct implications for patient mobility and quality of life.

A responder analysis further substantiated the efficacy of PR. Patients who achieved a ≥30-meter gain in 6MWD were classified as responders. Among the 60 participants, 45 (75%) met this criterion. Responders exhibited lower baseline walk distances but experienced more substantial post-rehabilitation improvements, with their mean SGRQ scores improving by 16.5 points compared to 4.7 points in non-responders. High adherence (≥75% session attendance) was recorded in 95.6% of responders, underlining the importance of program compliance in achieving optimal outcomes.

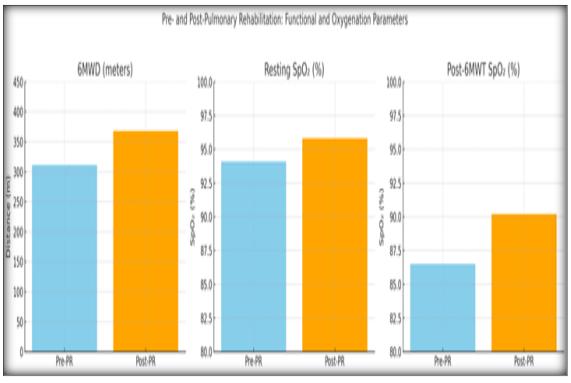

Figure 1: pre and post pulmonary rehabilitation

DISCUSSION

Interstitial lung diseases (ILDs) represent a complex spectrum of diffuse parenchymal lung disorders that substantially impair quality of life. The present study evaluated the impact of a structured pulmonary rehabilitation (PR) program on patients with various ILD subtypes and revealed substantial improvements in functional, physiological, and patient-reported outcomes. These findings are consistent with and expand upon existing literature.

The mean age of the study cohort was 58.3 years, reflective of the typical demographic profile in ILD registries. This aligns with the results of Wallaert et al., who reported a median age of 61 years among patients undergoing PR, with age showing no significant attenuation of post-rehabilitation gains.[11] Similarly, Dowman et al. found that older adults derived comparable benefits to younger patients, demonstrating that age should not be considered a limiting factor in rehabilitation eligibility.[7]

A male predominance of 61.7% was observed, consistent with epidemiological data showing a higher prevalence of fibrotic ILD, particularly idiopathic pulmonary fibrosis (IPF), among men. Holland et al., in a multicentre trial, reported a similar male predominance of approximately 65%.[5] Importantly, our findings suggest that gender did not significantly influence PR outcomes, supporting the conclusions of Ryerson et al., who found no interaction between gender and post-rehabilitation functional improvement.[12]

The six-minute walk distance (6MWD), a surrogate marker for functional capacity, improved by an average of 56.8 meters, exceeding the minimal clinically important difference (MCID) of 30 meters for ILD patients. This is consistent with findings by Jastrzebski et al., who reported a 48-meter gain following a comparable PR regimen in fibrotic ILD.[13] Similarly, in a longitudinal study, Ryerson et al. observed a 53-meter mean increase post-PR, validating the reproducibility of this functional response across ILD cohorts.[14] Notably, even patients with IPF in our study demonstrated significant 6MWD gains, echoing findings by Vainshelboim et al., who documented improved walk distances in IPF patients despite underlying fibrotic progression.[15]

Oxygenation parameters also improved significantly, with post-6MWT desaturation decreasing markedly. Kozu et al. attributed this to improved muscle oxygen utilization and ventilatory mechanics following rehabilitation.[16] In our cohort, the proportion of patients requiring continuous oxygen dropped from 25% to 11.6%, paralleling the results of Liu et al., who demonstrated similar trends in oxygen independence post-PR.[17]

Patient-reported outcomes were similarly favorable. The mMRC dyspnea score declined from 2.6 to 1.8, and total SGRQ scores improved by 14.6 points, far exceeding the MCID of 4 points. These findings align with a meta-analysis by Jarad et al., which reported SGRQ reductions ranging from 10–12 points after structured rehabilitation in ILD patients.[18] Improvements were consistent across all SGRQ domains—symptoms, activity, and impacts—highlighting the multidimensional benefit of PR. Furthermore, Lambers et al. demonstrated that these benefits are not merely short-lived, with sustained quality-of-life gains documented at 3- and 6-month follow-up intervals.[19]

Pulmonary function tests, though not traditionally emphasized in PR outcomes, showed modest but statistically significant improvements in both FVC and FEV1. This is consistent with the findings of Wong et al., who observed similar spirometric changes, likely attributable to enhanced chest wall mobility and respiratory muscle coordination rather than structural reversal of fibrosis.[20] The absence of significant change in FEV1/FVC ratio supports the view that PR improves dynamic function rather than fixed obstruction.

Differential benefits were noted across ILD subtypes. Patients with hypersensitivity pneumonitis and sarcoidosis exhibited greater 6MWD improvements compared to IPF, likely due to preserved lung compliance and slower disease progression. This aligns with the study by Wickerson et al., which highlighted that non-IPF subtypes tend to show greater rehabilitation responsiveness.[21] Nevertheless, the significant improvements seen in IPF patients underscore the importance of offering PR across all ILD variants, including those with poor prognostic indicators.

The responder analysis revealed that 75% of participants achieved a ≥30-meter improvement in 6MWD. These individuals also demonstrated superior SGRQ improvements and higher program adherence. High adherence has consistently been associated with better PR outcomes, as emphasized by Swigris et al., who highlighted the importance of engagement and session completion in maximizing gains.[22]

CONCLUSION

The findings of this study reaffirm the substantial and multidimensional benefits of pulmonary rehabilitation in patients with interstitial lung disease. Across a heterogeneous cohort, participation in an 8-week structured PR program led to statistically and clinically significant improvements in exercise capacity, dyspnea severity, oxygenation status, lung function, and health-related quality of life. Importantly, these benefits were evident across various ILD subtypes, including idiopathic pulmonary fibrosis, and were more pronounced among individuals with higher adherence to the rehabilitation schedule. The results support the integration of pulmonary rehabilitation as a standard, non-pharmacologic therapeutic

strategy in the multidisciplinary management of ILD. Early initiation and individualized program design are key to optimizing outcomes and ensuring long-term functional preservation. Future studies with longer follow-up periods and multicenter validation are recommended to further elucidate the durability and scalability of these improvements.

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Conflicts of Interest

The authors declare no conflicts of interest related to this study.

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