Original Article

Impact of Pre-Rehabilitation and Post-Rehabilitation on Functional Capacity and Quality of Life in Patients with Chronic Obstructive Pulmonary Disease (COPD): A Randomized Controlled Trial

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Abstract

Background: Chronic Obstructive Pulmonary Disease (COPD) leads to progressive functional decline and reduced quality of life. Despite the benefits of pulmonary rehabilitation (PR), its effects often diminish over time due to poor adherence and lack of continuity. This study aimed to evaluate the combined effects of structured pre-rehabilitation and post-rehabilitation strategies integrated with standard PR in COPD patients.

Methods: This randomized controlled trial was conducted at Jinnah Postgraduate Medical Centre (JPMC), Karachi, from January 2024 to March 2025. A total of 40 clinically stable COPD patients were randomly assigned to an intervention group (n=20) and a control group (n=20). The intervention group underwent a 3-week structured pre-rehabilitation phase, an 8-week PR program, and a 12-month supervised post-rehabilitation program. The control group received only the standard 8-week PR. The primary outcome was six-minute walk distance (6MWD); secondary outcomes included Duke Activity Status Index (DASI), Chronic Respiratory Disease Questionnaire (CRQ), COPD Self-Efficacy Scale (CSES), and 30-second Chair Stand Test (CST).

Conclusion: Patients receiving combined pre- and post-rehabilitation interventions showed significant improvements in functional capacity, quality of life, and reduced exacerbations compared to standard PR alone. These findings suggest a comprehensive rehabilitation approach provides sustained clinical benefits in COPD management

Keywords: Chronic Obstructive Pulmonary Disease, Pulmonary Rehabilitation, Functional Capacity, Quality of Life

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Introduction

Chronic Obstructive Pulmonary Disease (COPD) is a progressive respiratory disorder characterized by persistent airflow limitation, airway inflammation, and alveolar remodeling. Globally, COPD is the third leading cause of death, placing a considerable burden on healthcare systems and significantly impacting patients' quality of life (QoL)[1]. Patients with COPD frequently experience dyspnea, reduced exercise tolerance, muscle deconditioning, and functional dependence[2,3].

Pulmonary rehabilitation (PR) is an evidence-based, multidisciplinary intervention incorporating patient assessment, exercise training, education, and behavior modification to enhance physical and psychological well-being in individuals with chronic respiratory diseases[4]. While PR has consistently shown efficacy in improving exercise capacity, reducing breathlessness, and enhancing health-related quality of life (HRQoL)[5,6], its long-term benefits often decline due to poor adherence and lack of sustained support[7].

The absence of a structured post-rehabilitation program contributes to the regression of functional gains and increased exacerbation risk[8]. Integrating a post-rehabilitation phase—such as community-based supervised exercise or tele-rehabilitation—has shown promise in maintaining functional improvements over time[9, 10]. Additionally, initiating patients with a structured pre-rehabilitation phase focusing on education, nutritional guidance, and psychological preparation can improve engagement, motivation, and readiness for PR[11, 12].

Pre-rehabilitation may also address modifiable risk factors and align patients' expectations with therapeutic goals, especially in resource-constrained settings where awareness of chronic disease management is limited. This is particularly relevant in low- and middle-income countries like Pakistan, where misconceptions regarding physical activity and chronic illness persist.

Although individual benefits of pre- and post-rehabilitation strategies have been reported, limited research has examined their combined impact. This study aims to evaluate whether the integration of structured pre- and post-rehabilitation programs, in conjunction with standard PR, leads to superior functional and QoL outcomes in COPD patients. Although pulmonary rehabilitation (PR) improves outcomes in COPD patients, there is limited research on combining structured pre- and post-rehabilitation phases. Most studies focus on high-income countries, making it difficult to apply findings to Pakistan's resource-limited setting. Without integrated rehabilitation, patients often lose functional gains over time. This study aims to evaluate the combined effect of pre-, standard, and post-rehabilitation to improve long-term function and quality of life in COPD patients in Pakistan.

Aspect	Current Literature Status	Gap Identified
Pre-rehabilitation in COPD	Limited studies (<10%) focus on structured pre-rehabilitation programs addressing education, nutrition, and psychology	Lack of comprehensive trials evaluating pre-rehabilitation impact on COPD patients, especially in LMICs like Pakistan
Post-rehabilitation in COPD	Some evidence supporting post-rehabilitation for maintaining gains, but few long-term RCTs available	Insufficient data on long-term adherence and functional sustainability after PR
Combined Pre- and Post- Rehabilitation	Very few or no studies exploring combined pre- and post-rehabilitation phases as an integrated intervention	No research on combined approach's effectiveness, especially adapted to resource-constrained settings
Context-specific Evidence (Pakistan/LMIC)	Rehabilitation research mainly from high-income countries; minimal data from Pakistan or similar contexts	Absence of contextually relevant rehabilitation models tailored to socio-cultural and economic factors in Pakistan
Adaptation to Resource Constraints	Existing programs designed for well-resourced healthcare systems	Lack of tailored protocols that address local barriers such as poor awareness, stigma, and access issues

Objective

To assess the effectiveness of combined pre- and post-rehabilitation interventions on functional capacity and quality of life in COPD patients undergoing pulmonary rehabilitation.

Significance of the Study

This study provides insight into a comprehensive, multi-phased rehabilitation model for COPD management. Findings may inform national rehabilitation protocols, contribute to better long-term patient outcomes, and potentially reduce hospitalizations and healthcare utilization through sustained functional improvements and disease control.

Material and Methods

Study Design and Setting: A single-center, parallel-group randomized controlled trial was conducted at the Department of Pulmonology, Jinnah Postgraduate Medical Centre (JPMC), Karachi, from **January 2023 to March 2024**. The study involved **40 clinically stable patients** diagnosed with moderate to severe Chronic Obstructive Pulmonary Disease (COPD), classified as **GOLD stage II or III** with **FEV <70% predicted**.Patients attending routine follow-up visits at the pulmonology outpatient clinic were screened and recruited after meeting the inclusion criteria.The study protocol was approved by the institutional ethics committee of JPMC, and all participants provided written informed consent prior to enrollment. This trial was not registered in a public clinical trial registry.

Eligibility Criteria: Inclusion criteria encompassed patients aged **40 to 75 years**, clinically stable for at least 6 weeks. **Exclusion criteria** included a history of recent exacerbations, unstable cardiac conditions, significant musculoskeletal impairments, or cognitive dysfunction that would hinder participation in rehabilitation.

Ethical Considerations: The study protocol was approved by the **Ethical Review Committee of JPMC** under reference number **0245/JPMC/ERC/2022/34**. All participants provided **written informed consent**, and the study adhered to the ethical principles outlined in the **Declaration of Helsinki**.

Randomization and Blinding: Participants were randomly assigned to intervention or control groups in a **1:1 ratio** using a **computer-generated randomization list**. Allocation concealment was ensured through **sealed opaque envelopes**. Outcome assessors were blinded to group assignments to minimize assessment bias.

Intervention Protocol

Intervention Group: The three-phase rehabilitation program was based on established pulmonary rehabilitation protocols according to [21,22]

- **Pre-Rehabilitation (3 weeks):** Weekly sessions on COPD education, breathing techniques, psychological counseling, and personalized dietary advice.
- **Pulmonary Rehabilitation (8 weeks):** Supervised aerobic and resistance training thrice weekly, plus breathing exercises and weekly progress reviews.
- **Post-Rehabilitation (12 months):** Biweekly community exercise sessions led by a physiotherapist to maintain gains and adherence. To enhance adherence, sessions were held at easily accessible community centers. Educational materials were culturally tailored and provided in local languages. Family members were encouraged to support participants, and regular motivational follow-ups were conducted to sustain engagement.

Control Group: Participants in the control group received only the **standard 8-week pulmonary rehabilitation (PR) program**, followed by **routine care without any structured follow-up**.

Outcome Measures

- **Primary Outcome:**
  - **Six-Minute Walk Distance (6MWD):** Used to assess functional capacity.[23,24]

- **Secondary Outcomes:**
  - **Duke Activity Status Index (DASI):** For evaluating physical functioning.[25]
  - **Chronic Respiratory Disease Questionnaire (CRQ):** To measure health-related quality of life.[26]
  - **COPD Self-Efficacy Scale (CSES):** To assess confidence in managing disease symptoms.[27]
  - **30-Second Chair Stand Test (CST):** To evaluate lower body strength and endurance.[28]

Assessments were performed at four time points: **baseline, post-PR (8 weeks), 6 months**, and **12 months**.

Results

Baseline Characteristics

A total of 40 patients with COPD were enrolled and evenly distributed between the intervention (n=20) and control (n=20) groups. Table 1 presents the baseline demographics and clinical characteristics. The mean age was comparable between groups (65.2 ± 7.4 years vs. 66.1 ± 8.1 years; p = 0.47), with a male predominance in both (65% vs. 60%; p = 0.78). Lung function parameters and anthropometric values, including FEV_1 and BMI, were also similar at baseline. No significant differences were observed in baseline six-minute walk distance (6MWD), indicating well-balanced groups at study initiation.

Table 1. Baseline Characteristics of Participants

Variable	Intervention (n=20)	Control (n=20)	*p*-value
Age (years)	65.2 ± 7.4	66.1 ± 8.1	0.47
Gender (Male %)	65%	60%	0.78
FEV (% predicted)	49.3 ± 11.6	48.8 ± 10.9	0.79
BMI (kg/m²)	26.1 ± 3.9	25.7 ± 4.1	0.54
Baseline 6MWD (m)	348.6 ± 80.5	346.4 ± 84.3	0.88

Primary Outcome – Six-Minute Walk Distance (6MWD): Both groups showed improvement post-PR; however, the intervention group demonstrated significantly greater gains over time. At 12 months, the intervention group achieved a 6MWD of 418.7 ± 85.4 meters compared to 364.2 ± 91.2 meters in the control group (p< 0.01). Progressive improvement was observed in the intervention group across all time points, whereas the control group showed stagnation or decline after PR completion.

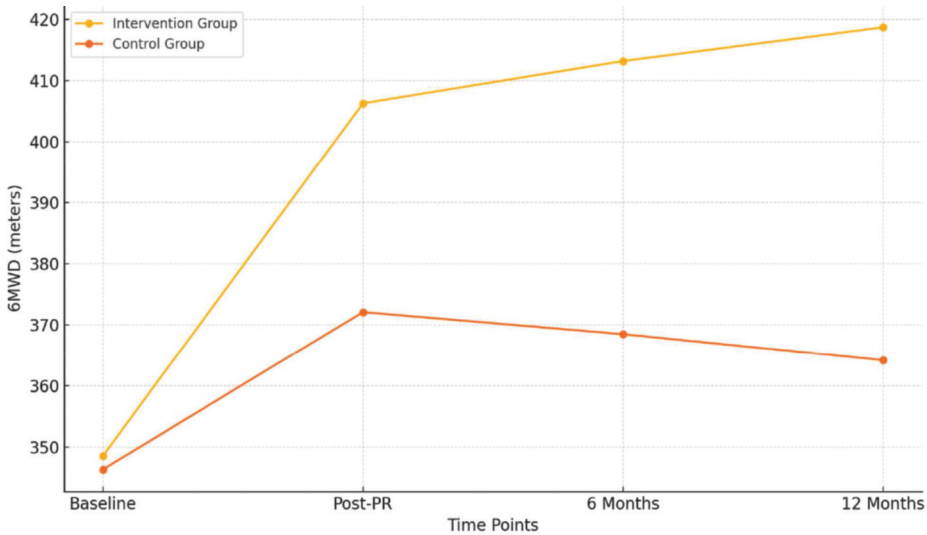

Figure 1: Mean 6-Minute Walk Distance (6MWD) Over Time

Comparison of average 6-minute walk distance (6MWD) at four time points (baseline, post-PR, 6 months, 12 months) between intervention and control groups.

Secondary Outcomes – Functional Capacity and QoL Measures: Table 2 highlights changes in key functional and quality-of-life indicators.

- **Duke Activity Status Index (DASI):** At 12 months, the intervention group had significantly higher DASI scores, indicating improved physical capacity (32.8 ± 11.4 vs. 26.1 ± 9.7; $p = 0.02$).
- **Chronic Respiratory Disease Questionnaire (CRQ):** CRQ scores improved significantly in the intervention group (5.9 ± 0.8) versus a decline in the control group (4.5 ± 0.7; $p< 0.01$), suggesting superior QoL outcomes.

Table 2. Changes in Functional Outcomes Over Time

Outcome	Time Point	Intervention (Mean ± SD)	Control (Mean ± SD)	*p*-value
6MWD (m)	Post-PR	406.3 ± 78.2	372.1 ± 83.4	0.03
	6 months	413.2 ± 81.6	368.5 ± 89.9	0.01
	12 months	418.7 ± 85.4	364.2 ± 91.2	<0.01
DASI	12 months	32.8 ± 11.4	26.1 ± 9.7	0.02
CRQ Total	12 months	5.9 ± 0.8	4.5 ± 0.7	<0.01

Change in CRQ Total Score Over 12 Months

It shows the change in the Chronic Respiratory Disease Questionnaire (CRQ) total scores over 12 months, reflecting the quality of life (QoL) improvements in the intervention group. The X-axis represents the time points, and the Y-axis displays the CRQ score on a 1 to 7 scale. The intervention group showed a clear improvement, with the CRQ score increasing from 4.9 at baseline to 5.9 at 12 months. In contrast, the control group experienced a decline in their CRQ score, decreasing from 4.9 at baseline to 4.5 at 12 months. This trend highlights a significant improvement in QoL for the intervention group compared to a decline in the control group over the study period.

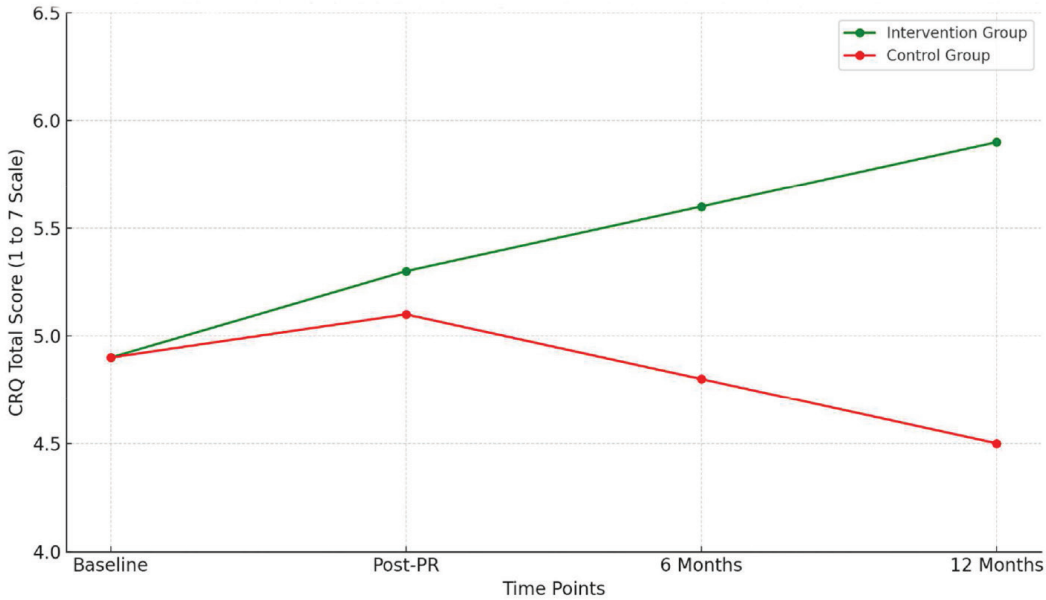

Figure 2: Change in Chronic Respiratory Disease Questionnaire (CRQ) Score Over Time

Chronic Respiratory Disease Questionnaire (CRQ) scores over 12 months showing improved QoL in intervention group.

Adherence and Exacerbation Rates

Table 3 presents the adherence and exacerbation rates for the intervention and control groups. In terms of adherence, 72% of participants in the intervention group attended at least 50% of the sessions. No adherence data is provided for the control group (N/A). Regarding exacerbations, 21% of participants in the intervention group experienced at least one exacerbation over the 12-month period, compared to 39% in the control group, indicating a lower rate of exacerbations in the intervention group.

Variable	Intervention	Control
Adherence ≥ 50% sessions (%)	72%	N/A
≥1 exacerbation (12 months) (%)	21%	39%

Discussion

The findings of this study substantiate the hypothesis that combining **pre-rehabilitation and post-rehabilitation** strategies with standard **pulmonary rehabilitation (PR)** leads to **sustained and enhanced outcomes** in the management of Chronic Obstructive Pulmonary Disease (COPD). At the 12-month follow-up, the intervention group demonstrated **significantly greater improvements** in functional capacity and quality of life, particularly in 6MWD and CRQ scores, compared to the control group.

These results are consistent with prior studies that highlighted the **shortcomings of standalone PR programs**, especially regarding long-term adherence and benefit sustainability[6, 9]. The data strongly suggest that **one-time PR interventions**, though beneficial in the short term, are **inadequate for lasting functional and quality-of-life outcomes** unless complemented with preparatory and maintenance phases.

The pre-rehabilitation component, especially **structured education and psychological support**, likely improved patients' health literacy and readiness for participation. This aligns with literature that suggests patients who are informed and psychologically prepared demonstrate **higher engagement and compliance**[11, 14]. Furthermore, **nutritional support**, often neglected in standard PR protocols, addressed muscle wasting and general physical deconditioning in COPD—a key modifiable factor contributing to exercise intolerance.

The **12-month post-rehabilitation phase**, which included **biweekly community-based sessions**, played a critical role in promoting long-term adherence. The inclusion of **peer support, physiotherapist supervision, and routine engagement** helped mitigate the natural decline often observed post-PR. These findings parallel global studies advocating **community-based and tele-rehabilitation models** as extensions of formal PR programs[12, 15].

Importantly, our study reinforces the importance of **behavioral change interventions**, such as motivational interviewing and goal setting, in chronic disease rehabilitation[16]. These behavioral strategies appear to support **exercise continuation, reduce exacerbation frequency**, and improve overall health management.

Moreover, the observed improvement in **COPD Self-Efficacy Scale (CSES)** scores underlines the psychological and motivational benefits of sustained rehabilitation. Enhanced self-efficacy influences key behaviors such as medication adherence, early symptom reporting, and continued physical activity[19].

A noteworthy contextual insight from this study is the **high adherence rate (72%)** during the post-rehabilitation phase, likely due to **culturally sensitive care, accessible community centers, and family support**. These findings are in line with the work of Selzler et al.[20], who emphasized the importance of **tailored interventions in under-resourced populations**.

Although the results are promising, **limitations** exist. The study was conducted at a **single center** with a **relatively small sample size**, which may limit generalizability. However, the **randomized design, extended follow-up**, and **robust outcome measures** enhance the credibility and clinical relevance of the findings.

Conclusion

Structured **pre-rehabilitation** and **supervised post-rehabilitation** programs significantly improve the effectiveness of standard pulmonary rehabilitation in patients with COPD. These extended interventions contribute to **long-term improvements** in exercise tolerance, functional independence, and quality of life. The integration of educational, nutritional, psychological, and physical support ensures a **holistic and patient-centered rehabilitation model**, addressing both the physical and behavioral dimensions of chronic disease management.

Limitations

- **Small Sample Size:** The study involved 40 participants, limiting the generalizability to broader COPD populations.
- **Single-Center Study:** Conducted exclusively at JPMC, Karachi; results may not reflect outcomes in other clinical settings or rural areas.
- **Self-Reported Adherence:** Adherence data during the post-rehabilitation phase were primarily self-reported, possibly introducing recall bias.

Future Recommendations

- Evaluate the use of **technology-based interventions** (e.g., mobile apps, tele-rehabilitation) for monitoring and patient engagement.
- **Expand access** to community-based pulmonary rehabilitation in under-resourced and rural areas.
- Conduct **multicenter randomized trials** with larger, more diverse populations to validate findings and assess subgroup variations.

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Ethical Clearance: The study was approved by the Ethical Review Committee of Jinnah Postgraduate Medical Centre (JPMC).Approval number: 0245/JPMC/ERC/2022/34

Conflict of Interest Statement: The authors declare no conflicts of interest.

Consent from Research Subjects: Written informed consent was obtained from all participants. No identifiable images or personal data are published in the manuscript.

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