



Publisher's Disclaimer. E-publishing ahead of print is increasingly important for the rapid dissemination of science. The **Early Access** service lets users access peer-reviewed articles well before print / regular issue publication, significantly reducing the time it takes for critical findings to reach the research community.

These articles are searchable and citable by their DOI (Digital Object Identifier).

The **Monaldi Archives for Chest Disease** is, therefore, e-publishing PDF files of an early version of manuscripts that have undergone a regular peer review and have been accepted for publication, but have not been through the typesetting, pagination and proofreading processes, which may lead to differences between this version and the final one.

The final version of the manuscript will then appear in a regular issue of the journal.

E-publishing of this PDF file has been approved by the authors.

All legal disclaimers applicable to the journal apply to this production process as well.

Monaldi Arch Chest Dis 2026 [Online ahead of print]

To cite this Article:

Mehta M, Dixit R, Mathur S, Goyal M. **Outcomes of pulmonary rehabilitation in post-tuberculosis sequelae: a comparative analysis of home-based and hospital-based programs.** *Monaldi Arch Chest Dis* doi: 10.4081/monaldi.2026.3900

Submitted: 15-01-2026

Accepted: 25-08-2026

Outcomes of pulmonary rehabilitation in post-tuberculosis sequelae: a comparative analysis of home-based and hospital-based programs

Manudev Mehta,¹ Ramakant Dixit,² Siddarth Mathur,² Mukesh Goyal³

¹Department of Respiratory Medicine, SP Medical College, Bikaner, Rajasthan; ²Department of Respiratory Medicine, J L N Medical College, Ajmer; ³Department of Respiratory Medicine, Vyas Medical College, Jodhpur, Rajasthan, India.

Correspondence: Ramakant Dixit, Department of Respiratory Medicine, J. L. N Medical College Ajmer, Near Agrasen Chauraha, Ajmer, Rajasthan, India.

E-mail: dr.ramakantdixit@gmail.com

Contributions: Manudev Mehta: Conceptualization, methodology, data collection, writing - original draft. Ramakant Dixit: conceptualization, supervision, writing - review and editing, project administration. Siddarth Mathur: formal analysis, writing - review and editing. Mukesh Goyal: interpretation of results and edited the final manuscript.

Conflict of interest: the authors have no conflict of interest to declare.

Ethics approval and consent to participate: the study protocol was reviewed and approved by the Institutional Ethics Committee of JLN Medical College, Ajmer in the letter No. 2429/Acad-III/MCA/2023 Dated 31/08/2023. All procedures followed were in accordance with the ethical standards of the institutional and/or national research committee and with the Helsinki Declaration of 1975, as revised in 2013.

Informed consent: written informed consent was obtained from all individual participants included in the study. Confidentiality of patient data was strictly maintained throughout the study.

Patient consent for publication: appropriate consent was taken from all for publication.

Availability of data and materials: the datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Funding: no external funding was received for the conduct of this study. The research was carried out as part of the academic thesis requirements of the Department of Respiratory Medicine, JLN Medical College, Ajmer.

Acknowledgments: the authors acknowledge the National Tuberculosis Elimination Programme (NTEP) and State TB Cell for their financial support in this study.

Declaration of generative artificial intelligence and artificial intelligence-assisted technologies in the writing process: generative artificial intelligence tools have not been used in the writing process of the manuscript.

Abstract

Post-tuberculosis lung disease (PTLD) is associated with persistent respiratory symptoms, reduced exercise capacity, impaired quality of life, and psychological morbidity despite successful completion of anti-tubercular therapy. Although pulmonary rehabilitation (PR) is an established therapeutic intervention, comparative evidence on home-based PR (HBPR) and hospital-based PR (HPR), particularly beyond 12 weeks, remains limited. So, to compare the effects of HBPR and HPR on clinical, functional, psychological, and pulmonary function outcomes in patients with PTLD, the study was done over a period of 24 weeks. This prospective comparative study included 50 patients with PTLD, of whom 30 underwent structured HBPR with weekly follow-up and 20 underwent supervised HPR. Allocation was based on feasibility and participant preference. Allocation was based on feasibility and participant preference. Participants were assessed at baseline, 12 weeks, and 24 weeks using the modified Medical Research Council (mMRC) dyspnea grade, body mass index (BMI), St. George's Respiratory Questionnaire (SGRQ), Depression Anxiety Stress Scale-21 (DASS-21), spirometry, and six-minute walk distance (6MWD). Changes within groups were analyzed for 0–12 weeks, 12–24 weeks, and 0–24 weeks, and change scores were compared between groups. Both rehabilitation strategies significantly improved dyspnea, nutritional status, quality of life, psychological well-being, pulmonary function, and exercise capacity over 24 weeks. In the HBPR group, mean 6MWD increased from 258.17 ± 82.72 m to 377.00 ± 82.38 m, while in the HPR group it increased from 308.00 ± 118.84 m to 429.00 ± 114.57 m (both $p < 0.001$). Mean SGRQ scores improved from 44.67 ± 9.28 to 29.73 ± 7.00 in the HBPR group and from 38.70 ± 10.35 to 25.10 ± 8.30 in the HPR group (both $p < 0.001$). Significant improvements were also observed in BMI, DASS-21 scores, forced expiratory volume in one second (FEV_1), forced vital capacity (FVC), FEV_1/FVC ratio, and forced expiratory flow between 25% and 75% of vital capacity predicted values. Although the greatest gains occurred during the first 12 weeks, several outcomes continued to improve between 12 and 24 weeks. Change-score analysis demonstrated comparable improvements between HBPR and HPR across most outcomes. This study concluded that both home-based and HPR significantly improved clinical, functional, psychological, and pulmonary outcomes in PTLD. Benefits extended beyond 12 weeks, with comparable improvements observed between rehabilitation strategies.

Key words: post-tuberculosis lung disease, pulmonary rehabilitation, home-based rehabilitation, hospital-based rehabilitation.

Introduction

Tuberculosis (TB) continues to pose a significant global health challenge, with India accounting for the highest number of cases worldwide [1]. While most patients achieve microbiological cure following anti-tubercular therapy, a substantial proportion develop long-term pulmonary sequelae, collectively referred to as post-tuberculosis sequelae (PTBS) [2]. These sequelae encompass structural, functional, and symptomatic impairments, including fibrosis, bronchiectasis, airflow obstruction, and reduced exercise tolerance, which persist well beyond the period of active disease. PTBS contributes significantly to chronic respiratory morbidity, healthcare utilization, and diminished health-related quality of life (HRQoL), yet remains under-recognized and under-treated within national TB programs [2].

Pulmonary rehabilitation (PR) is a well-established, evidence-based intervention for chronic respiratory disorders such as chronic obstructive pulmonary disease (COPD), and has shown substantial benefits in ameliorating dyspnea and enhancing functional exercise capacity, psychological well-being, and HRQoL [3]. Its application in PTBS, however, has been relatively underexplored, despite the pathophysiological overlap in functional limitation and symptomatology. The requirement for sustainable, scalable models of PR is further underscored in resource-limited settings, where barriers to facility-based rehabilitation programs often hinder patient access and long-term adherence [4].

In this context, home-based PR has emerged as a potentially viable alternative to conventional hospital-based programs, offering greater accessibility, reduced cost, and improved patient convenience [4]. However, comparative data evaluating the efficacy of home-based versus hospital-based PR specifically in the PTBS population remain sparse. Furthermore, multidimensional outcome assessment including spirometry, exercise tolerance, symptom burden, psychological status, and nutritional indices is essential to comprehensively evaluate PR results in this group.

This study was conducted to evaluate the comparative effectiveness of home-based and hospital-based PR in patients with PTBS over a 24-week intervention period. The primary outcomes included pulmonary function parameters (FEV₁, FVC, FEV₁/FVC, FEF_{25–75%}), 6-minute walk test (6MWT) distance, HRQoL as assessed by the St. George's Respiratory Questionnaire (SGRQ), psychological status using the Depression Anxiety Stress Scale-21 (DASS-21), and body mass index (BMI). This investigation aims to generate evidence to inform clinical practice and policy decisions regarding the optimal mode of PR delivery in the post-tuberculosis population.

Materials and Methods

This prospective, non-randomized comparative interventional study was conducted in a tertiary health care center in India. The study was designed to compare the effectiveness of home-based pulmonary rehabilitation (HBPR) and hospital-based pulmonary rehabilitation (HPR) in patients with post-tuberculosis lung disease (PTLD). Ethical approval was obtained from the Institutional Ethics Committee prior to study initiation, and written informed consent was obtained from all participants before enrolment.

Adult patients with a previous history of pulmonary tuberculosis who had successfully completed anti-tubercular treatment and subsequently developed PTLD were screened for eligibility. PTLD was defined by the presence of persistent respiratory symptoms and/or residual radiological abnormalities attributable to prior pulmonary tuberculosis. Patients aged 18 years or older, who were clinically stable and able to participate in pulmonary rehabilitation exercises and follow-up assessments, were included in the study. Patients with active tuberculosis, unstable cardiovascular disease, severe musculoskeletal, neurological, or psychiatric disorders limiting participation in rehabilitation, malignancy, contraindications to spirometry or exercise testing, or inability to provide informed consent were excluded. The spectrum of post-tuberculosis lung disease was documented for all participants based on clinical evaluation and radiological findings. Patients were categorized according to the predominant pattern of post-tuberculous lung involvement, including fibrosis, bronchiectasis, fibrocavitary disease, destroyed lung, and mixed post-tuberculous sequelae.

As there is limited published evidence directly comparing home-based and hospital-based pulmonary rehabilitation in patients with post-tuberculosis lung disease, the present study was conducted as an exploratory prospective comparative study. A convenience sample of all eligible and consenting patients presenting during the study period was included. A total of 50 participants were enrolled, comprising 30 patients in the home-based rehabilitation group and 20 patients in the hospital-based rehabilitation group.

Allocation of participants

A total of 50 eligible participants were enrolled in the study. Participants were allocated to either the home-based pulmonary rehabilitation (HBPR) group (n=30) or the hospital-based pulmonary rehabilitation (HPR) group (n=20) based on the feasibility of attending regular hospital-based rehabilitation sessions. Factors considered during allocation included distance from the hospital, availability of transportation, occupational commitments, financial

constraints, and patient preference. Individuals who were willing and able to attend supervised outpatient rehabilitation sessions twice weekly were enrolled in the HPR group, whereas those unable to attend regular hospital visits were assigned to the HBPR group. As the study was designed to evaluate the effectiveness of two rehabilitation strategies under real-world clinical conditions, randomization was not performed.

Pulmonary rehabilitation interventions

Both rehabilitation programs were based on standard pulmonary rehabilitation principles and included aerobic exercise training, breathing exercises, airway clearance techniques, nutritional counselling, and psychological support. The rehabilitation components were standardized across both groups. The principal distinction between the two groups was not merely the frequency of hospital attendance but the setting and supervision of the exercise sessions. Participants in the home-based pulmonary rehabilitation group performed all prescribed rehabilitation exercises independently at home. Their weekly hospital visits did not include supervised exercise training and were restricted to assessment of adherence, review of exercise records, reinforcement of previously taught techniques, evaluation of progress and resolution of difficulties. In contrast, participants in the hospital-based pulmonary rehabilitation group performed two exercise sessions per week at the hospital under the direct supervision of trained healthcare personnel. The remaining prescribed exercises were continued at home.

Home-based pulmonary rehabilitation (HBPR)

Participants allocated to the home-based pulmonary rehabilitation group received an initial supervised training and demonstration session. Thereafter, all prescribed rehabilitation exercises, including walking exercises, breathing exercises, airway clearance techniques and physical conditioning, were performed independently at home. Participants visited the hospital once weekly only for monitoring of adherence, review of progress, reinforcement of previously taught techniques and resolution of difficulties. No supervised exercise or rehabilitation session was conducted during these weekly follow-up visits. Thus, the active rehabilitation component was delivered entirely at home, while the hospital visits served only as follow-up and monitoring contacts.

Hospital-based pulmonary rehabilitation (HPR)

Participants allocated to the hospital-based pulmonary rehabilitation group attended two rehabilitation sessions per week at the outpatient pulmonary rehabilitation unit. These sessions involved active exercise training under the direct supervision of trained healthcare personnel. Exercise intensity and progression were individualized according to participant tolerance and clinical status. Participants were also advised to continue the prescribed exercises at home between supervised hospital sessions.

Outcome assessment

All participants were evaluated at baseline (0 weeks), 12 weeks, and 24 weeks.

Dyspnea severity was assessed using the Modified Medical Research Council (mMRC) Dyspnea Scale. Nutritional status was assessed using body mass index (BMI), calculated as weight in kilograms divided by height in meters squared (kg/m^2). Health-related quality of life was evaluated using the St. George's Respiratory Questionnaire (SGRQ), with lower scores indicating better quality of life. Psychological well-being was assessed using the Depression Anxiety Stress Scale-21 (DASS-21), which provides separate scores for depression, anxiety, and stress domains.

Pulmonary function testing was performed using standardized spirometry according to established guidelines. Parameters assessed included pre- and post-bronchodilator forced expiratory volume in one second (FEV_1), forced vital capacity (FVC), FEV_1/FVC ratio, and forced expiratory flow between 25% and 75% of vital capacity ($\text{FEF}_{25-75\%}$), expressed as percentage predicted values.

Functional exercise capacity was assessed using the six-minute walk test (6MWT), performed according to American Thoracic Society recommendations. The total six-minute walk distance (6MWD) was recorded in metres.

Follow-up duration

Conventional pulmonary rehabilitation programmes are commonly conducted over 8–12 weeks. However, limited evidence is available regarding the sustainability of rehabilitation benefits in patients with PTLD beyond this period. Therefore, participants in the present study were followed for 24 weeks to evaluate both short-term and longer-term responses to pulmonary rehabilitation and to determine whether improvements were sustained beyond the initial rehabilitation phase.

Statistical analysis

Data were entered into Microsoft Excel and analysed using Statistical Package for Social Sciences (SPSS) software version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean $\pm$ standard deviation (SD) or median with interquartile range (IQR), depending on data distribution, while categorical variables were expressed as frequencies and percentages.

Baseline demographic, clinical, radiological, functional, and quality-of-life characteristics were compared between the home-based and hospital-based pulmonary rehabilitation groups using the independent samples t-test or Mann–Whitney U test for continuous variables and the Chi-square test or Fisher’s exact test for categorical variables, as appropriate.

Changes in outcome measures within each rehabilitation group were evaluated across the study period by comparing values between baseline and 12 weeks, 12 weeks and 24 weeks, and baseline and 24 weeks. Outcome measures assessed included dyspnea grade (mMRC), body mass index (BMI), St. George’s Respiratory Questionnaire (SGRQ) score, Depression Anxiety Stress Scale-21 (DASS-21) scores, spirometric parameters (FEV₁, FVC, FEV₁/FVC ratio, and FEF_{25–75}%), and six-minute walk distance (6MWD).

To compare the effectiveness of the two rehabilitation strategies, the magnitude of change in outcome measures over the intervals of 0–12 weeks, 12–24 weeks, and 0–24 weeks was calculated and compared between the two groups using appropriate parametric or non-parametric statistical tests based on data distribution.

All statistical tests were two-tailed, and a p-value of less than 0.05 was considered statistically significant.

Results

A total of 50 patients with post-tuberculosis lung disease (PTLD) were enrolled in the study, including 30 participants in the home-based pulmonary rehabilitation (HBPR) group and 20 participants in the hospital-based pulmonary rehabilitation (HPR) group. All participants completed the planned follow-up assessments at baseline, 12 weeks, and 24 weeks.

Baseline demographic, clinical, radiological, functional, and quality-of-life characteristics are summarized in Table 1. The mean age of participants was comparable between the HBPR and HPR groups (45.97 ± 2.16 vs. 43.10 ± 3.20 years, $p = 0.45$). Sex distribution, smoking history, alcohol use, tobacco use, socioeconomic status, and PTLD spectrum were also similar between groups.

A significant difference was observed in residence status, with all HBPR participants residing in rural areas compared to a predominantly urban population in the HPR group ($p < 0.001$). At baseline, the HPR group demonstrated lower dyspnea severity, better health-related quality of life, lower depression scores, and higher post-bronchodilator FEV₁ values compared with the HBPR group.

The longitudinal changes in clinical, psychological, and functional outcomes are presented in Tables 2 and 3. Both rehabilitation strategies resulted in significant reductions in dyspnea severity over the study period. In the HBPR group, mean mMRC grade improved from 2.43 at baseline to 1.50 at 12 weeks and 1.33 at 24 weeks ($p < 0.001$ for 0–24 weeks). In the HPR group, mean mMRC grade improved from 1.95 to 1.25 over the same period ($p < 0.001$). Most of the improvement occurred during the first 12 weeks, with relatively smaller gains thereafter.

Nutritional status improved significantly in both groups. Mean BMI increased from 19.09 ± 3.99 kg/m² to 19.96 ± 3.79 kg/m² in the HBPR group and from 21.51 ± 4.34 kg/m² to 22.33 ± 4.28 kg/m² in the HPR group over 24 weeks (both $p < 0.001$).

Health-related quality of life showed marked improvement following pulmonary rehabilitation. Mean SGRQ scores decreased from 44.67 ± 9.28 to 29.73 ± 7.00 in the HBPR group and from 38.70 ± 10.35 to 25.10 ± 8.30 in the HPR group over 24 weeks (both $p < 0.001$), indicating substantial reduction in disease-related impairment.

Similarly, depression, anxiety, and stress scores progressively improved throughout the study period in both groups. Significant reductions were observed during both the early rehabilitation phase (0–12 weeks) and the later phase (12–24 weeks), suggesting sustained psychological benefits with continued rehabilitation.

Exercise capacity improved significantly in both groups. Mean six-minute walk distance increased from 258.17 ± 82.72 m to 377.00 ± 82.38 m in the HBPR group and from 308.00 ± 118.84 m to 429.00 ± 114.57 m in the HPR group over 24 weeks (both $p < 0.001$), demonstrating substantial enhancement in functional exercise tolerance.

Changes in spirometric parameters are summarized in Table 4. Both rehabilitation strategies were associated with significant improvements in pulmonary function over 24 weeks. In the HBPR group, pre-bronchodilator FEV₁ increased from 36.83% predicted at baseline to 53.40% predicted at 24 weeks, while post-bronchodilator FEV₁ increased from 41.37% to 59.30% predicted (both $p < 0.001$). Similar improvements were observed in the HPR group, with pre-bronchodilator FEV₁ increasing from 47.15% to 60.90% predicted and post-bronchodilator FEV₁ increasing from 53.10% to 67.00% predicted (both $p < 0.001$).

Forced vital capacity also improved progressively in both groups, increasing from 46.80% to 58.23% predicted in the HBPR group and from 54.25% to 64.25% predicted in the HPR group over 24 weeks (both $p < 0.001$).

The FEV₁/FVC ratio demonstrated gradual improvement in both groups. In the HBPR group, significant improvement was observed throughout the study period ($p < 0.001$), whereas in the HPR group the most pronounced improvement occurred between 12 and 24 weeks, resulting in a significant overall increase at 24 weeks ($p = 0.044$).

Small airway function, assessed by FEF_{25–75%} predicted, improved substantially in both rehabilitation groups. Mean FEF_{25–75%} predicted increased from 26.23% to 47.13% in the HBPR group and from 31.45% to 51.45% in the HPR group over 24 weeks (both $p < 0.001$). Overall, these findings indicate that pulmonary rehabilitation was associated with sustained improvements in airflow limitation, lung volumes, and small airway function irrespective of the mode of programme delivery.

Comparison of the magnitude of improvement achieved by the two rehabilitation strategies is presented in Tables 5 and 6. Both HBPR and HPR demonstrated comparable improvements across most clinical, functional, psychological, and pulmonary function outcomes. Significant between-group differences were observed for dyspnea improvement and early reduction in depression scores, favouring HBPR. However, no significant differences were observed between groups in changes in BMI, SGRQ scores, anxiety scores, stress scores, six-minute walk distance, or spirometric parameters.

Although participants in the HPR group generally demonstrated numerically higher absolute values at follow-up assessments, the magnitude of improvement achieved over 12 and 24 weeks was largely comparable between the two rehabilitation strategies. These findings suggest that both home-based and hospital-based pulmonary rehabilitation are effective approaches for improving respiratory function, exercise capacity, quality of life, and psychological well-being in patients with PTLD.

Discussion

The present study evaluated the effectiveness of home-based pulmonary rehabilitation (HBPR) and hospital-based pulmonary rehabilitation (HPR) in patients with post-tuberculosis lung disease (PTLD) over a 24-week period. Both rehabilitation strategies resulted in significant improvements in dyspnea severity, nutritional status, health-related quality of life, psychological well-being, pulmonary function, and exercise capacity. Importantly,

improvements were observed not only during the initial 12 weeks but also during the subsequent 12-week period, indicating sustained benefits with prolonged rehabilitation. These findings are consistent with the recent systematic review and meta-analysis by Gebremedhn et al., which demonstrated significant improvements in exercise capacity, lung function, and quality of life following pulmonary rehabilitation in PTLD patients [5].

Significant reductions in dyspnea and substantial improvements in exercise capacity were observed in both groups. Mean six-minute walk distance increased by approximately 119 m in the HBPR group and 121 m in the HPR group over 24 weeks. Similar findings were reported by Ando et al., who demonstrated improvement in exercise tolerance and symptom burden following pulmonary rehabilitation in patients with post-tuberculosis lung disorders [6]. Likewise, Sinha et al. reported significant gains in functional exercise capacity and health-related quality of life following pulmonary rehabilitation in a multicentric Indian PTLD cohort [7]. The observed improvement in exercise performance in our study likely reflects enhanced physical conditioning, improved respiratory muscle efficiency, and reduced symptom burden. Pulmonary rehabilitation also produced meaningful improvements in nutritional status, quality of life, and psychological well-being. Significant reductions in SGRQ scores were observed in both groups, accompanied by improvements in depression, anxiety, and stress scores. Daniels et al. highlighted that many TB survivors continue to experience impaired quality of life, exercise intolerance, and persistent respiratory symptoms despite microbiological cure [8]. Our findings support the growing recognition of PTLD as a chronic disabling condition and reinforce the role of pulmonary rehabilitation as a comprehensive intervention addressing both physical and psychosocial consequences of the disease. Similar improvements in health-related quality of life following rehabilitation have also been reported by Sinha et al. and Gebremedhn et al. [5,7].

A notable finding of the present study was the progressive improvement in pulmonary function parameters throughout the 24-week follow-up period. Significant gains were observed in FEV₁, FVC, FEV₁/FVC ratio, and FEF_{25–75%} predicted values in both rehabilitation groups. These findings are in agreement with the meta-analysis by Gebremedhn et al., which reported favorable effects of pulmonary rehabilitation on pulmonary function in PTLD patients [5]. Importantly, several outcomes in our study continued to improve between 12 and 24 weeks. This observation is clinically relevant because most pulmonary rehabilitation programmes traditionally focus on durations of 8–12 weeks. Mtei et al., who evaluated PTLD patients over a longer follow-up period, similarly reported sustained improvements in quality of life and

exercise performance beyond the early rehabilitation phase [9]. Our findings therefore suggest that extending pulmonary rehabilitation beyond 12 weeks may provide additional benefit in selected PTLD patients.

Although both groups demonstrated comparable improvements across most outcomes, the interventions differed substantially in the setting and supervision of exercise delivery. Participants in the structured home-based group performed all rehabilitation exercises independently at home, and their weekly hospital visits were limited to monitoring, adherence assessment and reinforcement without supervised exercise training. In contrast, participants in the hospital-based group underwent two directly supervised exercise sessions per week at the hospital. Therefore, the comparison was between independently performed home-based rehabilitation supported by weekly follow-up and directly supervised hospital-based rehabilitation, rather than between groups differing only by one hospital visit per week. Nevertheless, the weekly face-to-face follow-up provided to the home-based group may have improved adherence and contributed to the observed outcomes. Kirakosyan et al. emphasized the need for accessible and scalable rehabilitation models for post-tuberculosis lung disease, particularly in low- and middle-income countries where rehabilitation services remain underdeveloped [10]. The findings of the present study support structured home-based pulmonary rehabilitation with weekly follow-up as a feasible approach for patients with limited access to regularly supervised hospital-based programmes. However, these findings should not be generalized to completely unsupervised home-based rehabilitation programmes.

Strengths and limitations

The strengths of this study include its prospective design, comprehensive assessment of clinical, functional, psychological, and spirometric outcomes, and the extended 24-week follow-up period, which allowed evaluation of both short-term and longer-term rehabilitation effects. Additionally, the study provides real-world comparative data on home-based and hospital-based pulmonary rehabilitation in PTLD, an area where evidence remains limited.

However, certain limitations should be acknowledged. The study included a relatively small convenience sample from a single tertiary-care centre, which may limit generalizability. Non-random allocation based on feasibility and participant preference, along with baseline differences between groups, may have introduced selection bias and residual confounding. Although participants in the home-based group performed all exercises independently at home, their weekly hospital visits for monitoring and reinforcement may have improved

adherence and motivation. Therefore, the intervention represents structured home-based rehabilitation with weekly facility-based follow-up, and the findings may not apply to completely unsupervised or remotely monitored programmes. Additionally, outcomes beyond 24 weeks were not assessed.

Conclusions

Both home-based and hospital-based pulmonary rehabilitation resulted in significant improvements in dyspnea, exercise capacity, nutritional status, quality of life, psychological well-being, and pulmonary function among patients with post-tuberculosis lung disease. Improvements continued beyond 12 weeks, suggesting that prolonged rehabilitation programmes may provide additional benefit in this population. Although hospital-based rehabilitation achieved numerically higher follow-up values, the magnitude of improvement was largely comparable between groups, supporting home-based pulmonary rehabilitation as an effective and accessible alternative for PTLD management.

References

1. World Health Organization. Global tuberculosis report 2023. Available from: <https://www.who.int/publications/i/item/9789240083851>.
2. Allwood BW, Byrne A, Meghji J, et al. Post-tuberculosis lung disease: clinical review of an under-recognised global challenge. *Respiration* 2021;100:751-63.
3. Spruit MA, Singh SJ, Garvey C, et al. An official American Thoracic Society/European Respiratory Society statement: key concepts and advances in pulmonary rehabilitation. *Am J Respir Crit Care Med* 2013;188:e13-64.
4. Holland AE, Mahal A, Hill CJ, et al. Home-based rehabilitation for COPD using minimal resources: a randomised, controlled equivalence trial. *Thorax* 2017;72:57-65.
5. Gebremedhn AT, Bobosha K, Adane HT, et al. Effect of pulmonary rehabilitation on lung function and quality of life in pulmonary tuberculosis survivors with post-tuberculosis lung disease: a systematic review and meta-analysis. *BMC Pulm Med* 2026;26:215.
6. Ando M, Mori A, Esaki H, et al. The effect of pulmonary rehabilitation in patients with post-tuberculosis lung disorder. *Chest* 2003;123:1988-95.
7. Sinha S, Titiyal R, Mounika P, et al. Effectiveness of pulmonary rehabilitation on functional exercise capacity and health related quality of life (HRQOL) among individuals with post

tuberculosis lung disease: a multicentric pre and post-interventional study. *Indian J Med Res* 2025;161:540-51.

8. Daniels KJ, Irusen E, Pharaoh H, Hanekom S. Post-tuberculosis health-related quality of life, lung function and exercise capacity in a cured pulmonary tuberculosis population in the Breede Valley District, South Africa. *S Afr J Physiother* 2019;75:1319.
9. Mtei FJ, Meadows I, Msaji K, et al. Pulmonary rehabilitation for post-TB lung disease led by TB survivors. *Public Health Action* 2025;15:82-7.
10. Kirakosyan O, Verbree H, van der Zalm MM, et al. Rehabilitation for individuals with post-tuberculosis lung disease. *Breathe* 2026;22:250056.

Table1. Baseline characteristics of study population.

Variable	Home-based PR (n=30)	Hospital-based PR (n=20)	p
Age (years)	45.97±2.16*	43.10±3.20*	0.45
Sex			
Male	21 (70.0%)	11 (55.0%)	0.43
Female	9 (30.0%)	9 (45.0%)	
Residence			
Rural	30 (100.0%)	3 (15.0%)	<0.001
Urban	0	17 (85.9%)	
Smoking history	12 (40.0%)	8 (40.0%)	1
Alcohol use	5 (16.7%)	3 (15.0%)	1
Tobacco use	12 (40.0%)	3 (15.0%)	0.12
Socioeconomic status			
Group II	3 (10.0%)	1 (5.0%)	0.09
Group III	3 (10.0%)	7 (35.0%)	
Group IV	19 (63.3%)	7 (35.0%)	
Group V	5 (16.7%)	5 (25.0%)	
PTLD spectrum			
Bronchiectasis	1 (3.3%)	3 (15.0%)	0.15
Fibrocavitary disease	16 (53.3%)	6 (30.0%)	
Fibrosis	13 (43.3%)	11 (55.0%)	
mMRC Dyspnea Grade			
Grade 1	0 (0%)	6 (30.0%)	0.005
Grade 2	17 (56.7%)	9 (45.0%)	
Grade 3	13 (43.3%)	5 (25.0%)	
BMI (kg/m²)	19.09±3.99	21.51±4.34	0.061
SGRQ Score	44.67±9.28	38.70±10.35	0.031
DASS-21 Depression	9.67±1.67	8.30±2.54	0.039
DASS-21 Anxiety	12.60±1.98	11.40±2.84	0.091
DASS-21 Stress	15.67±2.47	14.60±2.44	0.082
FEV₁ (% predicted, pre-BD)	36.83±20.06	47.15±21.20	0.081
FEV₁ (% predicted, post-BD)	41.37±20.94	53.10±20.38	0.049
FVC (% predicted)	46.80±22.12	54.25±18.50	0.156
FEV₁/FVC (%)	74.83±15.04	83.65±17.03	0.061
FEF25–75 (% predicted)	26.23±20.15	31.45±17.38	0.223
Bronchodilator reversibility positive	1 (3.3%)	2 (10.0%)	0.556
6MWD (m)	258.17±82.72	308.00±118.84	0.134

Table 2. Longitudinal changes in dyspnea, nutritional, psychosocial and functional parameters among participants undergoing home-based pulmonary rehabilitation.

Variable	Baseline	12 weeks	24 weeks	p (0–12)	p (12–24)	p (0–24)
mMRC	2.43±0.50	1.50±0.51	1.33±0.48	0.001	0.025	0.001
BMI	19.09±3.99	19.57±3.87	19.96±3.79	0.001	0.001	0.001
SGRQ	44.67±9.28	36.87±7.62	29.73±7.00	0.001	0.001	0.001
DASS-D	9.67±1.67	7.87±1.48	6.00±1.39	0.001	0.001	0.001
DASS-A	12.60±1.98	10.67±1.52	8.67±1.42	0.001	0.001	0.001
DASS-S	15.67±2.47	13.13±2.08	10.73±1.44	0.001	0.001	0.001
6MWD	258.17±82.72	328.00±82.44	377.00±82.38	0.001	0.001	0.001

Table 3. Longitudinal changes in dyspnoea, nutritional, psychosocial and functional parameters among participants undergoing Hospital -based pulmonary rehabilitation

Variable	Baseline	12 weeks	24 weeks	p (0–12)	p (12–24)	p (0–24)
mMRC	1.95±0.76	1.25±0.44	1.25±0.44	0.001	1	0.001
BMI	21.51±4.34	21.94±4.17	22.33±4.28	0.001	0.001	0.001
SGRQ	38.70±10.35	31.90±9.46	25.10±8.30	0.001	0.001	0.001
DASS-D	8.30±2.54	7.00±1.89	5.20±1.51	0.001	0.001	0.001
DASS-A	11.40±2.84	9.70±2.18	7.80±1.58	0.001	0.001	0.001
DASS-S	14.60±2.44	12.40±2.01	10.10±1.65	0.001	0.001	0.001
6MWD	308.00±118.84	378.00±115.92	429.00±114.57	0.001	0.001	0.001

Table 4. Longitudinal changes in pulmonary function parameters among participants undergoing home-based and hospital-based pulmonary rehabilitation.

Parameter	Group	Baseline	12 Weeks	24 Weeks	p (0–12)	p (12–24)	p (0–24)
FEV ₁ (% predicted, pre-BD)	HBPR	36.83±20.06	46.07±18.26	53.40±16.20	0.001	0.001	0.001
	HPR	47.15±21.20	54.90±19.16	60.90±16.60	0.001	0.001	0.001
FEV ₁ (% predicted, post-BD)	HBPR	41.37±20.94	53.03±17.93	59.30±15.54	0.001	0.001	0.001
	HPR	53.10±20.38	61.55±17.95	67.00±15.81	0.001	0.001	0.001
FVC (% predicted)	HBPR	46.80±22.12	52.47±20.98	58.23±18.72	0.001	0.001	0.001
	HPR	54.25±18.50	58.95±17.22	64.25±15.86	0.001	0.001	0.001
FEV ₁ /FVC (%)	HBPR	74.83±15.04	78.00±12.48	81.53±10.10	0.001	0.001	0.001
	HPR	83.65±17.03	85.40±13.16	87.10±11.10	0.001	0.001	0.001
FEF _{25–75} (% predicted)	HBPR	26.23±20.15	37.50±18.35	47.13±16.34	0.001	0.001	0.001
	HPR	31.45±17.38	42.05±14.92	51.45±13.50	0.001	0.001	0.001

Table 5. Comparison of magnitude of improvement in dyspnoea, nutritional, psychosocial and functional parameters between home-based and hospital-based pulmonary rehabilitation.

Variable	$\Delta 0-12$ Home	$\Delta 0-12$ Hospital	p	$\Delta 12-24$ Home	$\Delta 12-24$ Hospital	p	$\Delta 0-24$ Home	$\Delta 0-24$ Hospital	p
mMRC	-0.93±0.25	-0.70±0.47	0.030	-0.17±0.38	0.00±0.00	0.059	-1.10±0.31	-0.70±0.47	0.001
BMI	0.47±0.29	0.43±0.29	0.896	0.39±0.36	0.39±0.35	0.952	0.86±0.45	0.82±0.36	0.728
SGRQ	-7.80±3.12	-6.80±2.19	0.430	-7.13±2.61	-6.80±2.09	0.703	-14.93±4.75	-13.60±3.47	0.372
DASS-D	-1.80±0.61	-1.30±0.98	0.033	-1.87±0.73	-1.80±0.89	0.768	-3.67±0.92	-3.10±1.52	0.151
DASS-A	-1.93±0.83	-1.70±1.34	0.584	-2.00±0.91	-1.90±1.21	0.738	-3.93±1.34	-3.60±1.67	0.423
DASS-S	-2.53±1.28	-2.20±1.44	0.575	-2.40±1.33	-2.30±0.98	0.687	-4.93±1.64	-4.50±1.43	0.246
6MWD	69.83±26.67	70.00±44.60	0.446	49.00±21.39	51.00±29.72	0.608	118.83±38.41	121.00±63.40	0.591

Table 6. Comparison of magnitude of improvement in pulmonary function parameters between home-based and hospital-based pulmonary rehabilitation.

Parameter	$\Delta 0-12$ HBPR	$\Delta 0-12$ HPR	p	$\Delta 0-24$ HBPR	$\Delta 0-24$ HPR	p
FEV ₁ (% predicted, pre-BD)	9.24	7.75	0.48	16.57	13.75	0.39
FEV ₁ (% predicted, post-BD)	11.66	8.45	0.27	17.93	13.9	0.21
FVC (% predicted)	5.67	4.7	0.63	11.43	10	0.57
FEV ₁ /FVC (%)	3.17	1.75	0.19	6.7	3.45	0.08
FEF ₂₅₋₇₅ (% predicted)	11.27	10.6	0.82	20.9	20	0.91