The Bioscan AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES 21(2): S.I (2), 404-418, 2026 www.thebioscan.com

EFFECT OF DIAPHRAGMATIC EXCURSION TRAINING ON PULMONARY FUNCTION, DYSPNEA AND FUNCTIONAL CAPACITY IN PATIENTS WITH STABLE CHRONIC OBSTRUCTIVE PULMONARY DISEASE

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DOI: https://doi.org/10.63001/tbs.2026.v21.i02.S.I(2).pp404-418

KEYWORDS

COPD, diaphragmatic excursion, pulmonary function, dyspnea, physiotherapy, 6MWT

Received on: 30/03/2026

Accepted on: 18/04/2026

Published on: 28/04/2026

Abstract

Background:
Chronic Obstructive Pulmonary Disease is characterized by persistent airflow limitation, dyspnea, and reduced functional capacity. Diaphragmatic dysfunction, particularly reduced diaphragmatic excursion, plays a key role in impaired respiratory mechanics. Targeted interventions focusing on improving diaphragmatic mobility may enhance clinical outcomes.

Objective:
To evaluate the effect of diaphragmatic excursion training on pulmonary function, dyspnea, and functional capacity in patients with stable COPD.

Methods:
A randomized controlled trial was conducted on 30 patients with stable COPD, aged 40–70 years. Participants were randomly allocated into two groups: an experimental group receiving diaphragmatic excursion training and a control group receiving conventional physiotherapy. The intervention was administered for 6 weeks, 5 sessions per week. Outcome measures included pulmonary function tests (FEV_1, FVC), dyspnea assessed using the Modified Medical Research Council (mMRC) scale, and functional capacity measured by the 6-Minute Walk Test (6MWT). Data were analyzed using paired and independent t-tests with a significance level set at $p < 0.05$.

Results:
The experimental group demonstrated statistically significant improvements in pulmonary function (FEV_1 and FVC), reduction in dyspnea scores, and increased functional capacity compared to the control group ($p < 0.05$). Although the control group also showed improvement, the magnitude of change was significantly greater in the experimental group.

Conclusion:
Diaphragmatic excursion training is an effective intervention for improving pulmonary function, reducing dyspnea, and enhancing functional capacity in patients with stable COPD. It can be considered a valuable addition to pulmonary rehabilitation programs.

INTRODUCTION

Chronic Obstructive Pulmonary Disease is a progressive respiratory disorder characterized by persistent airflow limitation, chronic inflammation, and significant extrapulmonary effects that impair functional capacity and quality of life. It remains a leading cause of morbidity and mortality worldwide, with increasing prevalence due to aging populations and continued exposure to risk factors such as smoking and air pollution[1].

A fundamental pathophysiological feature of COPD is lung hyperinflation, which alters respiratory mechanics and reduces the efficiency of the diaphragm. Hyperinflation leads to flattening of the diaphragm, shortening of muscle fibers, and impaired contractility, ultimately reducing diaphragmatic excursion and ventilatory efficiency[2]. Recent imaging-based studies using ultrasound have demonstrated that patients with COPD exhibit significantly reduced diaphragmatic mobility compared to healthy individuals, confirming diaphragmatic dysfunction as a key contributor to disease severity[3].

Diaphragmatic excursion has gained increasing attention as a clinically relevant biomarker in COPD. Advances in ultrasonography have enabled accurate, non-invasive assessment of diaphragmatic motion, thickness, and contractility. A recent systematic review and meta-analysis reported that diaphragmatic ultrasound can effectively identify functional impairment in COPD patients and is strongly associated with reduced pulmonary function parameters such as FEV_1 and FVC[4]. Furthermore, prospective observational studies have shown that reduced diaphragmatic excursion correlates with impaired respiratory mechanics and disease progression[5].

Dyspnea is the most prominent and disabling symptom in COPD and is closely linked to altered respiratory mechanics and neuromuscular inefficiency. Increased air trapping and reduced diaphragmatic function contribute to an imbalance between respiratory demand and ventilatory capacity, leading to heightened perception of breathlessness[6]. Interventions targeting respiratory muscle performance may therefore play a crucial role in reducing dyspnea and improving patient outcomes.

Pulmonary rehabilitation is widely recognized as a cornerstone in the

management of COPD. Contemporary guidelines emphasize the role of individualized exercise training and respiratory muscle interventions in improving exercise tolerance and quality of life[7]. Recent randomized controlled trials have demonstrated that inspiratory muscle training significantly improves pulmonary function, dyspnea, and functional capacity in patients with moderate to severe COPD[8]. Additionally, emerging evidence suggests that targeted diaphragm-focused interventions, including electrical stimulation and structured muscle training, can enhance diaphragmatic function and clinical outcomes[9].

Functional capacity, commonly assessed using the 6-minute walk test, is a critical indicator of disease impact and prognosis in COPD. Improvements in respiratory mechanics and diaphragm performance have been associated with enhanced exercise tolerance and reduced functional limitation[8]. Despite these advances, most rehabilitation programs focus on general respiratory training rather than specifically targeting diaphragmatic excursion.

Although recent studies have highlighted the importance of diaphragmatic dysfunction in COPD, there remains a lack of structured and clinically validated interventions specifically designed to improve diaphragmatic excursion. Therefore, this study aims to evaluate the effect of diaphragmatic excursion training on pulmonary function, dyspnea, and functional capacity in patients with stable COPD.

METHODOLOGY:

- **Study Design**:

  A prospective, parallel-group randomized controlled trial (RCT) was conducted to evaluate the effect of diaphragmatic excursion training on pulmonary function, dyspnea, and functional capacity in patients with stable Chronic Obstructive Pulmonary Disease.

- **Participants:**

  Patients diagnosed with COPD

- **Sample Size:**

  The sample size for the present study was determined using power analysis based on previous studies. A statistical power of 80% and a confidence level of 95% were considered to ensure adequate detection of clinically meaningful differences between groups. An effect size of 0.8, representing a moderate to large effect, was assumed based on prior literature. The minimum required sample size was calculated to be 27 participants. To account for potential dropouts and ensure adequate group representation, a total of 30 participants were recruited.

- **Sampling Method**

Participants were recruited using convenience sampling and randomly allocated into two groups.

GROUP A: Experimental (Diaphragmatic excursion training protocol**)**

GROUP B: Control (Conventional physiotherapy**)**

Inclusion Criteria

- Patients diagnosed with stable Chronic Obstructive Pulmonary Disease classified as GOLD stage II–III based on spirometric criteria[1]
- Age between 40 and 70 years[2]
- Clinically stable condition with no acute exacerbations in the preceding 4 weeks[3]
- Ability to understand and follow verbal instructions and participate in the intervention protocol

Exclusion Criteria

- Presence of acute exacerbation of COPD at the time of recruitment[3]
- History of severe cardiovascular disease (e.g., unstable angina, recent myocardial infarction)[4]
- Presence of neurological or musculoskeletal disorders affecting mobility or exercise performance[5]
- History of recent thoracic or abdominal surgery (within the last 3–6 months)[6]

INTERVENTION PROTOCOL

GROUP A (EXPERIMENTAL GROUP)
DIAPHRAGMATIC EXCURSION TRAINING PROTOCOL

Diaphragmatic excursion training is a structured intervention program consisting of diaphragmatic breathing exercises, manual facilitation, and positional optimization aimed at enhancing diaphragmatic mobility and excursion during respiration.

Components

1. **Diaphragmatic Breathing (10 repetitions)**

   - **Position:** Crook lying / semi-Fowler
   - One hand on chest, one on abdomen
   - Slow deep inhalation through nose
   - Abdomen rises (not chest)
   - Inhale (4 sec) → abdomen rises
   - Exhale (6 sec) → abdomen falls

2. **Manual Facilitation (10 repetitions)**
   Therapist places hands below costal margin provides Gentle inward/upward resistance during inspiration.
3. **Segmental (Lower Costal) Breathing (10 repetitions)**
   Focus on lateral rib expansion

4. **Inspiratory Resistance Training (10 repetitions)**

5. **Position-Based Training (5 breaths per position)**
   Perform diaphragmatic breathing in:
   - Crook lying
   - Sitting
   - Forward lean sitting

Total session Duration: 30 minutes; 5 days/week for 6 weeks

GROUP B (CONTROL GROUP)

CONVENTIONAL PHYSIOTHERAPY

- Breathing exercises
- Chest expansion exercises
- General mobility exercises

Total Session Duration: 30 minutes; 5 days/week for 6 weeks

OUTCOME MEASURES

- Pulmonary Function Test -FEV_1, FVC (Spirometry)
- Dyspnea: Modified Medical Research Council (mMRC) scale
- Functional Capacity: 6-Minute Walk Test (6MWT)

STATISTICAL ANALYSIS

Statistical analysis was performed using SPSS version 26.0. Data were expressed as mean ± standard deviation (SD). The normality of data distribution was assessed using the Shapiro-Wilk test. For within-group comparisons, the paired t-test was applied to evaluate pre and post-intervention differences. For between-group comparisons, the independent t-test was used to determine differences between the experimental and control groups. A p-value of less than 0.05 was considered statistically significant.

Table 1: Within-Group Comparison – Experimental Group

Outcome Measure	Pre-test Mean ± SD	Post-test Mean ± SD	p-value
FEV_1 (L)	1.46 ± 0.28	1.80 ± 0.30	0.001
FVC (L)	2.10 ± 0.35	2.45 ± 0.37	0.002
mMRC Score	3.0 ± 0.6	1.8 ± 0.5	0.001
6MWT (m)	322 ± 38	395 ± 42	0.001

The above table shows a statistically significant improvement in pulmonary function (FEV_1, FVC), reduction in dyspnea, and increase in functional capacity following diaphragmatic excursion training in patients with Chronic Obstructive Pulmonary Disease ($p < 0.05$).

Table 2: Within-Group Comparison – Control Group

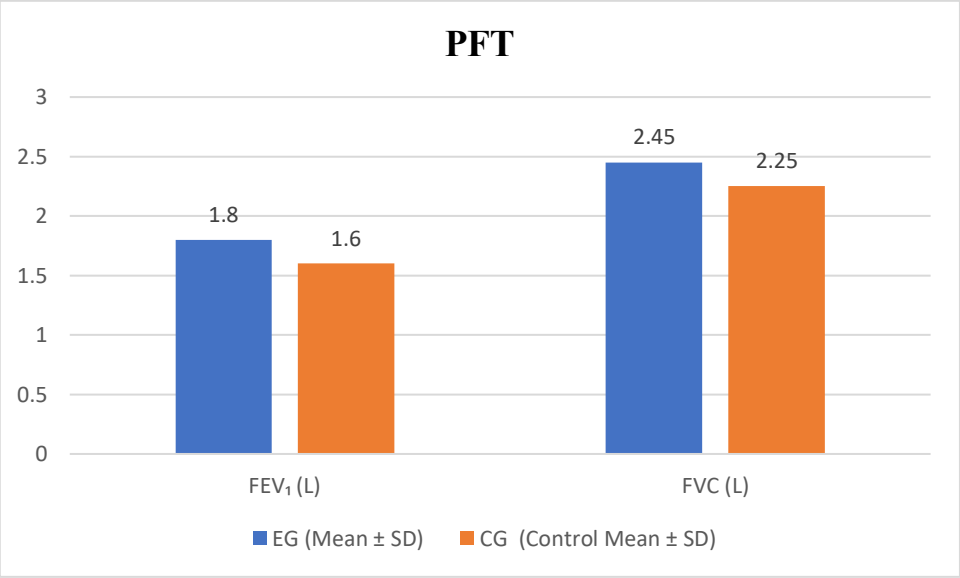
Outcome Measure	Pre-test Mean ± SD	Post-test Mean ± SD	p-value
FEV_1 (L)	1.48 ± 0.30	1.60 ± 0.31	0.04
FVC (L)	2.12 ± 0.33	2.25 ± 0.35	0.03
mMRC Score	3.1 ± 0.5	2.6 ± 0.6	0.02
6MWT (m)	325 ± 40	348 ± 39	0.03

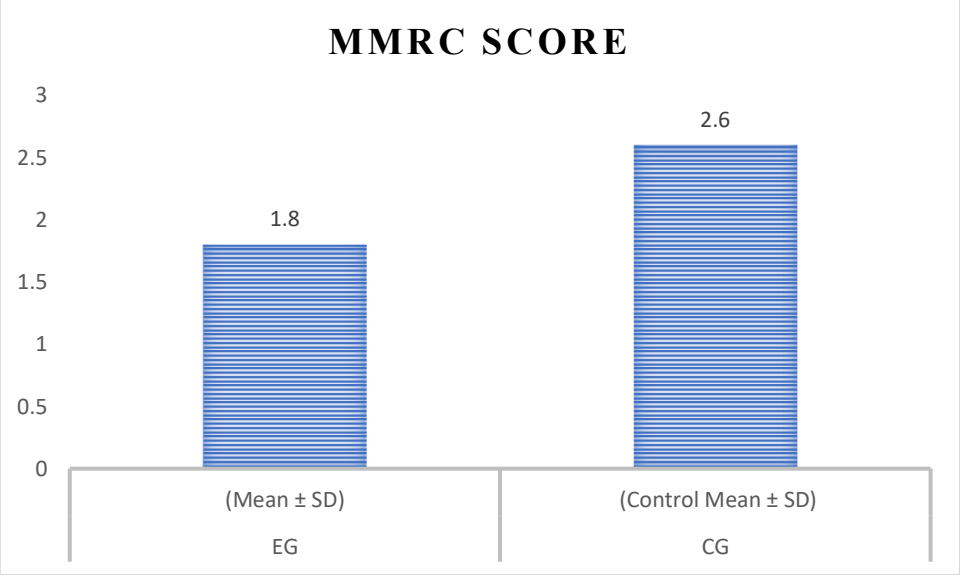
The control group also demonstrated statistically significant improvements in all outcome measures; however, the magnitude of improvement was smaller compared to the experimental group.

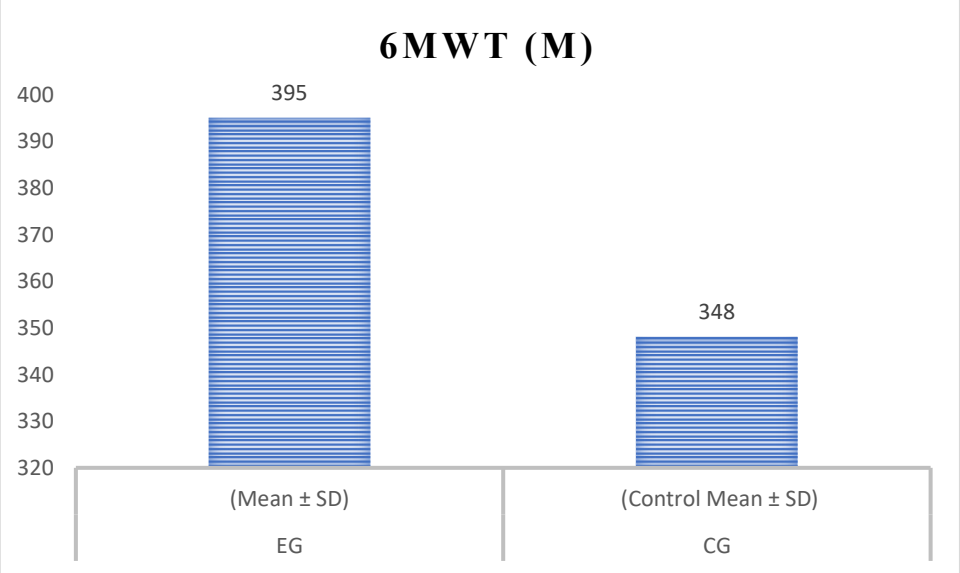
Table 3: Between-Group Comparison (Post-test Values)

Outcome Measure	EG (Mean ± SD)	CG (Control Mean ± SD)	p-value
FEV_1 (L)	1.80 ± 0.30	1.60 ± 0.31	0.02
FVC (L)	2.45 ± 0.37	2.25 ± 0.35	0.03
mMRC Score	1.8 ± 0.5	2.6 ± 0.6	0.001
6MWT (m)	395 ± 42	348 ± 39	0.001

The above table shows that the experimental group demonstrated significantly greater improvement in pulmonary function, dyspnea reduction, and functional capacity compared to the control group ($p < 0.05$).







RESULTS

The findings of the study indicate that diaphragmatic excursion training led to significant improvements in pulmonary function (FEV_1 and FVC), reduction in dyspnea as measured by the mMRC scale, and enhanced functional capacity as assessed by the 6-Minute Walk Test in patients

with Chronic Obstructive Pulmonary Disease. Although conventional therapy also showed beneficial effects, the improvements observed in the experimental group were significantly greater, suggesting that targeted diaphragmatic training provides superior clinical outcomes.

DISCUSSION:

The present study investigated the effect of diaphragmatic excursion training on pulmonary function, dyspnea, and functional capacity in patients with Chronic Obstructive Pulmonary Disease and demonstrated significant improvements across all outcome measures in the experimental group compared to conventional therapy. These findings support the growing body of evidence emphasizing the importance of targeted respiratory muscle interventions in COPD management.

The observed improvement in pulmonary function parameters (FEV_1 and FVC) in the experimental group may be attributed to enhanced diaphragmatic mobility and improved ventilatory mechanics. Recent studies have shown that respiratory training interventions significantly improve lung function by optimizing diaphragm performance and reducing dynamic hyperinflation.[20] A randomized controlled study reported that structured respiratory training led to significant increases in diaphragmatic excursion and pulmonary function, highlighting the direct relationship between diaphragm mobility and ventilatory efficiency.[21] Furthermore, systematic reviews have demonstrated that respiratory muscle training contributes to measurable improvements in FEV_1 and FVC, supporting the findings of the present study.[22]

Dyspnea, a primary limiting symptom in COPD, was significantly reduced following diaphragmatic excursion training. This improvement can be explained by enhanced neuromuscular coordination and reduced work of breathing. Contemporary evidence suggests that respiratory muscle training improves the balance between ventilatory demand and capacity, thereby reducing the sensation of breathlessness.[23] A recent meta-analysis reported significant reductions in dyspnea scores following respiratory muscle training interventions, indicating improved respiratory efficiency and decreased reliance on accessory muscles.[22] These findings align with the results of the current study, where a substantial reduction in mMRC scores was observed.

Functional capacity, as measured by the 6-Minute Walk Test, showed significant improvement in the experimental group. This may be attributed to improved oxygen utilization and reduced ventilatory limitation during physical activity. Recent literature indicates that pulmonary rehabilitation programs incorporating respiratory muscle training significantly enhance exercise tolerance and walking distance in COPD patients.[24] A 2025 cohort study demonstrated that combining pulmonary rehabilitation with respiratory muscle training resulted in sustained improvements in functional capacity and quality of life.[25] These findings are consistent with the present study, where diaphragmatic excursion training led to superior improvements in 6MWT performance compared to conventional therapy.

The superiority of the experimental intervention over conventional physiotherapy observed in this study highlights the importance of targeted diaphragm-focused training. While conventional therapy improves general respiratory function, it may not sufficiently address diaphragmatic dysfunction, which is a key contributor to disease pathology. Emerging evidence suggests that interventions specifically targeting diaphragm function, including breathing retraining and inspiratory resistance training, produce greater clinical benefits compared to non-specific rehabilitation approaches.[26]

Overall, the findings of this study are consistent with recent systematic reviews and randomized trials emphasizing the role of respiratory muscle training in improving pulmonary function, dyspnea, and functional capacity in COPD patients. The integration of diaphragmatic excursion-focused exercises provides a novel and clinically relevant approach that directly addresses underlying pathophysiological impairments.

CONCLUSION

The present study concludes that diaphragmatic excursion training is an effective and clinically beneficial intervention for patients with Chronic Obstructive Pulmonary Disease. The intervention resulted in significant improvements in pulmonary function parameters (FEV_1 and FVC), reduction in dyspnea levels, and enhancement of functional capacity as measured by the 6-Minute Walk Test. Compared to conventional physiotherapy, diaphragmatic excursion training demonstrated superior outcomes, likely due to its targeted approach in improving diaphragmatic mobility and optimizing respiratory mechanics. By addressing diaphragmatic dysfunction, a key contributor to symptom severity in COPD this intervention enhances ventilatory efficiency and reduces the work of breathing. Therefore, diaphragmatic excursion training can be recommended as an effective adjunct to pulmonary rehabilitation programs for improving clinical outcomes and functional independence in patients with stable COPD.

CONFLICT OF INTEREST:

None

FUNDING:

None

REFERENCES:

1. López-Campos JL, et al. Global burden and trends in COPD. *Lancet Respir Med*. 2022.

2. Wangüemert-Pérez A, et al. Ultrasound assessment of diaphragmatic dynamics in COPD. *Rev Clin Esp*. 2023.

3. An TJ, et al. Diaphragm ultrasound as biomarker in COPD. *Int J Chron Obstruct Pulmon Dis*. 2022.

4. Kakhaki HES, et al. Diaphragmatic ultrasound in COPD: systematic review and meta-analysis. *Ethiop J Health Sci*. 2023.

5. Li X, et al. Multimodal ultrasound assessment of diaphragm in COPD. *Respir Med*. 2024.

6. O'Donnell DE, Milne KM, James MD, et al. Pathophysiology of dyspnea in COPD: recent advances. *Eur Respir Rev*. 2021;30(159):200350.

7. Holland AE, Cox NS, Houchen-Wolloff L, et al. Defining modern pulmonary rehabilitation: an official European Respiratory Society statement. *Eur Respir J*. 2021;58(6):2100121.

8. Abdelsalam EM, et al. Inspiratory muscle training improves pulmonary function and functional capacity in COPD: randomized controlled trial. *Physiother Res Int*. 2025.

9. Zhang L, et al. Diaphragm training and ultrasound monitoring in COPD. *BMC Pulm Med*. 2025.

10. An TJ, Yoo WG. Effects of diaphragmatic breathing on respiratory function in patients with COPD. *Int J Chron Obstruct Pulmon Dis*. 2022;17:2101–2110.

11. Lee CT, Chien JY, Hsu MJ, Wu HD, Wang LY. Inspiratory muscle activation during inspiratory muscle training in patients with COPD. *Respir Med*. 2021;190:106676.

12. Aggarwal D, Waghmode P. Trends in Search Patterns and Public Interest in Vaping, Cigarette Products, and Oral & Oropharyngeal Cancer: An Infodemiology Analysis. Oral Sphere J. Dent. Health Sci. 2026;2(1):1-8

13. Abdelsalam EM, et al. Inspiratory muscle training improves pulmonary function and functional capacity in COPD: randomized controlled trial. *Physiother Res Int*. 2025.

14. Kisner C, Colby LA. *Therapeutic Exercise: Foundations and Techniques*. 7th ed. Philadelphia: F.A. Davis; 2018.

15. Global Initiative for Chronic Obstructive Lung Disease. Global strategy for the diagnosis, management, and prevention of COPD; 2024 report.

16. Wedzicha JA, Miravitlles M, Hurst JR, et al. Management of COPD exacerbations: recent advances. *Lancet Respir Med*. 2023.

17. Anderson L, et al. Exercise-based rehabilitation for patients with cardiovascular disease. *Cochrane Database Syst Rev*. 2022.

18. Spruit MA, et al. Pulmonary rehabilitation and comorbidities. *Am J Respir Crit Care Med*. 2013.

19. Boden I, Skinner EH, Browning L, et al. Postoperative pulmonary complications and physiotherapy. *Lancet Respir Med*. 2020.

20. Zhu B, Xue F, Li M, Chen Y. Long-term benefits of pulmonary rehabilitation with respiratory muscle training in COPD. *Respir Med*. 2025;245:108214.

21. Guo H, Yan F, Li X. Impact of respiratory training on diaphragmatic function in COPD patients. *BMC Pulm Med*. 2025;26:6.

22. Qi XH, Ren HM, Wang N, et al. Effects of respiratory muscle training on COPD: systematic review and meta-analysis. *Ann Thorac Med*. 2025;20(4):213–221.

23. O'Donnell DE, Milne KM, James MD, et al. Pathophysiology of dyspnea in COPD: recent advances. *Eur Respir Rev*. 2021;30:200350.

24. Zhu Z, Muhamad AS, Omar N, et al. Efficacy of exercise treatments in COPD: systematic review. *J Bodyw Mov Ther*. 2024;38:106–127.

25. Zhu B, et al. Respiratory muscle training and long-term COPD outcomes. *Respir Med*. 2025.

26. Chen X, Xu L, Li S, et al. Respiratory support therapies in pulmonary rehabilitation: systematic review. *BMC Med*. 2024.