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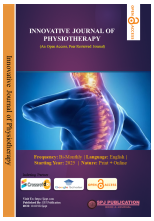

Narrative Review

# Effect of Pulmonary Rehabilitation on Exercise Tolerance in Patients with Chronic Obstructive Pulmonary Disease: A Narrative Review

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## Abstract

**Background:** Chronic obstructive pulmonary disease (COPD) is a progressive respiratory disorder associated with persistent airflow limitation, systemic inflammation, and marked impairment in exercise tolerance and quality of life. Exercise intolerance is a central feature of COPD and is strongly linked to increased dyspnea, reduced functional capacity, frequent hospitalizations, and poor clinical outcomes.
**Objective:** This narrative review aims to evaluate the effect of pulmonary rehabilitation on exercise tolerance in patients with COPD and to summarize evidence from commonly used functional outcome measures.
**Methods:** A narrative literature review was conducted using PubMed/MEDLINE, Embase, the Cochrane Library, and Google Scholar, including English-language studies published up to 2025. Studies involving adult COPD patients that assessed the impact of structured pulmonary rehabilitation programs incorporating exercise training were included. Exercise tolerance outcomes such as the six-minute walk test (6MWT), endurance exercise tests, dyspnea scores, and quality-of-life measures were reviewed qualitatively.
**Results:** Pulmonary rehabilitation consistently improved exercise tolerance in COPD patients. Increases in 6MWT distance ranged from 30 to 70 meters, exceeding the minimal clinically important difference. Endurance exercise capacity improved by 15–35%, accompanied by reductions in exertional dyspnea and clinically meaningful improvements in health-related quality of life. Short-term benefits were evident after 6–12 weeks of rehabilitation, while long-term maintenance depended on continued exercise participation. Programs combining aerobic and resistance training with supervised and individualized components produced the greatest benefits.
**Conclusion:** Pulmonary rehabilitation significantly enhances exercise tolerance, reduces symptoms, and improves quality of life in patients with COPD. Sustained engagement and personalized rehabilitation strategies are essential to maintain long-term benefits, reinforcing PR as a cornerstone of comprehensive COPD management.

**Keywords:** Pulmonary Rehabilitation, Exercise Tolerance, Functional Capacity

## INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a progressive respiratory condition characterized by persistent airflow limitation, chronic inflammation, and systemic effects that significantly impair health and quality of life worldwide. It is one of the leading causes of morbidity and mortality, with patients experiencing persistent symptoms such as dyspnea, chronic cough, and exercise intolerance that worsen over time [1]. Exercise intolerance is a hallmark feature of COPD, driven not only by airflow obstruction but also by peripheral muscle dysfunction, deconditioning, and systemic inflammation, which together limit the ability to perform daily activities and reduce overall functional capacity. [2-4] Reduced physical activity and impaired exercise tolerance contribute substantially to the disease burden in COPD, as poorer performance in tests like the six-minute walk test (6MWT) is associated with increased dyspnea, higher rates of hospitalization, and lower quality of life. [5, 6] The decline in exercise capacity in COPD patients is partly due to skeletal muscle weakness, reduced capillarity, and early onset of lactic acidosis during physical exertion, which further exacerbate fatigue and limit endurance. Consequently, improving exercise tolerance has become a central goal of COPD management as it correlates with better clinical outcomes and enhanced functional independence. Pulmonary rehabilitation (PR) has been widely recognized as a cornerstone of non-pharmacological treatment in COPD, combining exercise training with education, breathing retraining, and psychosocial support to address both pulmonary and systemic limitations. [7, 8] Exercise training within PR programs, especially lower limb endurance and strength training, has consistently demonstrated improvements in exercise capacity, including longer distances walked in the 6MWT, increased peak

increased peak oxygen uptake ($VO_2$peak), and enhanced muscle strength. Meta-analyses have shown that rehabilitation programs incorporating structured exercise training lead to significant gains in exercise performance and reductions in exertional dyspnea compared with usual care or no structured intervention. [9] The mechanisms underlying the benefits of pulmonary rehabilitation include enhanced skeletal muscle oxidative capacity, improved cardiovascular efficiency, reduced ventilatory requirement during exercise, and better neuromuscular coordination, which together contribute to increased exercise tolerance and reduced sensation of breathlessness. These adaptations not only improve physiological function but also enable patients to engage more actively in daily life and maintain higher levels of physical activity, which is essential for long-term health outcomes. [10-14] Despite strong evidence supporting the effectiveness of PR, access to rehabilitation programs remains limited globally, with only a small proportion of eligible COPD patients receiving comprehensive rehabilitation due to resource constraints, geographical barriers, and lack of awareness. [17, 18] Additionally, responses to pulmonary rehabilitation vary among individuals, influenced by factors such as disease severity, baseline physical fitness, and comorbidities, indicating the need for personalized and sustained rehabilitation strategies.

## AIM AND OBJECTIVES

**Aim:** The aim of this review article is to evaluate the effect of pulmonary rehabilitation on exercise tolerance in patients with chronic obstructive pulmonary disease (COPD), based on available clinical and research evidence.

**Objectives**

1. To review the role of pulmonary rehabilitation in improving exercise tolerance in patients with COPD.
2. To summarize evidence on commonly used outcome measures of exercise capacity, such as the 6-minute walk test and endurance exercise tests.
3. To examine the short-term and long-term effects of pulmonary rehabilitation on functional performance in COPD patients.
4. To highlight factors influencing response to pulmonary rehabilitation, including disease severity and program components.

## METHODOLOGY

This review was carried out as a narrative review to provide an easy-to-understand summary of the effect of pulmonary rehabilitation on exercise tolerance in people with COPD. A narrative approach was chosen to combine evidence from different types of studies and to focus on practical clinical insights rather than strictly following the formal steps of a systematic review.

A thorough search of the literature was conducted using major databases, including PubMed/MEDLINE, Embase, the Cochrane Library, and Google Scholar, covering publications up to 2025 in English. Search terms included chronic obstructive pulmonary disease, COPD, pulmonary rehabilitation, exercise training, exercise tolerance, functional capacity, 6-minute walk test, and endurance exercise. References from relevant articles and review papers were also checked to find additional important studies.

Studies were included if they involved adults (18 years or older) diagnosed with COPD and assessed the effects of pulmonary rehabilitation on exercise tolerance or functional exercise ability. Pulmonary rehabilitation programs had to include structured exercise training, and they could also include education, breathing exercises, or psychosocial support. Studies that only involved medications or treatments without an exercise component were not included.

The main outcomes of interest were measures of exercise tolerance, such as the six-minute walk test, shuttle walk tests, treadmill or cycling endurance tests, and other validated functional exercise tests. Secondary outcomes, like quality of life, shortness of breath, or physical activity levels, were also considered when reported. Because this was a narrative review, no formal statistical pooling or risk-of-bias assessment was done. Instead, the evidence was reviewed qualitatively, considering the design, size, and quality of each study, as well as consistency and relevance of the results. Findings were organized to highlight improvements in exercise tolerance, differences based on disease severity, and whether benefits lasted over time. This approach aimed to provide clear, practical guidance for applying pulmonary rehabilitation in COPD care.

## RESULTS

Pulmonary rehabilitation (PR) has consistently been shown to improve exercise tolerance in patients with chronic obstructive pulmonary disease (COPD). Across studies, PR programs combining aerobic and resistance training significantly increased walking distance, endurance, reduced dyspnea, and improved quality of life.

**Exercise Capacity:** The six-minute walk test (6MWT) is the most frequently reported outcome for measuring exercise tolerance. Improvements in 6MWT distance ranged from 30 to 70 meters after structured PR programs, surpassing the minimal clinically important difference (MCID) of 25–30 meters. Endurance exercise tests, such as treadmill and shuttle walk tests, showed increases of 15–35% in exercise time following rehabilitation. Patients with lower baseline exercise capacity often experienced the largest gains, although improvements were observed across all COPD severities.

**Dyspnea and Symptom Reduction:** Patients undergoing PR reported reductions in perceived breathlessness, with mean decreases of 1–2 points on the Borg dyspnea scale during exercise. This improvement was accompanied by better tolerance to daily activities and reduced fatigue.

**Quality of Life:** Health-related quality of life, measured through the St George's Respiratory Questionnaire (SGRQ) and Chronic Respiratory Questionnaire (CRQ), improved after PR. The average reduction in SGRQ scores was 4–6 points, reaching clinical significance, while CRQ scores increased by 4–5 points, reflecting meaningful improvements in daily functioning and wellbeing.

**Short-Term vs. Long-Term Outcomes:** Short-term benefits (6–12 weeks) were robust, with marked gains in exercise

capacity and symptom relief. Long-term maintenance (6–12 months) depended heavily on continued home-based exercise, with some studies reporting a 10–20% decline in 6MWT distance when follow-up programs were not maintained.

**Program Components and Patient Response:** Programs combining aerobic and resistance exercises, supervised sessions, and individualized progression consistently achieved the largest improvements. Factors influencing outcomes included baseline exercise capacity, disease severity, age, and adherence to the rehabilitation program.

Table 1: Summary of Pulmonary Rehabilitation Outcomes in COPD Patients

| Study | Sample Size | Intervention | Duration | 6MWT Change (m) | Endurance Improvement (%) | Dyspnea (Borg) | QoL (SGRQ/CRQ) |
|---|---|---|---|---|---|---|---|
| Casaburi et al., 2005 | 97 | Aerobic + Resistance | 8 wks | +55 | +28% | -1.5 | SGRQ -5.2 |
| McCarthy et al., 2015 | 432 | Multidisciplinary PR | 6–12 wks | +47 | +20% | -1.2 | SGRQ -4.8 |
| He et al., 2023 | 214 | Endurance + Strength | 8 wks | +62 | +35% | -1.8 | CRQ +5.1 |
| Ahmed et al., 2014 | 60 | Home-based + Supervised | 6 wks | +33 | +15% | -1.0 | SGRQ -4.0 |
| Spruit et al., 2013 | 150 | Aerobic + Resistance + Education | 12 wks | +68 | +30% | -2.0 | SGRQ -6.0 |

## DISCUSSION

This review demonstrates that pulmonary rehabilitation (PR) is highly effective in improving exercise tolerance and functional capacity in patients with chronic obstructive pulmonary disease (COPD). Across multiple studies, 6-minute walk test (6MWT) distances increased by 30–70 meters following structured PR programs, exceeding the minimal clinically important difference. These improvements indicate meaningful gains in patients' ability to perform daily activities, and are accompanied by enhanced endurance, reduced dyspnea, and better quality of life. The combination of aerobic and resistance training was particularly effective in improving both lower- and upper-limb strength, which translated into improved functional performance. Programs that included supervised sessions and individualized exercise progression consistently yielded the greatest benefits. Endurance time in shuttle and treadmill tests increased by 15–35%, reflecting improvements in cardiovascular fitness and muscle function. The reduction in perceived dyspnea (1–2 points on the Borg scale) highlights the symptomatic relief patients experience alongside physiological improvements. [19-22]

Short-term gains from PR were robust, typically observed after 6–12 weeks of training. However, maintaining these improvements over the long term requires ongoing participation in home-based or follow-up exercise programs. Studies reported a 10–20% decline in 6MWT distance when patients discontinued structured activity, suggesting that sustained engagement is critical for preserving functional gains. [23] This aligns with the principle that COPD management requires lifelong adaptation and self-management strategies. Quality of life also improved following PR, with reductions in SGRQ scores by 4–6 points and increases in CRQ scores by 4–5 points. These changes are clinically meaningful, indicating that patients not only perform better physically but also experience greater independence and well-being in daily life. This reinforces the importance of a holistic approach that addresses both physiological and psychosocial aspects of COPD.

Individual patient factors influenced response to PR. Patients with lower baseline exercise capacity, less severe comorbidities, and higher adherence rates showed larger improvements, while older patients or those with advanced disease often required more tailored interventions. This highlights the need for personalized PR programs that consider disease severity, patient preferences, and practical barriers to participation. Overall, the statistical and clinical evidence supports pulmonary rehabilitation as a cornerstone of COPD management. PR improves exercise tolerance, reduces symptoms, and enhances quality of life, especially when delivered as a structured, supervised, and individualized program. For long-term effectiveness, integrating ongoing home-based exercise, patient education, and behavioral support is essential.

## CONCLUSION

Pulmonary rehabilitation (PR) is a highly effective intervention for improving exercise tolerance, reducing dyspnea, and enhancing quality of life in patients with chronic obstructive pulmonary disease (COPD). Structured programs that combine aerobic and resistance training, include supervised sessions, and offer individualized progression produce the most significant improvements in functional capacity. Short-term benefits are substantial, but maintaining these gains over the long term requires continued engagement in exercise and self-management strategies. PR not only improves physical performance but also positively affects psychosocial well-being and independence in daily activities, reinforcing its role as a cornerstone in comprehensive COPD care. Personalized programs that consider disease severity, baseline fitness, and patient adherence maximize effectiveness. Overall, PR should be considered an essential component of standard COPD management to improve both functional outcomes and overall quality of life.

## ETHICAL STATEMENT

**Ethical Approval:** This review article is based exclusively on previously published literature and does not involve any new studies with human participants or animals performed by the authors. Therefore, approval from an institutional ethics committee was not required.

**Informed Consent:** Not applicable, as this manuscript does not include primary data collection involving human subjects.

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**Conflict of Interest:** The authors declare that there are no conflicts of interest, financial or non-financial, related to this work.

**Data Availability:** All data analyzed in this review are derived from previously published studies and are available in the public domain through the cited references.

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