

## Pulmonary Rehabilitation Improves Functional Capacity, Dyspnea, and Physiological Responses in COPD: A Case Report

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### Abstract

**Background:** Chronic Obstructive Pulmonary Disease (COPD) is a progressive respiratory disorder characterized by persistent airflow limitation, dyspnea, and reduced functional capacity. Pulmonary rehabilitation is a key non-pharmacological intervention that improves clinical outcomes.

**Objective:** This study aimed to evaluate the effects of a structured pulmonary rehabilitation program on dyspnea, physiological responses, and functional capacity in a patient with COPD.

**Methods:** This single-case report involved a 48-year-old female with COPD who underwent a 4-week pulmonary rehabilitation program (3 sessions/week), including breathing exercises, airway clearance, graded walking, and energy conservation. Exercise intensity was maintained at Borg Scale 3–4. Outcomes included Borg Scale, oxygen saturation (SpO<sub>2</sub>), respiratory rate, heart rate, and Six-Minute Walk Test (6MWT). Data were analyzed descriptively without inferential statistics.

**Results:** Borg Scale decreased from 5 to 3, SpO<sub>2</sub> increased from 90% to 94%, respiratory rate decreased from 28 to 22 breaths/min, and heart rate decreased from 98 to 88 beats/min. The 6MWT distance increased from 216 m to 298 m (+82 m), exceeding the minimal clinically important difference (MCID) and indicating clinically meaningful improvement. Additional findings included reduced accessory muscle use and improved sputum clearance.

**Conclusion:** This case suggests that pulmonary rehabilitation may improve dyspnea, cardiorespiratory responses, and functional capacity in COPD. However, results should be interpreted cautiously due to the single-case design.

### Keywords

Chronic Obstructive Pulmonary Disease; Pulmonary Rehabilitation; Exercise Therapy; Breathing Exercises; Six-Minute Walk Test

### Introduction

Chronic Obstructive Pulmonary Disease (COPD) is a progressive respiratory disorder characterized by persistent airflow limitation and chronic inflammatory responses in the airways and lungs. It is a major contributor to global morbidity and mortality, with substantial impact on healthcare systems and patient quality of life.<sup>1</sup> Contemporary guidelines emphasize that COPD is not only a pulmonary condition but also a systemic disease involving skeletal muscle dysfunction, reduced exercise tolerance, and functional decline.<sup>2</sup>

Clinically, patients with COPD commonly present with progressive dyspnea, chronic cough, sputum production, and reduced exercise capacity.<sup>1</sup> These symptoms often lead to decreased participation in physical activity, initiating a cycle of deconditioning that further worsens functional status. The Six-Minute Walk Test (6MWT) has been widely used to assess functional capacity in COPD, as it reflects integrated cardiopulmonary and muscular responses during daily activities.<sup>3</sup>

Pulmonary rehabilitation is a cornerstone of non-pharmacological management in COPD and is strongly recommended by international guidelines. Evidence from the American Thoracic Society indicates that pulmonary rehabilitation significantly improves exercise capacity, reduces dyspnea, and enhances health-related quality of life in patients with chronic respiratory disease.<sup>2</sup> In addition, structured exercise training, including aerobic and functional components, has been shown to improve endurance and reduce symptom burden when performed at appropriate intensity and frequency.<sup>4</sup>

Breathing exercises such as diaphragmatic breathing and pursed lip breathing play a critical role in optimizing ventilatory mechanics, reducing dynamic hyperinflation, and improving gas exchange. Airway clearance techniques further contribute by facilitating mucus removal, thereby enhancing airway patency and reducing respiratory symptoms.<sup>5</sup> These interventions are commonly integrated into pulmonary rehabilitation programs to address both physiological and functional impairments in COPD.<sup>2</sup>

Recent systematic reviews and meta-analyses have demonstrated that pulmonary rehabilitation not only improves exercise capacity but also increases the proportion of patients achieving minimal clinically important difference (MCID) in functional outcomes.<sup>2,6</sup> The MCID for the 6MWT in COPD has been reported to range approximately between 25 and 80 meters, indicating that relatively small improvements may still represent clinically meaningful changes.<sup>2</sup>

However, despite the strong body of evidence supporting pulmonary rehabilitation, several limitations remain in the current literature.<sup>2</sup> First, most studies are conducted in controlled environments such as randomized controlled trials, which may not fully represent real-world clinical practice. Second, previous studies tend to evaluate isolated components of intervention rather than integrated programs combining breathing exercises, airway clearance, and functional training. Third, evidence from low- and middle-income countries, including Indonesia, remains limited, particularly in terms of detailed clinical reasoning and individualized patient response.

Moreover, although pulmonary rehabilitation generally provides beneficial effects, substantial heterogeneity has been reported in outcomes and treatment response. Differences in disease severity, patient characteristics, adherence, and rehabilitation program components may contribute to variability in treatment response, suggesting that the effectiveness of pulmonary rehabilitation may not be uniform across all patients.<sup>2,7–10</sup> This highlights the need for detailed clinical reporting that captures individual variability and contextual factors influencing outcomes.<sup>11</sup>

In addition, there is limited documentation regarding how pulmonary rehabilitation protocols are implemented in routine physiotherapy settings, including progression strategies, adherence monitoring, and integration of multiple intervention components. This gap restricts the translation of evidence into practical clinical application, particularly in resource-constrained healthcare environments.

Therefore, this case report aims to describe the implementation of a structured pulmonary rehabilitation program integrating breathing exercises, airway clearance techniques, and functional training in a patient with COPD. The study specifically evaluates changes in dyspnea, physiological responses, and functional capacity.

It is hypothesized that a combined pulmonary rehabilitation approach may improve dyspnea and functional capacity in patients with COPD through enhanced ventilatory efficiency and exercise tolerance, although the magnitude of response may vary depending on individual clinical characteristics.

## Methods

This study employed a single-case report design to describe the clinical implementation and outcomes of a structured pulmonary rehabilitation program in a patient with Chronic Obstructive Pulmonary Disease (COPD). The report was prepared in accordance with the CARE (CAse REport) guidelines to ensure transparency, completeness, and reproducibility in clinical reporting.<sup>11</sup>

The subject was a 48-year-old female diagnosed with COPD and referred to the physiotherapy department of a pulmonary hospital. The patient was selected purposively based on clinical relevance, as she presented with typical COPD manifestations including exertional dyspnea, ineffective cough, fatigue, and reduced walking tolerance. The patient had a history of recurrent dyspnea since February 2023, with exacerbation in October 2024, and was formally diagnosed by a pulmonologist in November 2024. Information regarding comorbidities and pharmacological treatment was not available in the medical record and is acknowledged as a potential confounding factor.

Baseline assessment was conducted prior to intervention and included vital signs, respiratory examination, and functional capacity evaluation. The patient was fully conscious (*compos mentis*), cooperative, and able to follow instructions. Clinical findings included barrel chest, use of accessory respiratory muscles, wheezing, and basal crackles. Vital signs indicated mild hypoxemia and tachypnea. Spirometry results demonstrated FEV<sub>1</sub> of 70–79% predicted with FEV<sub>1</sub>/FVC <0.70, consistent with moderate airflow obstruction according to GOLD classification.<sup>1</sup> To provide a clear chronological overview of the patient's clinical course and intervention process, the timeline is presented in Table 1.

**Table 1.** Clinical Timeline of the Patient

| Time Point     | Clinical Event Description                               |
|----------------|----------------------------------------------------------|
| February 2023  | First episode of dyspnea requiring hospitalization       |
| October 2024   | Recurrence and exacerbation of respiratory symptoms      |
| November 2024  | Diagnosis of COPD confirmed by pulmonologist             |
| September 2025 | Referral to physiotherapy department                     |
| Week 0         | Baseline assessment (clinical and functional evaluation) |
| Week 1–4       | Implementation of pulmonary rehabilitation program       |
| Week 4         | Post-intervention evaluation                             |

Functional capacity was assessed using the Six-Minute Walk Test (6MWT), a valid and reliable instrument widely used in pulmonary rehabilitation to evaluate exercise tolerance in patients with COPD. The test was conducted according to standardized procedures recommended by the American Thoracic Society (ATS), including a flat walking course, standardized encouragement, and monitoring of physiological responses.<sup>12</sup> Dyspnea was assessed using the Borg Rating of Perceived Exertion Scale, which has been widely used in respiratory rehabilitation and demonstrates acceptable validity for assessing perceived exertion in clinical populations.

The intervention consisted of a structured pulmonary rehabilitation program delivered over four weeks, with a frequency of three sessions per week and duration of 30–45 minutes per session. The program was supervised by a licensed physiotherapist with clinical experience in cardiorespiratory physiotherapy, although detailed certification was not formally documented. The intervention was designed based on the FITT principle (Frequency, Intensity, Time, Type) and included pursed lip breathing (10 minutes per session), diaphragmatic breathing (10 minutes), active cycle breathing technique (10–15 minutes), airway clearance techniques including huffing and effective coughing as needed, graded walking exercise (10–20 minutes), and energy conservation education during each session.

Exercise intensity was maintained at a moderate level corresponding to Borg Scale 3–4. Objective parameters such as percentage of maximum heart rate or oxygen consumption were not utilized; therefore, exercise intensity was primarily guided by subjective perception and physiological monitoring. Physiological responses including heart rate, oxygen saturation (SpO<sub>2</sub>), respiratory rate, and perceived dyspnea were continuously monitored to ensure patient safety.<sup>2</sup> Exercise was temporarily discontinued if SpO<sub>2</sub> decreased below 88% or if the patient experienced severe dyspnea, chest pain, dizziness, or excessive fatigue.

Progression of the walking exercise was implemented gradually based on patient tolerance, primarily by increasing walking duration and reducing rest intervals across sessions. However, precise quantification of progression parameters such as speed or distance increments per session was not formally recorded. Adherence was monitored through direct supervision and attendance records, and the patient completed all scheduled sessions.

Outcome evaluation was conducted at baseline and at the end of week four using the same instruments, including Borg Scale, SpO<sub>2</sub>, respiratory rate, heart rate, and 6MWT distance. The 6MWT was interpreted using the minimal clinically important difference (MCID), which ranges approximately from 25 to 80 meters in patients with COPD, allowing clinical relevance of change to be assessed.<sup>2</sup>

Data analysis was performed descriptively by comparing pre- and post-intervention values. Given the single-case design, no inferential statistical analysis or variability measures (e.g., confidence intervals) were calculated. Interpretation focused on clinical significance, consistency across outcome measures, and triangulation between subjective (dyspnea perception) and objective (physiological and functional) findings.

Ethical considerations were addressed in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained from the patient prior to participation and publication of clinical data. Formal documentation of consent was obtained, although a specific reference number was not assigned. Given the nature of a single-case report, formal institutional ethical approval was not mandated; however, confirmation or exemption from an institutional review board (IRB) should be provided in accordance with the requirements of the target journal.

## Results

Following the 4-week pulmonary rehabilitation program conducted three times per week, changes were observed across all measured clinical and functional parameters. The results are presented to describe variations in dyspnea, physiological responses, functional capacity, and additional clinical findings. To provide a structured comparison of pre- and post-intervention outcomes, the primary quantitative results are summarized in Table 2.

**Table 2.** Changes in Clinical and Functional Outcomes Before and After Intervention

| Variable                       | Baseline | Post-Intervention | Absolute Change |
|--------------------------------|----------|-------------------|-----------------|
| Borg Scale                     | 5        | 3                 | -2              |
| SpO <sub>2</sub> (%)           | 90       | 94                | +4              |
| Respiratory Rate (breaths/min) | 28       | 22                | -6              |
| Heart Rate (beats/min)         | 98       | 88                | -10             |
| 6MWT Distance (m)              | 216      | 298               | +82             |

At baseline, spirometry findings indicated moderate airflow obstruction (FEV<sub>1</sub> 70–79% predicted; FEV<sub>1</sub>/FVC <0.70), consistent with GOLD stage II classification. This classification is presented to contextualize the patient's disease severity in relation to functional outcomes.

The 6MWT distance increased from 216 m to 298 m, with an absolute change of +82 m. This value exceeded the minimal clinically important difference (MCID) range reported for COPD. No variability measures such as standard deviation or confidence intervals were calculated due to the single-case design. To complement the quantitative findings, clinical observations related to respiratory function are presented in Table 3.

**Table 3.** Changes in Respiratory Clinical Findings

| Clinical Parameter       | Baseline Condition | Post-Intervention Condition |
|--------------------------|--------------------|-----------------------------|
| Use of accessory muscles | Present            | Reduced                     |
| Tripod positioning       | Frequent           | Occasional                  |
| Wheezing                 | Present            | Minimal                     |
| Basal crackles           | Present            | Reduced                     |
| Effective cough          | Impaired           | Improved                    |
| Sputum clearance         | Difficult          | Easier                      |

All results are presented descriptively without inferential statistical testing. No effect size calculations were performed, and findings should be interpreted within the context of individual clinical response. The clinical timeline of the intervention and evaluation process has been presented in the Methods section in accordance with CARE reporting standards.

## Discussion

This case report demonstrates improvements in dyspnea, physiological parameters, and functional capacity following a structured pulmonary rehabilitation program in a patient with COPD. These findings are consistent with current evidence indicating that pulmonary rehabilitation is an effective non-pharmacological intervention for improving exercise tolerance and symptom burden in patients with chronic respiratory disease.<sup>2</sup> However, given the single-case design, the observed changes should be interpreted as associative rather than causal, and cannot be generalized beyond the individual patient.

The reduction in dyspnea, reflected by a decrease in Borg Scale from 5 to 3, suggests improved ventilatory efficiency and reduced work of breathing. This improvement may be associated with the combined effects of pursed lip breathing and diaphragmatic breathing, which have been reported to reduce dynamic hyperinflation, prolong expiratory time, and improve alveolar ventilation.<sup>5</sup> These mechanisms contribute to improved breathing patterns and reduced perception of breathlessness during activity, although the magnitude of response may vary between individuals.

The observed decrease in respiratory rate and heart rate indicates a shift toward improved cardiorespiratory efficiency. A reduction in respiratory rate from 28 to 22 breaths per minute reflects a more economical ventilatory pattern, while the decrease in heart rate suggests reduced physiological demand.<sup>4</sup> Nevertheless, these improvements should be interpreted cautiously, as they may also be influenced by external factors such as pharmacological treatment, environmental conditions, or natural recovery processes that were not controlled in this report.

The increase in oxygen saturation from 90% to 94% indicates improved oxygenation following physiotherapy intervention. This improvement may be associated with enhanced ventilation and respiratory mechanics; however, direct improvement in ventilation-perfusion matching cannot be confirmed from oxygen saturation measurements alone.<sup>1,13,14</sup> However, variability in oxygen saturation responses has been reported in previous studies, indicating that not all patients experience consistent improvements following breathing interventions.

A key finding of this case was the improvement in functional capacity, with an 82-meter increase in 6-minute walk distance (6MWD). This change substantially exceeded the minimally important difference reported for patients with COPD, indicating a clinically meaningful improvement in functional exercise capacity. This finding is consistent with recent evidence showing that pulmonary rehabilitation can significantly improve 6MWD and exercise capacity in patients with COPD.<sup>2,15–17</sup> However, some studies have reported smaller or non-significant improvements, particularly in patients with severe disease, low adherence, or shorter intervention duration, highlighting variability in treatment response.

From a dose-response perspective, the intervention in this case was delivered three times per week over four weeks at moderate intensity (Borg 3–4). Recent evidence indicates that pulmonary rehabilitation outcomes may be influenced by program characteristics, including exercise modality, intensity, supervision, and duration. However, the optimal duration and dose remain uncertain, and longer programs do not necessarily produce greater improvements in functional outcomes. Therefore, the four-week intervention in this case should be interpreted within the context of the specific exercise dose and individual patient response.<sup>2,18,19</sup>

Therefore, the observed improvement in this case may reflect an early response, and further gains could potentially be achieved with extended intervention duration.

In addition to quantitative outcomes, qualitative improvements were observed, including reduced use of accessory respiratory muscles, decreased wheezing and crackles, and improved sputum clearance. These findings suggest that airway clearance techniques, particularly the active cycle breathing technique, contributed to improved airway patency and mucus mobilization.<sup>5</sup>

These results are aligned with the Global Initiative for Chronic Obstructive Lung Disease (GOLD) recommendations, which emphasize pulmonary rehabilitation as a core component of COPD management to improve symptoms, exercise capacity, and health status. However, GOLD guidelines also highlight that individual response to rehabilitation may vary depending on disease severity, comorbidities, and adherence, reinforcing the importance of individualized treatment planning.<sup>1</sup>

Despite these findings, several limitations must be acknowledged. First, as a single-case report, the study lacks generalizability and cannot establish causal relationships. Second, information regarding comorbidities and pharmacological management was not available, which may act as confounding factors influencing outcomes. Third, objective monitoring of exercise intensity using parameters such as percentage of maximum heart rate or oxygen consumption was not performed, limiting precision in intervention dosing.

Fourth, adherence was monitored through attendance rather than standardized compliance measures, and progression of exercise intensity was not quantitatively recorded. Fifth, no variability measures or effect size calculations were performed, limiting statistical interpretation of the results. Sixth, the study did not include validated quality-of-life instruments such as the COPD Assessment Test (CAT) or modified Medical Research Council (mMRC) Dyspnea Scale. Finally, potential placebo effects and observational bias cannot be excluded, as both patient and therapist were aware of the intervention.

From a clinical perspective, this case highlights the feasibility of implementing an integrated pulmonary rehabilitation program in routine physiotherapy settings. The combination of breathing exercises, airway clearance techniques, and functional training provides a practical framework that can be adapted to individual patient needs, particularly in resource-limited environments.

Future research should focus on larger sample sizes using controlled study designs to validate these findings and explore dose–response relationships of pulmonary rehabilitation interventions. Further studies should also incorporate standardized outcome measures, objective intensity monitoring, and long-term follow-up to better understand the sustainability of clinical improvements.

## Conclusion

This case report suggests that a structured pulmonary rehabilitation program may improve dyspnea, physiological responses, and functional capacity in a patient with COPD. The observed increase in 6MWT distance exceeded the minimal clinically important difference, indicating clinically meaningful functional improvement.

However, given the single-case design and absence of inferential statistical analysis, these findings should be interpreted cautiously and cannot be generalized. From a practical perspective, the integration of breathing exercises, airway clearance techniques, and graded functional training provides a feasible approach for physiotherapy management in clinical settings, particularly in patients with moderate COPD. Future research with larger sample sizes, controlled study designs, and standardized outcome measures is required to confirm these findings and to determine optimal intervention dosage and long-term effectiveness.

## Author Contribution

Muhammad Fadhillah: Conceptualization, Data curation, Investigation, Writing original draft.

Isnaini Herawati: Supervision, Methodology, Writing review and editing.

Ririt Ika Lestari: Clinical supervision, Investigation, Writing review and editing.

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## Conflict of Interest Statement

The authors declare no conflict of interest.

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## Ethics Statement

This case report was conducted in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained from the patient for participation and publication of clinical data. Documentation of informed consent was obtained; however, no formal reference number was assigned. Institutional ethical review was not formally required for this type of case report, and documentation of exemption may be provided upon request in accordance with journal policy.

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