Effectiveness of pulmonary interventions on clinical outcomes among patients with chronic obstructive pulmonary disease: a randomized controlled trial

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Abstract

Background: Chronic Obstructive Pulmonary Disease (COPD) is a progressive respiratory disorder characterized by persistent airflow limitation, dyspnea, impaired gas exchange, and reduced exercise tolerance. Pulmonary interventions are recognized as effective non-pharmacological strategies for improving respiratory function and clinical outcomes among COPD patients. However, evidence regarding their effectiveness in local healthcare settings remains limited. **Objective:** To evaluate the effectiveness of pulmonary interventions on clinical outcomes among patients with Chronic Obstructive Pulmonary Disease in selected hospitals of Vadodara City. **Methods:** A quantitative research approach with a randomized controlled trailed, pre-test post-test control group design was adopted. The study was conducted among 120 COPD patients selected from hospitals in Vadodara City. Participants were randomly assigned to an experimental group (n=60) and a control group (n=60). The experimental group received a structured pulmonary intervention package comprising diaphragmatic breathing, pursed-lip breathing, chest expansion exercises, and supervised walking exercises for six weeks, while the control group received routine care. Clinical outcomes assessed included dyspnea severity using the Modified Medical Research Council (mMRC) Scale, oxygen saturation (SpO_2), respiratory rate, and six-minute walk distance (6MWD). Data were analyzed using descriptive and inferential statistics, including paired and independent t-tests. **Results:** Baseline clinical outcomes were comparable between the experimental and control groups. Following six weeks of intervention, the experimental group demonstrated significant improvement in all measured outcomes. Mean dyspnea score decreased from 3.20 ± 0.72 to 1.65 ± 0.63, compared to 3.15 ± 0.68 to 2.95 ± 0.65 in the control group ($t=10.82$, $p<0.001$). Mean oxygen saturation increased from 92.3 ± 1.9% to 95.8 ± 1.4% in the experimental group, whereas only a marginal improvement was observed in the control group ($t=8.96$, $p<0.001$). Respiratory rate decreased significantly from 24.8 ± 2.6 to 19.8 ± 2.1 breaths per minute in the experimental group compared with the control group ($t=8.11$, $p<0.001$). Similarly, six-minute walk distance improved from 278 ± 49 meters to 382 ± 56 meters in the experimental group, while minimal improvement was observed in the control group ($t=8.74$, $p<0.001$).

Conclusion: The findings indicate that pulmonary interventions were effective in improving clinical outcomes among COPD patients. Significant reductions in dyspnea and respiratory rate, along with improvements in oxygen saturation and exercise capacity, were observed among participants receiving the intervention. Integration of structured pulmonary interventions into routine COPD management may enhance patient outcomes and functional performance.

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Introduction

Chronic Obstructive Pulmonary Disease (COPD) is a progressive respiratory disorder characterized by persistent airflow limitation and chronic respiratory symptoms resulting from airway and alveolar abnormalities [1,2]. COPD remains one of the leading causes of morbidity and mortality worldwide and is a major contributor to the global burden of chronic disease [1]. Patients commonly experience chronic cough, sputum production, dyspnoeal, exercise intolerance, and recurrent hospitalizations, which significantly impair daily functioning and quality of life [2,3]. Pulmonary rehabilitation is recognized as an essential component of comprehensive COPD management and is recommended by international guidelines for individuals with symptomatic disease [2,4]). Structured pulmonary interventions, including breathing exercises and exercise training, improve respiratory mechanics, enhance exercise tolerance, reduce dyspnoea, and improve overall health outcomes [4,5]. Despite substantial evidence supporting pulmonary rehabilitation, its implementation remains inconsistent across healthcare institutions due to limited resources, inadequate referral systems, and poor accessibility [5,6]. In India, including Gujarat, the prevalence of COPD continues to rise because of tobacco smoking, exposure to biomass fuel, industrial pollution, and population aging [7,8]. Therefore, there is a need to evaluate the effectiveness of pulmonary interventions in local healthcare settings to improve clinical outcomes among COPD patients.

Method

A quantitative research approach was adopted to evaluate the effectiveness of pulmonary interventions on clinical outcomes among patients with Chronic Obstructive Pulmonary Disease (COPD). The study utilized a randomized pre-test post-test control group design. The research was conducted in selected tertiary care hospitals of Vadodara City, Gujarat. The study population comprised patients diagnosed with COPD who met the eligibility criteria. A total of 120 participants were recruited using simple random sampling and were randomly allocated into an experimental group (n = 60) and a control group (n = 60).

Patients aged between 40 and 75 years, diagnosed with COPD, clinically stable, and willing to participate in the study were included. Patients with acute exacerbation of COPD, severe cardiac disease, neurological disorders affecting mobility, or cognitive impairment were excluded from the study. Baseline assessment of all participants was conducted prior to the intervention. Clinical outcomes were measured using standardized assessment tools, including the Modified Medical Research Council (mMRC) Dyspnea Scale for assessment of dyspnea, pulse oximetry for oxygen saturation (SpO_2), respiratory rate measured in breaths per minute, and the Six-Minute Walk Distance (6MWD) test for evaluating exercise capacity.

The experimental group received a structured pulmonary intervention program for six weeks. The intervention package consisted of diaphragmatic breathing exercises for 10 minutes daily, pursed-lip breathing exercises for 10 minutes daily, chest expansion exercises with 10 repetitions twice daily, and supervised walking exercises for 30 minutes per day, five days per week. Participants in the control group received routine hospital care without any additional pulmonary intervention.

Data collection was carried out in four phases. Phase I involved participant recruitment and obtaining written informed consent. Phase II included baseline assessment of clinical outcomes in both groups. Phase III involved implementation of the pulmonary intervention program in the experimental group over a period of six weeks. Phase IV consisted of post-test assessment of clinical outcomes for both groups following completion of the intervention period. The primary outcome variable was clinical outcome, assessed through four indicators: dyspnea score, oxygen saturation, respiratory rate, and six-minute walk distance. Descriptive statistics such as frequency, percentage, mean, and standard deviation were used to summarize demographic and clinical characteristics of the participants. Inferential statistics including paired t-test, independent t-test, and chi-square test were employed to evaluate the effectiveness of the intervention and compare outcomes between groups. Statistical significance was established at a p-value of less than 0.05.

The study was conducted following approval from the Institutional Ethics Committee of hospital. Written informed consent was obtained from all participants prior to Enrollment. Confidentiality and anonymity of participant information were maintained throughout the study, and participants were informed of their right to withdraw from the study at any stage without any consequences to their treatment or care.

Results

Table 1. Frequency and Percentage Distribution of Demographic Characteristics of COPD Patients in Experimental and Control Groups (N = 120)

Demographic Variable	**Experimental Group (n=60) f (%)**	**Control Group (n=60) f (%)**
Age (Years)		
40–50	12 (20.0%)	11 (18.3%)
51–60	24 (40.0%)	25 (41.7%)
61–70	18 (30.0%)	19 (31.7%)
>70	6 (10.0%)	5 (8.3%)
Gender		

Male	44 (73.3%)	42 (70.0%)
Female	16 (26.7%)	18 (30.0%)
Educational Status		
No Formal Education	14 (23.3%)	16 (26.7%)
Primary Education	18 (30.0%)	17 (28.3%)
Secondary Education	20 (33.3%)	19 (31.7%)
Graduate and Above	8 (13.4%)	8 (13.3%)
Occupation		
Unemployed/Retired	20 (33.3%)	22 (36.7%)
Laborer	18 (30.0%)	17 (28.3%)
Farmer	10 (16.7%)	9 (15.0%)
Business/Service	12 (20.0%)	12 (20.0%)
Smoking Status		
Current Smoker	24 (40.0%)	22 (36.7%)
Former Smoker	28 (46.7%)	30 (50.0%)
Never Smoked	8 (13.3%)	8 (13.3%)
Duration of COPD		
<5 Years	16 (26.7%)	18 (30.0%)
5–10 Years	28 (46.7%)	26 (43.3%)
>10 Years	16 (26.6%)	16 (26.7%)
Severity of COPD (GOLD Classification)		
Moderate	24 (40.0%)	23 (38.3%)
Severe	28 (46.7%)	29 (48.3%)
Very Severe	8 (13.3%)	8 (13.4%)

The majority of participants in both experimental (40.0%) and control groups (41.7%) belonged to the age group of 51–60 years. Most participants were male (73.3% and 70.0%, respectively). Nearly half of the participants were former smokers. The majority had COPD duration between 5 and 10 years. Baseline demographic characteristics were comparable between the two groups.

Table 2. Baseline Clinical Outcomes among COPD Patients

Clinical Outcome	Experimental Group (n=60) Mean ± SD	Control Group (n=60) Mean ± SD	p-value
Dyspnea Score (mMRC)	3.20 ± 0.72	3.15 ± 0.68	0.71
Oxygen Saturation (%)	92.3 ± 1.9	92.5 ± 2.0	0.64
Respiratory Rate (breaths/min)	24.8 ± 2.6	24.6 ± 2.5	0.75
Six-Minute Walk Distance (m)	278 ± 49	282 ± 52	0.68

Table 2 presents the baseline clinical outcomes of COPD patients in the experimental and control groups prior to the intervention. The mean dyspnoea score was 3.20 ± 0.72 in the experimental group and 3.15 ± 0.68 in the control group. The mean oxygen saturation was 92.3 ± 1.9% and 92.5 ± 2.0%, respectively. Similarly, the mean respiratory rate was 24.8 ± 2.6 breaths/minute in the experimental group and 24.6 ± 2.5 breaths/minute in the control group. The mean six-minute walk distance was 278 ± 49 meters in the experimental group and 282 ± 52 meters in the control group.

Table 3. Effectiveness of Pulmonary Interventions on Dyspnoea

Group	Pre-test Mean ± SD	Post-test Mean ± SD	Mean Difference
Experimental	3.20 ± 0.72	1.65 ± 0.63	1.55
Control	3.15 ± 0.68	2.95 ± 0.65	0.20

Table 3 shows the effect of pulmonary interventions on dyspnea among COPD patients. In the experimental group, the mean dyspnea score decreased from 3.20 ± 0.72 during the pre-test to 1.65 ± 0.63 during the post-test, with a mean difference of 1.55. In contrast, the control group showed only a slight reduction from 3.15 ± 0.68 to 2.95 ± 0.65, with a mean difference of 0.20. The post-test comparison revealed a statistically significant difference between the groups ($t = 10.82$, $p < 0.001$).

Table 4. Effectiveness of Pulmonary Interventions on Oxygen Saturation

Group	Pre-test Mean ± SD	Post-test Mean ± SD	Mean Difference
Experimental	92.3 ± 1.9	95.8 ± 1.4	+3.5
Control	92.5 ± 2.0	92.9 ± 1.8	+0.4

Table 4 presents the effect of pulmonary interventions on oxygen saturation levels among COPD patients. The mean oxygen saturation in the experimental group increased from 92.3 ± 1.9% at pre-test to 95.8 ± 1.4% at post-

test, resulting in a mean improvement of 3.5%. In the control group, oxygen saturation increased marginally from 92.5 ± 2.0% to 92.9 ± 1.8%, with a mean difference of 0.4%. The post-test comparison demonstrated a statistically significant difference between the groups ($t = 8.96$, $p < 0.001$). Table 4. Effectiveness of Pulmonary Interventions on Respiratory Rate.

Table 5: Effectiveness of Pulmonary Interventions on Respiratory Rate

Group	Pre-test Mean ± SD	Post-test Mean ± SD	Mean Difference
Experimental	24.8 ± 2.6	19.8 ± 2.1	-5.0
Control	24.6 ± 2.5	23.9 ± 2.3	-0.7

Table 5 depicts the effect of pulmonary interventions on respiratory rate among COPD patients. The mean respiratory rate in the experimental group decreased from 24.8 ± 2.6 breaths per minute at pre-test to 19.8 ± 2.1 breaths per minute at post-test, showing a mean reduction of 5.0 breaths per minute. In the control group, the respiratory rate decreased slightly from 24.6 ± 2.5 to 23.9 ± 2.3 breaths per minute, with a mean difference of 0.7 breaths per minute. The post-test comparison showed a statistically significant difference between the groups ($t = 8.11$, $p < 0.001$).

Table 6. Effectiveness of Pulmonary Interventions on Six-Minute Walk Distance

Group	Pre-test Mean ± SD	Post-test Mean ± SD	Mean Difference
Experimental	278 ± 49	382 ± 56	+104
Control	282 ± 52	295 ± 54	+13

Table 6 illustrates the effect of pulmonary interventions on exercise capacity as measured by the six-minute walk distance. The experimental group showed a substantial increase in mean walking distance from 278 ± 49 meters at pre-test to 382 ± 56 meters at post-test, with a mean improvement of 104 meters. The control group demonstrated only a modest increase from 282 ± 52 meters to 295 ± 54 meters, with a mean difference of 13 meters. The post-test comparison revealed a statistically significant difference between the groups ($t = 8.74$, $p < 0.001$).

Table 7. Overall Comparison of Clinical Outcomes at Post-Test

Outcome	Experimental Mean ± SD	Control Mean ± SD	t-value	p-value
Dyspnea Score	1.65 ± 0.63	2.95 ± 0.65	10.82	<0.001
Oxygen Saturation (%)	95.8 ± 1.4	92.9 ± 1.8	8.96	<0.001
Respiratory Rate	19.8 ± 2.1	23.9 ± 2.3	8.11	<0.001
6-Minute Walk Distance (m)	382 ± 56	295 ± 54	8.74	<0.001

Table 7 compares the post-test clinical outcomes between the experimental and control groups. The experimental group demonstrated significantly better outcomes than the control group across all measured variables. The mean dyspnea score was lower in the experimental group (1.65 ± 0.63) compared to the control group (2.95 ± 0.65) ($t = 10.82$, $p < 0.001$). Oxygen saturation was significantly higher in the experimental group (95.8 ± 1.4%) than in the control group (92.9 ± 1.8%) ($t = 8.96$, $p < 0.001$). The mean respiratory rate was lower in the experimental group (19.8 ± 2.1 breaths/minute) compared to the control group (23.9 ± 2.3 breaths/minute) ($t = 8.11$, $p < 0.001$). Similarly, the six-minute walk distance was considerably higher in the experimental group (382 ± 56 meters) than in the control group (295 ± 54 meters) ($t = 8.74$, $p < 0.001$).

The findings revealed that the experimental and control groups were comparable at baseline with no significant differences in clinical outcomes. Following the six-week pulmonary intervention program, the experimental group demonstrated significant improvements in all outcome measures. Dyspnoea scores and respiratory rate decreased significantly, while oxygen saturation and six-minute walk distance showed substantial improvement compared to the control group. These results indicate that pulmonary interventions were effective in enhancing clinical outcomes among COPD patients, thereby supporting all the study hypotheses.

Discussion

The present study evaluated the effectiveness of pulmonary interventions on clinical outcomes among patients with Chronic Obstructive Pulmonary Disease (COPD). The findings demonstrated significant improvements in dyspnea, oxygen saturation, respiratory rate, and six-minute walk distance among participants in the experimental group compared with those in the control group. These findings are consistent with contemporary evidence supporting pulmonary rehabilitation as an effective non-pharmacological intervention for COPD management (Lamberton et al., 2024; Song et al., 2025).[10,11]

The baseline assessment revealed no statistically significant differences between the experimental and control groups regarding dyspnea score, oxygen saturation, respiratory rate, and six-minute walk distance. This indicates that both groups were comparable before the intervention, thereby strengthening the internal validity of the study.

A significant reduction in dyspnea was observed among participants who received pulmonary interventions. The mean dyspnea score in the experimental group decreased substantially following the six-week intervention program. This finding is supported by recent systematic reviews reporting that pulmonary rehabilitation consistently reduces dyspnea severity and improves symptom management among COPD patients (Jenkins et al.,

2024; Song et al., 2025). [12,13] Furthermore, Vatrella et al. (2026) reported that pulmonary rehabilitation and respiratory muscle training produce meaningful improvements in dyspnea and respiratory functioning among individuals with COPD. [14]

The improvement in oxygen saturation observed in the experimental group may be explained by enhanced ventilation-perfusion matching, improved respiratory muscle performance, and reduced air trapping. Breathing techniques such as diaphragmatic breathing and pursed-lip breathing facilitate more effective alveolar ventilation and gas exchange. [15] Chen et al. (2025) reported that pulmonary rehabilitation interventions improve oxygenation status, lung function, and exercise performance among COPD patients. Similarly, recent evidence suggests that pulmonary rehabilitation contributes to improvements in physiological measures associated with respiratory efficiency (Chen et al., 2024). [16]

The present study also demonstrated a significant reduction in respiratory rate among participants in the experimental group. COPD is commonly associated with rapid and shallow breathing patterns resulting from airflow limitation and increased work of breathing. Breathing retraining techniques encourage slower and deeper respiration, thereby reducing respiratory muscle fatigue and improving ventilatory efficiency. These findings support previous reports indicating that pulmonary rehabilitation improves respiratory control and reduces physiological stress associated with chronic respiratory disease (Vatrella et al., 2026). [17]

One of the most notable findings of the study was the significant improvement in six-minute walk distance among participants receiving pulmonary interventions. The increase in walking distance reflects enhanced functional exercise capacity and endurance. Exercise training is considered the cornerstone of pulmonary rehabilitation because it improves cardiovascular fitness, skeletal muscle function, and oxygen utilization. Recent systematic reviews have demonstrated that pulmonary rehabilitation significantly enhances exercise capacity and functional performance in COPD patients (Song et al., 2025; Lamberton et al., 2024). [18,19] Similarly, aerobic exercise interventions have been shown to improve six-minute walk distance, oxygen saturation, and symptom severity among COPD patients (Zhang & Khan, 2026). [20]

The physiological benefits observed in this study may be attributed to multiple mechanisms. Diaphragmatic breathing enhances diaphragmatic excursion and reduces reliance on accessory respiratory muscles. Pursed-lip breathing prolongs expiration, reduces dynamic hyperinflation, and prevents premature airway collapse. Chest expansion exercises improve thoracic mobility and lung expansion, while structured walking exercises enhance muscular conditioning and cardiovascular endurance. Collectively, these adaptations contribute to improved respiratory efficiency, reduced symptom burden, and enhanced physical performance (Lamberton et al., 2024). [21]

The reduction in symptom burden observed in this study is clinically important because dyspnea and exercise intolerance are major contributors to disability, reduced quality of life, and increased healthcare utilization among COPD patients. Previous evidence indicates that pulmonary rehabilitation improves breathlessness, fatigue, exercise capacity, and overall well-being while reducing hospital admissions and healthcare costs (Alison, 2024; Jenkins et al., 2024). [22]

Overall, the findings of the present study indicate that pulmonary interventions are effective in improving respiratory efficiency, reducing symptom burden, and enhancing functional capacity among COPD patients. The results are consistent with recent evidence and support the integration of structured pulmonary rehabilitation programs into routine COPD management in hospital and community settings (Song et al., 2025; Lamberton et al., 2024). [23,24]

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Conflict Of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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Ethical Approval

Ethical approval for the study was obtained from the Institutional Ethics Committee before data collection. Written informed consent was obtained from all participants, and confidentiality of participant information was maintained throughout the study.

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