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Research Article

Tele-Rehabilitation for Rural Pulmonary Care: Feasibility and Outcomes

Abdulrehman Khalid Makki¹, Misbah Shakeel²✉

¹Evercare Hospital, Lahore, Pakistan, ²Iqra University, Chack Shehzad Campus, Islamabad, Pakistan

ABSTRACT

Background Pulmonary rehabilitation (PR) is an essential intervention for chronic respiratory diseases, yet access remains a challenge in rural areas. Tele-rehabilitation (tele-PR) offers a promising alternative to traditional center-based PR, addressing barriers like geographic isolation and resource constraints. **Objective** To evaluate the feasibility, safety, and effectiveness of tele-PR in improving exercise capacity, symptoms, and quality of life in rural populations. **Methods** This pilot feasibility study utilized a mixed-methods approach involving 100 participants with chronic respiratory diseases. Participants underwent an 8-week tele-PR program, including supervised exercise sessions, educational modules, and self-management support via a telehealth platform. Outcomes were assessed at baseline, post-intervention, and at a 12-week follow-up. Exercise capacity was measured using the six-minute walk test (6MWT), symptom severity using the COPD Assessment Test (CAT), and patient satisfaction using a Likert scale. Data was analyzed using IBM SPSS Statistics 25, with significance set at $p < 0.05$. **Results** Participants demonstrated a significant improvement in 6MWT distance (baseline: 330.5 ± 45.3 m; post-intervention: 372.8 ± 48.1 m; $p < 0.001$) and CAT scores (baseline: 21.7 ± 5.2 ; post-intervention: 16.1 ± 4.8 ; $p < 0.001$). Adherence was 92%, and satisfaction scored 4.6 ± 0.3 . **Conclusion** Tele-PR is a feasible, effective, and accessible intervention for rural populations, significantly improving exercise capacity, symptoms, and satisfaction. Further research is needed to refine and scale tele-PR programs.

Keywords: Telemedicine, Pulmonary Rehabilitation, Rural Health, Chronic Obstructive Pulmonary Disease, Exercise Therapy, Patient Satisfaction, Feasibility Studies

INTRODUCTION

Tele-rehabilitation has emerged as a transformative approach in pulmonary care, addressing the critical barriers faced by patients in rural and underserved areas. Chronic respiratory diseases, including chronic obstructive pulmonary disease (COPD), significantly impair patients' quality of life and impose a substantial burden on healthcare systems. Pulmonary rehabilitation (PR), a cornerstone of non-pharmacological management for such conditions, has consistently demonstrated benefits in enhancing exercise capacity, alleviating symptoms, and improving health-related quality of life. However, the accessibility of traditional center-based PR programs remains limited, particularly in rural areas where logistical, financial, and geographic barriers often deter patients from participating in these essential interventions (1). Tele-rehabilitation (tele-PR) leverages modern communication technologies to bridge this accessibility gap, offering home-based or remotely delivered PR programs as a viable alternative. Its emergence has gained considerable momentum during the COVID-19 pandemic, which necessitated rapid shifts from in-person to virtual healthcare delivery to minimize infection risks (2).

Recent evidence underscores the feasibility, safety, and effectiveness of tele-PR in managing chronic respiratory diseases. Studies have demonstrated comparable improvements in exercise capacity and quality of life between tele-PR and traditional PR programs, with some research highlighting higher program completion rates among tele-PR participants due to reduced travel burdens and increased convenience (3, 4). Moreover, tele-PR has been particularly impactful in rural settings, where geographic isolation and resource limitations previously hindered the delivery of standard PR services (5). Despite these advancements, challenges persist in the standardization of tele-PR protocols, particularly in tailoring exercise prescriptions and ensuring the delivery of core PR components remotely. Furthermore, technological barriers, such as lack of access to devices or digital literacy among older patients, pose additional hurdles to widespread adoption (6, 7).

The advent of tele-PR has also prompted exploration into hybrid models that integrate in-person and remote components. These models have shown promise in balancing accessibility with the preservation of exercise intensity and program fidelity typically associated with center-based PR. Nevertheless, the heterogeneity in tele-PR delivery methods has complicated efforts to establish a robust evidence base to guide its implementation on a larger scale (8). As the healthcare landscape continues to adapt to post-pandemic realities, tele-rehabilitation represents a significant step forward in expanding access to pulmonary care while maintaining clinical outcomes. Further research is warranted to optimize tele-PR delivery, address implementation challenges, and explore its cost-effectiveness in comparison to traditional PR models (9).

Disclaimers

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MATERIAL AND METHODS

This study was conducted as a pilot feasibility study employing a mixed-methods approach to assess adherence, clinical outcomes, and patient satisfaction with tele-rehabilitation for pulmonary care in rural populations. A sample size of 100 participants was enrolled, selected through convenience sampling based on predefined inclusion and exclusion criteria. Participants were adults diagnosed with chronic respiratory diseases, including chronic obstructive pulmonary disease (COPD), residing in rural areas with limited access to traditional pulmonary rehabilitation services. Inclusion criteria required participants to have a stable clinical condition, access to a smartphone or internet-enabled device, and basic digital literacy. Exclusion criteria included severe cognitive impairment, recent hospitalizations for acute exacerbations, or inability to provide informed consent (1).

Ethical approval for the study was obtained from the relevant institutional review board, ensuring compliance with the Declaration of Helsinki and its subsequent amendments. All participants provided written informed consent before enrollment. The study design and procedures were clearly explained to the participants, emphasizing voluntary participation and confidentiality of their data. Participants retained the right to withdraw from the study at any stage without any repercussions (2).

Data collection was carried out using a combination of quantitative and qualitative methods. Quantitative data included clinical outcomes such as exercise capacity, measured using the six-minute walk test (6MWT), and symptom severity, assessed with validated tools like the COPD Assessment Test (CAT). Qualitative data focused on patient satisfaction and adherence to the tele-rehabilitation program, collected through structured interviews and surveys. Baseline measurements were obtained prior to the initiation of the program, followed by assessments at the midpoint, immediately post-intervention, and at a 12-week follow-up to evaluate sustainability of outcomes (3).

The tele-rehabilitation intervention consisted of an eight-week structured program delivered via a telehealth platform. Participants engaged in twice-weekly supervised exercise sessions guided by trained physiotherapists, supplemented by educational modules addressing disease self-management, nutrition, and mental health support. The telehealth platform enabled real-time video

communication, ensuring interactive and personalized care. Adherence to the program was monitored through digital attendance logs and patient-reported compliance. Technical support was provided to participants as needed to address any digital access challenges (4).

Data analysis was performed using IBM SPSS Statistics, version 25. Quantitative data were analyzed using descriptive and inferential statistical methods. Continuous variables were summarized as means and standard deviations, while categorical variables were expressed as frequencies and percentages. Between-group comparisons were conducted using paired t-tests or Wilcoxon signed-rank tests for continuous variables, and chi-square tests for categorical variables. A p-value of <0.05 was considered statistically significant. Qualitative data were transcribed and analyzed thematically to identify key patterns related to patient satisfaction and program feasibility (5).

This study aimed to provide preliminary evidence on the feasibility, safety, and effectiveness of tele-rehabilitation in enhancing access to pulmonary care for rural populations while addressing existing barriers such as geographic isolation and limited healthcare resources. Insights from this pilot study will inform the design of larger-scale clinical trials and contribute to the development of standardized tele-rehabilitation protocols (6).

RESULTS

The study included 100 participants, of whom 92 completed the tele-rehabilitation program, resulting in a high adherence rate of 92%. The analysis focused on primary outcomes, including changes in exercise capacity and symptoms, and secondary outcomes such as quality of life and patient satisfaction. The findings demonstrate significant improvements across multiple metrics, emphasizing the feasibility and efficacy of tele-rehabilitation for pulmonary care in rural populations.

The baseline characteristics of participants are summarized in Table 1. The mean age of participants was 65.4 years, with a slight male predominance (58%). Most participants (75%) had a primary diagnosis of chronic obstructive pulmonary disease (COPD). The mean baseline six-minute walk test (6MWT) distance was 330.5 meters, and the mean COPD Assessment Test (CAT) score was 21.7, indicating moderate to severe symptoms.

Table 1. Baseline Characteristics

Characteristic	Value
Total participants (n)	100
Mean age (years)	65.4 ± 8.2
Male (%)	58
COPD (%)	75
Mean baseline 6MWT (meters)	330.5 ± 45.3
Baseline CAT score (mean ± SD)	21.7 ± 5.2

Significant improvements were observed in exercise capacity, as measured by the 6MWT. Table 2 illustrates the progression of 6MWT results across different time points. Participants demonstrated an average increase of 42.3 meters post-intervention

($p < 0.001$), with sustained improvements at the 12-week follow-up (mean increase: 39.1 meters, $p < 0.001$). These findings highlight the clinical benefits of tele-rehabilitation in enhancing functional exercise capacity.

Table 2. Changes in Exercise Capacity (6MWT)

Time Point	6MWT Distance (meters)	Mean Difference (meters)	p-value
Baseline	330.5 ± 45.3	-	-
Post-intervention	372.8 ± 48.1	+42.3	<0.001
12-week follow-up	369.6 ± 46.9	+39.1	<0.001

Symptom severity also improved significantly, as reflected by reductions in CAT scores (Table 3). The mean CAT score decreased by 5.6 points post-intervention ($p < 0.001$) and remained 4.8 points below baseline at the 12-week follow-up ($p < 0.001$). These results indicate a substantial reduction in symptom burden and an improvement in health-related quality of life. Participant satisfaction with the tele-rehabilitation program was notably high, with a mean score of 4.6 ± 0.3 on a 5-point Likert scale. Qualitative feedback identified convenience, reduced travel time, and personalized care as

significant factors contributing to satisfaction. Importantly, no major adverse events occurred during the intervention, further supporting its safety.

The results demonstrate that tele-rehabilitation is a feasible and effective modality for delivering pulmonary care in rural populations. The significant improvements in exercise capacity, symptom management, and patient satisfaction underscore its potential to overcome barriers to traditional pulmonary rehabilitation, offering an accessible and safe alternative for underserved communities

Table 3. Changes in Symptom Severity (CAT Scores)

Time Point	CAT Score (mean \pm SD)	Mean Difference	p-value
Baseline	21.7 \pm 5.2	-	-
Post-intervention	16.1 \pm 4.8	-5.6	<0.001
12-week follow-up	16.9 \pm 5.0	-4.8	<0.001

DISCUSSION

The findings of this study demonstrated the feasibility, safety, and efficacy of tele-rehabilitation in improving pulmonary health outcomes among rural populations, aligning with and expanding upon existing literature. Participants achieved significant improvements in exercise capacity, as indicated by the six-minute walk test (6MWT), and reductions in symptom severity, as reflected in COPD Assessment Test (CAT) scores. These results were consistent with prior studies that highlighted tele-rehabilitation as a viable alternative to traditional center-based pulmonary rehabilitation, particularly for populations with limited access to healthcare facilities (1, 2).

The observed adherence rate of 92% was noteworthy, exceeding typical adherence rates reported for center-based programs. This could be attributed to the convenience of remote participation, reduced travel burdens, and the integration of personalized care through telehealth platforms. Previous research has similarly emphasized the role of tele-rehabilitation in enhancing program completion rates and accessibility, particularly in underserved areas (3). However, while the improvements in exercise capacity and symptom burden were significant, the degree of change, particularly in sustained outcomes at 12 weeks, warrants further investigation. Some studies have suggested that tele-rehabilitation may not achieve equivalent long-term benefits to center-based programs, particularly for complex cases requiring close physical supervision (4).

One of the strengths of this study was its mixed-methods design, which enabled a comprehensive evaluation of both quantitative outcomes and patient-reported experiences. The inclusion of qualitative feedback enriched the understanding of patient satisfaction, highlighting the importance of convenience and individualized care. Furthermore, the rigorous adherence to ethical standards and robust data collection methods ensured the reliability and generalizability of the findings. However, limitations included the reliance on self-reported adherence data, which could introduce reporting bias, and the relatively small sample size, which, while adequate for a pilot study, limits the broader applicability of the results. Technological barriers, such as connectivity issues experienced by some participants, also represented a challenge, underscoring the need for scalable infrastructure to support tele-rehabilitation in resource-limited settings (5).

Another limitation was the lack of a direct comparison with a control group receiving traditional center-based rehabilitation. While the improvements observed were clinically meaningful, the absence of a comparative arm limits the ability to draw definitive conclusions regarding the relative efficacy of tele-rehabilitation. This aligns with findings from other studies that have called for larger, randomized controlled trials to evaluate the equivalence or superiority of tele-rehabilitation in various contexts (6).

The study findings underscored the potential of tele-rehabilitation to address critical barriers to pulmonary care in rural populations, particularly in the wake of the COVID-19 pandemic, which disrupted traditional care delivery models. This study added to the growing body of evidence advocating for the integration of tele-rehabilitation into routine clinical practice, particularly for chronic respiratory disease management. However, successful implementation requires addressing technological disparities, standardizing protocols, and ensuring equitable access across diverse patient populations. Future research should focus on comparing long-term outcomes between tele-rehabilitation and traditional models, exploring cost-effectiveness, and identifying patient subgroups that would benefit most from remote interventions (7, 8).

Conclusion

In conclusion, tele-rehabilitation presented a promising solution to improve access to pulmonary care, offering substantial improvements in exercise capacity, symptom management, and patient satisfaction. While its implementation addressed many barriers inherent to rural healthcare, further studies are needed to refine its protocols, assess its scalability, and establish its role within comprehensive pulmonary care frameworks. This pilot study provided critical insights, laying the groundwork for larger-scale trials aimed at optimizing tele-rehabilitation as a cornerstone of modern healthcare delivery for chronic respiratory diseases.

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