ORIGINAL ARTICLE

Effect of Radiological Patterns on Response to Pulmonary Rehabilitation in Post-tuberculosis Lung Sequelae: A Prospective Observational Study

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Abstract

Background: Post-tuberculosis sequelae (PTBS) are increasingly recognized as a significant cause of long-term respiratory morbidity, manifesting with dyspnea, reduced pulmonary function, impaired exercise capacity, and diminished quality of life. Despite their burden, PTBS patients often lack access to structured rehabilitation. Pulmonary rehabilitation (PR), well-established in COPD, may offer functional and psychological benefits in PTBS, but its implementation in India and comparison across radiological phenotypes remains understudied.

Objectives: To evaluate the impact of a 24-week pulmonary rehabilitation program on clinical, functional, psychological, and radiological outcomes in patients with PTBS, and to compare the response among different radiological subtypes—fibrosis, fibrocavitary lesions, bronchiectasis, and combined lesions.

Materials and methods: In this prospective observational study, 60 patients with PTBS underwent hospital- or home-based PR. Assessments were conducted at baseline, 12 weeks, and 24 weeks and included spirometry (FEV_1, FVC, FEV_1/FVC, $FEF_{25–75}$), 6-minute walk test (6MWT), body mass index (BMI), St. George's Respiratory Questionnaire (SGRQ), modified Medical Research Council (mMRC) dyspnea grade, DASS-21 scale for psychological health, and radiological classification. Statistical analysis was performed to assess within-group and between-group changes over time.

Results: Significant improvements were observed in BMI ($p < 0.005$), 6MWT (mean improvement >150 m in most groups), and DASS-21 scores across all radiological subtypes. FEV1% predicted improved significantly ($p < 0.05$), especially in patients with fibrosis and bronchiectasis (>60% by week 24), while those with fibrocavitary + bronchiectasis showed the least gain (38%). Quality of life (SGRQ) improved in all groups, though intergroup differences were not statistically significant. Bronchodilator reversibility was rare (5%) and did not vary with lesion type.

Conclusion: Pulmonary rehabilitation significantly improves nutritional status, exercise capacity, psychological well-being, and spirometric parameters in PTBS patients, with variable responses depending on radiological pattern. Despite greater impairment, patients with fibrocavitary lesions derived meaningful benefit, highlighting PR's role as an essential component of post-TB care. Tailored PR strategies should be integrated into national TB programs to address the long-term sequelae of TB in high-burden settings such as India.

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Introduction

Tuberculosis (TB) continues to be a major global public health challenge, particularly in high-burden countries such as India, which accounts for nearly a quarter of the world's TB cases.[1] Despite successful microbiological cure following anti-tubercular therapy, a significant proportion of patients develop residual structural and functional abnormalities in the lungs, collectively termed post-tuberculosis sequelae (PTBS). These sequelae—ranging from fibrosis and bronchiectasis to fibrocavitary destruction—can result in persistent dyspnea, impaired exercise tolerance, and significantly reduced quality of life (QoL), often mimicking chronic respiratory diseases such as COPD or bronchiectasis.[2]

Recent evidences suggest that postpulmonary tuberculosis patients continue to experience significantly impaired lung function and reduced health-related QoL after treatment completion, echoing the pattern of long-term morbidity seen in adult PTLD patients.[3] Moreover, radiological patterns such as fibrocavitary lesions have been shown to correlate with worse functional status and prolonged symptomatology. However, despite their high burden, patients with PTBS are often neglected in national TB control programs, receiving little to no post-treatment rehabilitation support.

Pulmonary rehabilitation (PR) has long been established as a cornerstone of nonpharmacologic management for chronic lung diseases such as COPD.[4] It encompasses exercise training, education, nutritional support, and psychosocial counseling, and has been shown to improve functional status, psychological well-being, and health-related quality of life. Yet, its use in PTBS has been scarcely explored, particularly in the Indian context.[5] With growing evidence supporting the role of PR in chronic respiratory morbidity, its application in post-TB care could represent a transformative shift in long-term disease management.

Further complicating access is the lack of scalable PR delivery models. Hospital-based programs, while structured and supervised, are limited by infrastructure, personnel, and patient mobility, especially in rural settings. In contrast, home-based PR—delivered through structured guidance and remote monitoring—offers a promising alternative. However, comparative evidence evaluating the efficacy of hospital-based vs. home-based PR in PTBS patients is limited.

Aims and Objectives

Aim

To evaluate and compare the impact of pulmonary rehabilitation on clinical, functional, and psychological outcomes in patients with post-tuberculosis sequelae.

Objectives

- To assess changes in spirometry (FEV_1, FVC, FEV_1/FVC, $FEF_{25–75}$%), 6MWT distance, dyspnea [modified Medical Research Council (mMRC)], quality of life (SGRQ), psychological status (DASS-21), and BMI over 24 weeks.
- To compare these outcomes across different radiological patterns of lung damage.

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Materials and Methods

Study Design and Setting

This was a prospective, interventional study conducted at the Department of Respiratory Medicine, JLN Medical College, Ajmer. The study aimed to assess and compare the effects of pulmonary rehabilitation (PR) in patients with post-tuberculosis sequelae (PTBS) with different radiological patterns over a 24-week period.

Study Population

A total of 60 patients with established post-tuberculosis sequelae were enrolled consecutively based on predefined inclusion and exclusion criteria. The diagnosis of PTBS was based on clinical, radiological, and spirometric evidence in patients with a past history of microbiologically confirmed pulmonary tuberculosis, with symptoms and/or radiological abnormalities persisting for at least 6 months after microbiological cure.

Inclusion Criteria

- Age ≥ 18 years.
- Documented history of pulmonary tuberculosis.
- Radiological evidence of sequelae (fibrosis, bronchiectasis, fibrocavitary changes).
- Persistent respiratory symptoms (e.g., dyspnea, cough) for at least 6 months post-treatment.
- Written informed consent.

Exclusion Criteria

- Active tuberculosis (based on sputum AFB/CBNAAT positivity).
- Severe cardiac, neurological, or orthopedic comorbidities precluding PR participation.
- Recent acute exacerbation or hospitalization (<4 weeks prior to enrollment).
- Psychiatric illness is impairing compliance.

Radiological Classification

Chest radiographs and high-resolution computed tomography (HRCT) were reviewed independently by two experienced radiologists and classified into four subgroups based on dominant patterns:

- Bronchiectasis.
- Fibrocavitary lesions.
- Fibrosis.
- Mixed fibrocavitary + bronchiectasis.

Pulmonary Rehabilitation Intervention

Patients were allocated to either hospital-based or home-based PR based on preference and feasibility.

Hospital-Based PR

Supervised sessions were conducted thrice weekly in the hospital outpatient PR unit, including:

- Aerobic training (walking, step-ups).
- Breathing exercises (pursed-lip, diaphragmatic breathing).
- Resistance training with elastic bands.
- Education and nutritional counseling.

Home-based PR

Patients were given structured booklets, telephonic guidance, and were advised to perform similar PR routines at home at least 5 days a week. Adherence was monitored weekly via telephonic interviews and monthly outpatient visits.

Outcome Measures and Follow-up

All patients were evaluated at baseline (week 0), 12 weeks, and 24 weeks. The following parameters were assessed at each visit:

- Pulmonary function tests (spirometry): FEV_1, FVC, FEV_1/FVC, FEF_{25-75} (% predicted) pre- and postbronchodilator.
- Exercise capacity: 6-minute walk test (6MWT).
- Symptom severity: mMRC dyspnea scale.
- Health-related quality of life: St. George's Respiratory Questionnaire (SGRQ).
- Psychological assessment: Depression Anxiety Stress Scale (DASS-21).
- Nutritional status: Body mass index (BMI, kg/m^2).

Ethical Considerations

The study was approved by the Institutional Ethics Committee of JLN Medical College, Ajmer. Written informed consent was obtained from all participants.

Statistical Analysis

Data were entered in Microsoft Excel and analyzed using SPSS version 26.0. Continuous variables were expressed as mean ± SD and compared using ANOVA or *t*-tests as appropriate. Categorical variables were expressed as proportions and compared using Chi-square or Fisher's exact test. A p-value < 0.05 was considered statistically significant.

Results

The study cohort (n = 60) predominantly comprised middle-aged individuals, with 30.0% aged 41–50 and 26.0% aged 31–40 years (Table 1). Male subjects were more common (64.0%), and most participants were from rural areas (68.0%). Socioeconomic assessment using the Modified Kuppuswamy scale showed that 52.0% of the cohort fell in the upper-lower class (score 4). Dyspnea was universally present (100%), followed by cough (78.0%), fatigue/malaise (64.0%), and weight loss (52.0%). Sputum production and chest pain were less frequent (22.0% and 32.0%, respectively). Most patients had illness durations ≤2 years, though 20% had chronicity beyond 5 years. Substance use was prevalent—40.0% had a history of smoking, 30.0% used tobacco, and 15.0% consumed alcohol.

Radiologically, fibrosis was the most frequent abnormality, n = 29 (48.0%), followed by fibrocavitary lesions, n = 24 (40.0%), with isolated bronchiectasis and mixed lesions accounting for n = 5 (8.0%) and n = 2 (4.0%), respectively. At baseline, patients with fibrocavitary lesions showed higher dyspnea burden, 11 cases at mMRC grade 2, 12 at grade 3, and 1 at grade 1, while fibrosis cases were more evenly distributed (4 at grade 1, 18 at grade 2, 7 at grade 3). Bronchiectasis was milder (1 at grade 1, 4 at grade 2), whereas mixed fibrocavitary + bronchiectasis had two cases at grade 3. Over follow-up, a clear shift toward lower grades was observed; by 24 weeks, 42 patients were at grade 1 and only 18 at grade 2. The association between radiological type and mMRC grade was near-significant at baseline (p = 0.065), trended at 12 weeks (p = 0.074), and reached significance at 24 weeks (p = 0.04; χ^2 = 8.294), indicating better dyspnea improvement in fibrosis and bronchiectasis compared to fibrocavitary phenotypes (Table 2).

Nutritional recovery varied across groups. Baseline BMI was lowest in the combined fibrocavitary + bronchiectasis group (15.75 kg/m^2), followed by fibrocavitary (18.01 kg/m^2), with fibrosis patients having the highest (21.95 kg/m^2). Differences remained significant throughout (p < 0.005 at all time points), indicating that radiological severity correlates with poorer BMI recovery (Table 3).

St. George's Respiratory Questionnaire (SGRQ) scores, reflecting quality of life, were highest in the combined group (54) and fibrocavitary group (44.9) at baseline. All groups improved over 24 weeks, though intergroup differences were not statistically significant (p = 0.258 at 24 weeks) (Table 3).

Functional capacity, measured via 6MWT, showed the lowest baseline distance in the combined group (150 m), compared to bronchiectasis (330 m) and fibrosis (314.58 m). By 24 weeks, bronchiectasis and fibrosis groups reached 420 m, while the combined group remained lower (280 m). Statistical significance was present at baseline (p = 0.01), but not at 24 weeks (Table 3).

Psychological improvement was seen across all DASS domains. At 24 weeks, depression

Table 1: Demographic characteristics of the study population

Variable	*Number of subjects*	*Percentage (%)*
Age group		
< 30 years	8	14.0
31–40 years	16	26.0
41–50 years	18	30.0
51–60 years	11	18.0
> 60 years	7	12.0
Sex		
Male	38	64.0
Female	22	36.0
Area		
Rural	41	68.0
Urban	19	32.0
Socioeconomic status (Modified Kuppuswamy score)		
Score 2	5	8.0
Score 3	12	20.0
Score 4	31	52.0
Score 5	12	20.0
Clinical symptoms		
Dyspnea	60	100.0
Cough	47	78.0
Fatigue/malaise	38	64.0
Weight loss	31	52.0
Chest pain	19	32.0
Sputum production	13	22.0
Total duration of illness		
0.5 years	14	24.0
1 year	7	12.0
2 years	13	22.0
3 years	4	8.0
4 years	1	2.0
5 years	7	12.0
7–10 years	7	12.0
12–20 years	5	8.0
Substance abuse		
Smoking	24	40.0
Tobacco chewing	18	30.0
Alcohol use	9	15.0
Smoking index		
0	36	60.0
20–100	8	14.0
101–300	8	13.0
301–600	8	13.0

scores declined from 9.79 to 6.32 in fibrocavitary patients and from 12 to 8 in the combined group. Intergroup differences became significant for depression ($p = 0.013$), anxiety ($p = 0.034$), and stress ($p = 0.049$) by week 24 (Table 3).

Spirometric improvements were evident across all radiological types. Pre-BD FEV1% predicted improved most in fibrosis (48.79% to 62.5%) and bronchiectasis (54% to 63%), while fibrocavitary and combined groups had lower gains (31.11% to 49.79% and 18% to 38%, respectively). These differences were statistically significant throughout ($p < 0.05$). Post-BD FEV1% showed a similar pattern. FVC% increased in all groups, but intergroup variation was not statistically significant. FEV1/FVC ratios and FEF_{25-75}%% predicted also improved, with bronchiectasis showing the highest small airway gains (to 57%) and the combined group the lowest (to 39%) (Table 4).

Bronchodilator reversibility (BDR) was detected in only three patients (5%) at baseline: two with fibrocavitary and one with bronchiectasis. This pattern remained constant at 12 and 24 weeks, with no significant association between BDR and radiological phenotype ($p = 0.188$) (Fig. 1).

Discussion

This study evaluated the differential impact of radiological phenotypes on the outcomes of pulmonary rehabilitation (PR) in patients with post-tuberculosis sequelae (PTBS). 60 patients with varying radiological lesions underwent structured PR over 24 weeks, with outcomes measured across multiple domains. The findings suggest that structural lung abnormalities significantly influence functional recovery, nutritional status, spirometric improvement, and psychosocial well-being.

Fibrosis was the most common radiological pattern, $n = 29$ (48%), followed by fibrocavitary lesions, $n = 24$ (40%), while bronchiectasis and combined lesions were less frequent. The predominance of fibrotic and cavitary patterns aligns with established post-TB structural damage profiles. These lesions likely reflect more extensive parenchymal destruction and thus served as an important framework for stratified analysis.

Dyspnea scores showed significant intergroup differences. At baseline, patients with fibrocavitary lesions had the highest mMRC grades, reflecting more severe breathlessness. By 24 weeks, 100% of bronchiectasis patients and 79.3% of fibrosis patients improved to mMRC grade 1, compared with 58.3% in the fibrocavitary group ($p = 0.022$). This suggests that patients with preserved airway architecture (bronchiectasis, fibrosis) respond better to pulmonary rehabilitation (PR), whereas extensive cavitary damage impairs symptomatic relief. These observations mirror findings by Di Naso et al.[6] who reported that extensive residual lesions—such as fibrocavitary lesions—predict permanent functional limitations, including breathlessness despite treatment completion.

Nutritional status, as measured by BMI, was poorest in patients with combined fibrocavitary + bronchiectatic lesions (15.75 kg/m^2 at baseline) and improved slowly despite pulmonary rehabilitation. In contrast, patients with fibrosis began with a higher baseline BMI (21.95 kg/m^2) and achieved greater gains (22.71 kg/m^2 at 24 weeks; $p < 0.005$). Malnutrition in cavitary disease likely stems from chronic inflammation, catabolic stress, and reduced appetite. Indeed, several researchers recommend nutritional counseling as an integral component of

Table 2: Distribution of mMRC dyspnea grades (grade 1, 2, 3) across radiological lesion subtypes at 0, 12, and 24 weeks. Significant improvement in dyspnea severity was observed across all subtypes over time, with notable intergroup variation

mMRC Grade	*Bronchiectasis*	*Fibrocavitary*	*Fibrocavitary + Bronchiectasis*	*Fibrosis*	*Total*	*p-value (Pearson)*	*Test Statistic*
1	1	1	0	4	6	0.065	11.859
2	4	11	0	18	33		
3	0	12	2	7	21		
Total	5	24	2	29	60		
1	5	12	0	19	36	0.074	6.944
2	0	12	2	10	24		
Total	5	24	2	29	60		
1	5	14	0	23	42	0.04	8.294
2	0	10	2	6	18		
Total	5	24	2	29	60		

B, bronchiectasis; F, fibrosis; FC, fibrocavitary; FCB, fibrocavitary + bronchiectasis

Table 3: Comparative analysis of BMI, SGRQ, 6MWT, and DASS-21 scores across different radiological lesion groups (bronchiectasis, fibrocavitary, combined fibrocavitary + bronchiectasis, and fibrosis) at baseline, 12 weeks, and 24 weeks

Parameter	*Radiological lesion*	*n*	*0 weeks*	*12 weeks*	*24 weeks*
BMI (kg/m^2)	Bronchiectasis	5	21.12	21.68	21.65
	Fibrocavitary	24	18.01	18.60	19.03
	Fibrocavitary + bronchiectasis	2	15.75	15.95	16.60
	Fibrosisw	29	21.95	22.30	22.71
	p-value		0.003	0.004	0.004
SGRQ score	Bronchiectasis	5	37.00	30.00	24.00
	Fibrocavitary	24	44.90	37.40	29.50
	Fibrocavitary + bronchiectasis	2	54.00	44.00	35.00
	Fibrosis	29	40.00	32.83	26.58
	p-value		0.069	0.082	0.258
6MWT (m)	Bronchiectasis	5	330.00	377.50	420.00
	Fibrocavitary	24	236.75	325.00	379.00
	Fibrocavitary + bronchiectasis	2	150.00	225.00	280.00
	Fibrosis	29	314.58	372.50	419.58
	p-value		0.010	0.087	0.145
DASS D score	Bronchiectasis	5	8.00	6.50	4.50
	Fibrocavitary	24	9.79	8.00	6.32
	Fibrocavitary + bronchiectasis	2	12.00	10.00	8.00
	Fibrosis	29	8.58	7.17	5.25
	p-value		0.115	0.088	0.013
DASS A score	Bronchiectasis	5	11.00	9.50	7.50
	Fibrocavitary	24	12.84	10.74	8.95
	Fibrocavitary + bronchiectasis	2	14.00	12.00	10.00
	Fibrosis	29	11.50	9.83	7.83
	p-value		0.185	0.171	0.034
DASS S score	Bronchiectasis	5	15.00	12.00	9.50
	Fibrocavitary	24	15.58	13.16	11.05
	Fibrocavitary + bronchiectasis	2	16.00	14.00	12.00
	Fibrosis	29	14.83	12.58	10.08
	p-value		0.577	0.523	0.049

post-TB rehabilitation programs, particularly for patients with fibrotic or cavitary lung changes.[7]

Quality of life, assessed via the SGRQ, was worst in patients with combined fibrocavitary + bronchiectatic lesions (score 54 at baseline). However, significant improvements were observed across all groups following pulmonary rehabilitation (PR), underscoring PR's effectiveness regardless of structural severity. These findings align with outcomes from van Ranst et al.,[8] who demonstrated that even patients with severely impaired health status (SGRQ 66) experienced clinically meaningful improvements in HRQoL and exercise capacity following an intensive PR program (75% showing significant SGRQ).

Exercise capacity, measured via the 6-minute walk test (6MWT), was significantly lower in combined lesion patients (150 m at baseline) but improved to 280 m by

Table 4: Comparison of spirometric parameters (pre- and postbronchodilator FEV1% predicted, FVC%, FEV1/FVC ratio, and $FEF_{25–75}$%) at baseline, 12 weeks, and 24 weeks across radiological lesion subgroups (bronchiectasis, fibrocavitary, combined fibrocavitary + bronchiectasis, and fibrosis)

Parameter	*Radiological lesion*	*n*	*Mean value at visits*		
		0 weeks	*12 weeks*	*24 weeks*	
FEV_1 % predicted pre	Bronchiectasis	5	54.00	58.75	63.00
	Fibrocavitary	24	31.11	41.79	49.79
	Fibrocavitary + bronchiectasis	2	18.00	26.00	38.00
	Fibrosis	29	48.79	56.62	62.50
	p-value		0.010	0.022	0.032
FEV_1 % predicted post	Bronchiectasis	5	60.75	66.25	70.50
	Fibrocavitary	24	37.05	49.32	56.26
	Fibrocavitary + bronchiectasis	2	22.00	32.00	42.00
	Fibrosis	29	53.04	62.88	68.00
	p-value		0.026	0.027	0.037
FVC % predicted	Bronchiectasis	5	56.25	61.25	66.00
	Fibrocavitary	24	41.74	49.05	55.05
	Fibrocavitary + bronchiectasis	2	29.00	35.00	43.00
	Fibrosis	29	57.12	60.88	66.21
	p-value		0.073	0.152	0.124
FEV_1/FVC	Bronchiectasis	5	91.50	93.50	93.00
	Fibrocavitary	24	74.95	78.79	82.00
	Fibrocavitary + bronchiectasis	2	63.00	67.00	72.00
	Fibrosis	29	80.42	82.04	85.00
	p-value		0.182	0.106	0.170
$FEF_{25–75}$% predicted	Bronchiectasis	5	37.75	46.25	57.00
	Fibrocavitary	24	22.53	35.32	45.16
	Fibrocavitary + bronchiectasis	2	8.00	28.00	39.00
	Fibrosis	29	33.29	42.88	51.96
	p-value		0.070	0.160	0.142

FEV_1, forced expiratory volume in 1 second; FVC, forced vital capacity; $FEF_{25–75}$, forced expiratory flow at 25–75% of FVC

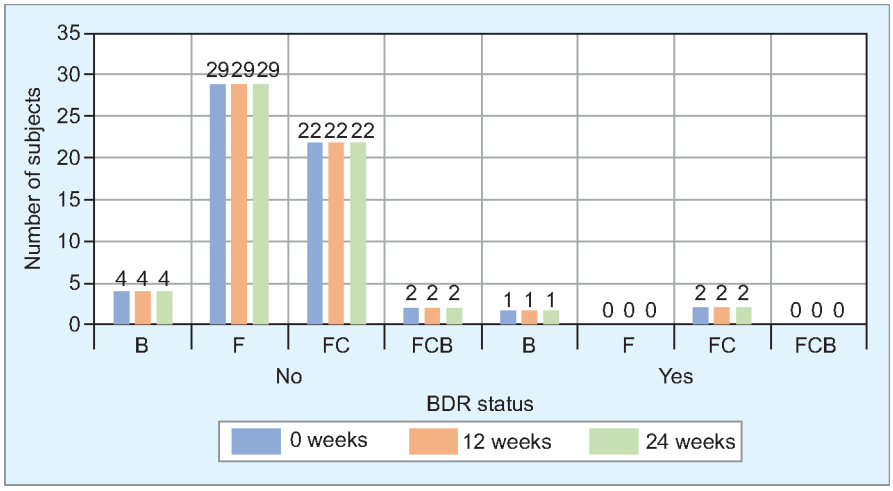

Fig. 1: Bar diagram showing distribution of bronchodilator reversibility (BDR) status across different radiological lesion types at 0, 12, and 24 weeks. No significant association was observed ($\chi^2 = 4.787$; $p = 0.188$) (B, bronchiectasis; F, fibrosis; FC, fibrocavitary; FCB, fibrocavitary + bronchiectasis)

24 weeks. In contrast, bronchiectasis and fibrosis groups exceeded 420 m by week 24. While differences were statistically significant at baseline (p = 0.01), they narrowed over time, underscoring PR's effectiveness in functional reconditioning. A study by Ando et al.[9] similarly demonstrated that pulmonary rehabilitation produced meaningful improvements in both post-TB lung disorder patients and COPD patients, with comparable gains in 6MWT distance and dyspnea scores (improvement of approximately 42–47 m post-PR).

Psychological parameters improved significantly over time, with the greatest reductions in depression, anxiety, and stress observed in patients with bronchiectasis and fibrosis. By week 24, intergroup differences were statistically significant (depression: $p = 0.013$; anxiety: $p = 0.034$; stress: $p = 0.049$), suggesting that patients with less extensive anatomical damage experience greater psychological benefit from PR. This aligns with findings from Pumar et al.,[10] who concluded that pulmonary rehabilitation improves anxiety and depression symptoms in chronic respiratory disease patients, reinforcing the value of integrated psychosocial support.

Pulmonary function improved across all radiological groups, with the lowest gains noted in patients with combined fibrocavitary and bronchiectasis lesions. In this subgroup, FEV_1% predicted increased from 18% at baseline to 38% at 24 weeks, whereas patients with fibrosis and bronchiectasis alone surpassed 60% by week 24 ($p < 0.05$). Postbronchodilator FEV_1 and $FEF_{25–75}$% showed parallel improvements, but remained

significantly lower in the combined lesion group, indicating that severe structural lung damage blunts spirometric recovery. These findings are consistent with observations by Hnizdo et al.,[11] who reported that cavitary and mixed lesions frequently lead to fixed and irreversible airflow obstruction in post-tuberculosis sequelae, limiting response to bronchodilator therapy and rehabilitation efforts.

Bronchodilator reversibility (BDR) was infrequent, noted in only 5% of patients, and limited to fibrocavitary and bronchiectasis subgroups. No statistically significant association was found between radiological lesion type and BDR status at any time point ($p = 0.188$). This low prevalence supports previous literature suggesting that airflow limitation in post-TB sequelae is typically nonreversible, as airway remodeling and parenchymal destruction dominate the pathophysiology rather than smooth muscle constriction.

In summary, this study highlights that while pulmonary rehabilitation improves clinical, functional, and psychological outcomes across all radiological phenotypes, patients with bronchiectasis and fibrosis benefit more consistently. Cavitary and mixed lesions are associated with poorer baseline parameters and slower recovery. These findings underscore the importance of lesion-specific stratification when designing and monitoring PR programs.

Importantly, there is a paucity of Indian studies comparing PR outcomes based on radiological phenotypes in PTBS. To our knowledge, this is the first study in India to assess multidimensional rehabilitation outcomes across radiological subtypes in post-TB patients. This fills a critical gap in the regional literature and offers context-specific insights for TB-endemic settings.

Clinically, these findings advocate for tailored PR models in PTBS care, with intensified support for patients with fibrocavitary or mixed lesions. Early identification and structured rehabilitation can potentially reverse or mitigate long-term morbidity. Integration of radiology-guided PR into national TB programs may significantly improve long-term outcomes and quality of life among TB survivors in high-burden countries such as India.

Conclusion

This study demonstrates that pulmonary rehabilitation (PR) leads to significant improvements in exercise capacity, spirometric indices, BMI, and psychological well-being in patients with post-tuberculosis sequelae (PTBS). Although patients with fibrocavitary and combined lesions exhibited greater baseline impairment, they still derived substantial benefit from PR. The findings highlight that radiological severity should not preclude rehabilitation efforts, and PR should be considered an essential component of long-term TB care. Importantly, the comparable benefits across radiological types underscore the need to integrate both hospital-based and scalable home-based PR models into national TB programs, particularly in resource-constrained, high-burden countries such as India.

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