

Effect of Inspiratory Muscle Training on Functional Capacity and Dyspnea in Patients with Moderate Chronic Obstructive Pulmonary Disease: A Case Series

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ABSTRACT

Background: Patients with moderate chronic obstructive pulmonary disease (COPD) frequently experience exertional dyspnea and reduced functional capacity during stable phases, and focused evidence on inspiratory muscle training (IMT) in moderate disease remains limited.

Objective: To investigate the effect of an eight-week structured IMT program on functional exercise capacity and perceived dyspnea in patients with moderate COPD.

Methods: A prospective case series of ten medically stable patients with moderate COPD (GOLD grade 2) was conducted. Participants performed threshold IMT for eight weeks (15 minutes per session, five days per week), starting at 30% and progressing to 40–50% of maximal inspiratory pressure (MIP). Functional capacity, dyspnea, health status, and inspiratory muscle strength were assessed before and after the intervention using the Six-Minute Walk Test (6MWT), the modified Medical Research Council (mMRC) scale, the COPD Assessment Test

(CAT), and MIP measurement. Data were analyzed using the paired samples t-test.

Results: All parameters improved significantly. Mean 6MWT distance increased from 334.8 ± 32.9 m to 372.2 ± 33.0 m ($p < 0.001$); mean mMRC score decreased from 2.1 ± 0.6 to 1.2 ± 0.4 ($p < 0.001$); mean CAT score reduced from 19.9 ± 2.2 to 13.5 ± 2.7 ($p < 0.001$); and mean MIP improved from 59.9 ± 7.3 cmH₂O to 73.9 ± 7.5 cmH₂O ($p < 0.001$).

Conclusion: An eight-week structured IMT program produced significant gains in functional capacity, reduced exertional breathlessness, and improved respiratory muscle strength, supporting targeted IMT as an effective component in the management of moderate COPD.

Key Words: Chronic obstructive pulmonary disease; Inspiratory muscle training; Functional capacity; Dyspnea; Six-minute walk test

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a major global health challenge

characterized by persistent respiratory symptoms and progressive airflow limitation resulting from airway remodeling and alveolar destruction. The disease predominantly arises from prolonged inhalation of noxious particulates or gases, with tobacco smoking the principal contributor, alongside biomass smoke, chemical vapors, and industrial dusts. Patients typically report chronic productive cough, wheezing, progressive exertional breathlessness, and fatigue, which lead to physical deconditioning and loss of functional autonomy. Formal diagnosis requires spirometric demonstration of a non-fully reversible post-bronchodilator FEV1/FVC ratio below 0.70.^[1]

The pathophysiology of COPD involves persistent airway inflammation, remodeling of small peripheral airways, increased airflow resistance, and elastolytic destruction of the lung parenchyma. As expiratory flow becomes limited, air trapping and progressive hyperinflation develop. Hyperinflation displaces the diaphragm into a flattened, shortened configuration, compromising its length-tension relationship and increasing the elastic and resistive work of breathing. The ventilatory muscles must therefore generate greater inspiratory effort to maintain alveolar ventilation, a demand that becomes especially limiting during exertion and provokes dyspnea and exercise cessation.^[1,2]

According to the Global Initiative for Chronic Obstructive Lung Disease (GOLD), airflow limitation is categorized by post-bronchodilator FEV1 as a percentage of the predicted value: mild (GOLD 1, $\geq 80\%$), moderate (GOLD 2, 50–79%), severe (GOLD 3, 30–49%), and very severe (GOLD 4, $<30\%$). Patients with moderate COPD frequently report substantial daily disability, exercise intolerance, and impaired quality of life despite only moderate spirometric deficits. Current management guidelines emphasize that FEV1 alone does not capture the full clinical burden and recommend concurrent

assessment of patient-reported dyspnea and functional status.^[1]

Dyspnea is widely regarded as the most debilitating COPD symptom, manifesting as sensations of respiratory effort, air hunger, and chest tightness. It reflects complex interactions among mechanical load, dynamic hyperinflation, increased neural respiratory drive, and neuromechanical uncoupling. Persistent breathlessness promotes a sedentary lifestyle, initiating a cycle of inactivity, peripheral muscle atrophy, cardiorespiratory deconditioning, and further functional decline.^[1,3]

Functional exercise capacity reflects the ability to perform the physical tasks of daily living. In COPD it is constrained by ventilatory limitation, limb muscle weakness, impaired gas exchange, and exertional breathlessness. The Six-Minute Walk Test (6MWT) is the standard field measure of submaximal functional capacity in chronic respiratory disease, integrating pulmonary, cardiovascular, and neuromuscular responses during self-paced walking.^[4]

Respiratory muscle dysfunction is a hallmark systemic feature of COPD. Chronic airflow obstruction and hyperinflation impose sustained mechanical overload on the diaphragm and accessory inspiratory muscles, and over time structural changes, oxidative stress, and mechanical disadvantage reduce inspiratory muscle strength and endurance. Strengthening the inspiratory musculature therefore offers a direct physiological strategy to relieve ventilatory constraint.^[2,5]

Inspiratory muscle training (IMT) is a specific physiotherapeutic intervention in which the patient breathes against an external threshold or resistive load, producing targeted conditioning of the inspiratory muscles. Clinical trials and systematic reviews show that IMT improves maximal inspiratory pressure (MIP) and can reduce perceived dyspnea and improve functional exercise capacity in stable respiratory populations.^[5-8]

Nevertheless, the literature shows considerable heterogeneity in training intensity, frequency, session duration, and patient selection, and most trials aggregate patients across disease stages rather than isolating the response in moderate COPD. A case-series design permits close documentation of individualized responses to a standardized protocol. Therefore, this study evaluated the effects of an eight-week structured IMT program on functional capacity and dyspnea in patients with moderate COPD.^[8]

MATERIALS AND METHODS

This case series was conducted at the outpatient physiotherapy department of the authors' institution. Written informed consent was obtained from all participants before enrolment, and the study protocol was explained to each participant. Baseline demographic and clinical data, including age, gender, smoking history, comorbidities, pharmacotherapy, spirometric data, and exacerbation history, were systematically documented. Men and women aged 45 to 70 years were included if they had a confirmed COPD diagnosis with a post-bronchodilator FEV1/FVC ratio below 0.70, moderate airflow obstruction classified as GOLD grade 2 (FEV1 50%–79% predicted), no respiratory exacerbation in the preceding four weeks, baseline exertional dyspnea graded 1–3 on the mMRC scale, adequate cognitive and physical ability to perform the 6MWT and IMT, and willingness to adhere to the eight-week intervention protocol. Patients were excluded from the study if they had an acute exacerbation of COPD or an active respiratory tract infection within the past month. Additional exclusion criteria included unstable cardiovascular disease, uncontrolled systemic hypertension, or a recent myocardial infarction; severe neuromuscular or musculoskeletal impairment restricting walking ability; recent thoracic or upper abdominal surgery or an unresolved pneumothorax; significant cognitive impairment precluding safe,

independent training; and physician advice contraindicating respiratory muscle loading.

Study design and sample

A prospective case-series design was employed. The cohort comprised ten medically stable patients diagnosed with moderate COPD, recruited by convenience sampling from the outpatient physiotherapy facility during the study period.

Materials used

A calibrated threshold inspiratory muscle training device; a digital/analog manometer for MIP measurement; a calibrated fingertip pulse oximeter; an aneroid sphygmomanometer and acoustic stethoscope; a digital stopwatch; a flat, hard-surfaced 30-metre walking corridor marked with cones for the 6MWT; validated Borg and mMRC dyspnea scales; standardized assessment forms; and a designated rest chair.

Procedure

Baseline assessment: Before training, resting physiological parameters (heart rate, respiratory rate, systemic blood pressure, and transcutaneous oxygen saturation [SpO₂]) were recorded. Exertional breathlessness was graded using the mMRC scale, disease-specific health impairment was assessed with the COPD Assessment Test (CAT), functional exercise capacity was measured with the 6MWT, and baseline inspiratory muscle strength was assessed by maximal inspiratory pressure (MIP) using a respiratory pressure manometer. Any pre-existing somatic complaints were catalogued.

Inspiratory muscle training: Training was administered with a spring-loaded threshold device. Participants sat upright and were instructed in diaphragmatic breathing. With a nose clip and a tight oral seal around the mouthpiece, they inhaled forcefully against the set threshold resistance and exhaled passively. The initial load was approximately 30% of each patient's

baseline MIP. The regimen comprised 15 minutes of training per session, five days per week, for eight consecutive weeks. MIP was re-measured weekly, and the resistance was progressively advanced toward 40–50% of the newly achieved MIP once the patient demonstrated consistent mastery and tolerance. Rest intervals were permitted whenever fatigue developed.

Monitoring during training: Cardiorespiratory vitals, SpO₂, perceived exertion, and dyspnea ratings were monitored as needed. Predefined stopping criteria were angina, extreme dyspnea, dizziness, presyncope, severe desaturation (SpO₂ < 85%), or musculoskeletal distress. Participants continued their prescribed baseline medications without alteration, and any changes were documented.

Post-intervention assessment: After the eight-week intervention, all outcome assessments (6MWT, mMRC, CAT, and MIP) were repeated under identical standardized conditions to evaluate therapeutic change.

Outcome measures

The primary outcomes were functional exercise capacity, assessed by the 6MWT, and exertional breathlessness, evaluated by the mMRC scale. The secondary outcomes were disease-specific health status (CAT) and inspiratory muscle strength (MIP). The 6MWT was performed along a marked 30-

metre indoor corridor according to established guidelines, recording the maximal distance walked in six minutes.^[4,6] The mMRC scale grades breathlessness during physical activity from grade 0 (“breathless only with strenuous exercise”) to grade 4 (“too breathless to leave the house or breathless when dressing”).^[1]

The CAT questionnaire contains eight items evaluating cough, phlegm, chest tightness, breathlessness, activity limitation, confidence, sleep, and energy. Each item is scored 0–5 (total 0–40), with higher scores indicating greater clinical impact.^[9]

Maximal inspiratory pressure (MIP) reflects the quasi-isometric pressure generated by the inspiratory muscles against an occluded airway at residual volume and is a validated index of inspiratory muscle strength.^[5,8]

Statistical Methods

Statistical analyses were performed using IBM SPSS Statistics for Windows, version 23.0 (IBM Corp., Armonk, NY, USA). Categorical variables (age group and gender) were summarized as frequencies and percentages. Continuous variables (age, 6MWT distance, mMRC grade, CAT score, and MIP) were expressed as mean ± standard deviation (SD). Within-group pre-to post-intervention comparisons were performed using the two-tailed paired samples t-test. A p value < 0.05 was considered statistically significant.

RESULTS

Table 1: Descriptive statistics of age and gender (N = 10)

Variable	Category	Frequency (n)	Percentage (%)
Age	51–60 years	5	50.0
	61–70 years	5	50.0
Gender	Female	4	40.0
	Male	6	60.0

The study included 10 patients with moderate COPD; five (50.0%) were aged 51–60 years and five (50.0%) were aged 61–70 years. The mean age was 59.7 ± 5.3 years.

Table 2: Comparison of 6MWT, mMRC, CAT, and MIP scores at baseline and follow-up (paired samples t-test, n = 10)

Outcome measure	Time point	Mean	SD	Mean change	t value	p value
6MWT (m)	Baseline	334.8	32.9			
	Follow-up	372.2	33.0	+37.4	71.83	<0.001*
mMRC (grade)	Baseline	2.1	0.6			
	Follow-up	1.2	0.4	-0.9	9.00	<0.001*
CAT (score)	Baseline	19.9	2.2			
	Follow-up	13.5	2.7	-6.4	16.00	<0.001*
MIP (cmH ₂ O)	Baseline	59.9	7.3			
	Follow-up	73.9	7.5	+14.0	93.92	<0.001*

*Statistically significant difference at $p < 0.05$. Positive mean change indicates improvement; negative mean change indicates reduction in score. 6MWT: Six-Minute Walk Test; mMRC: modified Medical Research Council; CAT: COPD Assessment Test; MIP: maximal inspiratory pressure; SD: standard deviation.

Paired comparisons revealed statistically significant improvements in all four outcomes ($p < 0.001$). Mean 6MWT distance increased by 37.4 m, mean mMRC grade decreased by 0.9, mean CAT score decreased by 6.4 points, and mean MIP increased by 14.0 cmH₂O (Table 2).

Individual case findings

Case 1. A 56-year-old man walked 338 m at baseline and 374 m at follow-up on the 6MWT, improving but remaining below the expected exercise capacity. His mMRC grade decreased from 2 to 1, and his CAT score decreased from 18 to 12, remaining within the medium-impact range. MIP increased from 62 to 76 cmH₂O; both values remained below the approximate male reference.

Case 2. A 61-year-old man improved from 310 m to 348 m on the 6MWT, remaining below the expected capacity. His mMRC grade decreased from 2 to 1 (minimal dyspnea), and his CAT score decreased from 20 to 14, remaining in the medium-impact range. MIP increased from 55 to 69 cmH₂O, below the approximate male reference at both time points.

Case 3. A 54-year-old woman improved from 365 m to 402 m on the 6MWT, reaching the expected exercise capacity. Her mMRC grade decreased from 2 to 1, and her CAT score decreased from 17 to 11, remaining in the medium-impact range. MIP increased from 68 to 82 cmH₂O, within the approximate female reference at both time points.

Case 4. A 66-year-old man improved from 286 m to 324 m on the 6MWT, remaining below the expected capacity. His mMRC grade decreased from 3 to 2, with breathlessness persisting during walking. His CAT score decreased from 24 to 18, changing from the high-impact to the medium-impact category. MIP increased from 49 to 63 cmH₂O, below the approximate male reference at both time points.

Case 5. A 59-year-old woman improved from 352 m to 389 m on the 6MWT, remaining below the expected capacity. Her mMRC grade decreased from 2 to 1 (minimal dyspnea), and her CAT score decreased from 19 to 13, remaining in the medium-impact range. MIP increased from 61 to 75 cmH₂O, within the approximate female reference at both time points.

Case 6. A 63-year-old man improved from 320 m to 356 m on the 6MWT, remaining below the expected capacity. His mMRC grade decreased from 2 to 1, and his CAT score decreased from 21 to 15, changing from the high-impact to the medium-impact category. MIP increased from 57 to 71 cmH₂O, below the approximate male reference at both time points.

Case 7. A 51-year-old man improved from 392 m to 428 m on the 6MWT, reaching the expected exercise capacity. His mMRC grade remained 1 at both time points (minimal dyspnea). His CAT score decreased from 19 to 9, changing from the medium-impact to the low-impact category. MIP increased from 72 to 86 cmH₂O, from

below to within the approximate male reference.

Case 8. A 68-year-old woman improved from 298 m to 334 m on the 6MWT, remaining below the expected capacity. Her mMRC grade decreased from 3 to 2, with persistent breathlessness during walking. Her CAT score decreased from 23 to 17, changing from the high-impact to the medium-impact category. MIP increased from 51 to 64 cmH₂O, from below to within the approximate female reference.

Case 9. A 57-year-old man improved from 360 m to 401 m on the 6MWT, reaching the expected exercise capacity. His mMRC grade decreased from 2 to 1, and his CAT score decreased from 18 to 12, remaining in the medium-impact range. MIP increased from 65 to 80 cmH₂O, from below to within the approximate male reference.

Case 10. A 62-year-old woman improved from 327 m to 366 m on the 6MWT, remaining below the expected capacity. Her mMRC grade decreased from 2 to 1, and her CAT score decreased from 20 to 14, remaining in the medium-impact range. MIP increased from 59 to 73 cmH₂O, from slightly below to within the approximate female reference.

DISCUSSION

This case series evaluated the effect of an eight-week structured IMT program on functional capacity and perceived dyspnea in patients with moderate COPD. All ten participants showed statistically significant improvements: six-minute walking distance increased, mMRC and CAT scores declined, and MIP increased. These consistent findings suggest that targeted inspiratory loading produces meaningful muscular and clinical adaptations even during stable phases of moderate airflow obstruction.

The physiological rationale linking IMT to clinical benefit centers on counteracting respiratory pump dysfunction. In moderate COPD, expiratory airflow limitation and loss of lung recoil produce dynamic hyperinflation, which shortens diaphragmatic fibers and places them at a

mechanical disadvantage on the length-tension curve. When ventilatory demand rises during activity, the overloaded inspiratory muscles cannot meet demand, triggering increased neural respiratory drive and distressing dyspnea. The baseline profile of our participants — reduced walking distance, elevated dyspnea scores, and impaired MIP — accurately reflects these mechanisms. [1-3]

Functional exercise capacity improved uniformly. Walking distance increased from a baseline range of 286–392 m to 324–428 m after training, with a mean gain of 37.4 m. By progressively overloading the inspiratory muscles, IMT improves their strength, aerobic capacity, and fatigue resistance, reducing the neural drive required to sustain ventilation during ambulation. This mean gain exceeds the accepted minimal clinically important difference (MCID) of 30 m for the 6MWT in respiratory populations, indicating a functionally meaningful improvement in ambulatory ability. [4,6]

Exertional dyspnea decreased substantially. Nine of the ten patients improved by one mMRC grade, while the remaining patient, already at grade 1, was sustained; the mean grade fell from 2.1 to 1.2. A stronger diaphragm reduces neuromechanical uncoupling — the disparity between neural respiratory drive and ventilatory output — thereby attenuating the perception of breathing effort during daily activities. Randomized trials have reported similar reductions in perceived breathlessness after targeted inspiratory training. [7,8,10,11]

Disease-specific health status, measured by the CAT, improved by a mean of 6.4 points (from 19.9 to 13.5), well above the established MCID of 2 points, signifying a meaningful reduction in patient-perceived disease burden. Individual scores shifted from the high-impact tier into the medium- or low-impact range. Because dyspnea and activity limitation are primary determinants of health-related quality of life in COPD, their alleviation translates directly into better daily functioning. [9]

The most direct objective marker of adaptation was the increase in MIP from 59.9 to 73.9 cmH₂O (mean gain 14.0 cmH₂O). As a non-invasive index of global inspiratory muscle strength, this consistent increase confirms that the threshold-loading protocol provided an adequate stimulus for muscular and neural adaptation in the diaphragm and accessory muscles. The parallel gains in physiological (MIP) and functional (6MWT, mMRC, CAT) outcomes reinforce the internal validity of the intervention.^[5,8]

Individual responses varied with baseline status. Patients with the lowest baseline capacity and strength, such as Case 4 (baseline 6MWT 286 m, MIP 49 cmH₂O), showed prominent functional gains, whereas those with higher baseline function, such as Case 7 (6MWT 392 m, MIP 72 cmH₂O), attained values within the normative range. Although baseline physical reserve influences the absolute performance ceiling, patients across the spectrum of moderate disease appear to derive functional benefit from structured IMT.

Our findings are consistent with the broader literature. Wu et al. confirmed that threshold and resistive IMT protocols of equal intensity effectively improve clinical outcomes in stable COPD.^[7] Saka et al., using an eight-week threshold protocol set at 30% of MIP, demonstrated marked improvement in dyspnea-related outcomes, closely paralleling our intervention.^[12] In a recent meta-analysis, Han et al. reported that IMT significantly improves inspiratory strength, reduces dyspnea, and enhances quality of life, with greater adaptations when sessions are performed at moderate intensity (<60% MIP) more than three times per week — characteristics directly reflected in our five-day-per-week regimen.^[13]

Some nuance remains. Charususin et al. found that adding IMT to multidisciplinary pulmonary rehabilitation did not invariably provide incremental benefit over rehabilitation alone, particularly in participants without baseline inspiratory

weakness.^[14] Beaumont et al. similarly observed that, although inspiratory strength improved, dyspnea reduction did not exceed that achieved by comprehensive pulmonary rehabilitation in severe COPD.^[15] Importantly, the Cochrane review by Ammous et al. concluded that when IMT is delivered as an isolated standalone intervention, it consistently improves dyspnea, exercise capacity, and quality of life.^[16] In the present study, IMT was administered as a targeted standalone physiotherapeutic modality rather than as an adjunct to structured exercise classes, which likely accounts for the consistent gains observed across all participants.

Several methodological limitations should be acknowledged. The case-series design, with a sample of ten participants and no control or sham-training group, means that spontaneous variation or test-retest learning effects cannot be entirely excluded. In addition, follow-up was limited to eight weeks, leaving the persistence of these adaptations uncharacterized. Future randomized controlled trials incorporating larger cohorts, sham controls, extended follow-up, and diaphragm ultrasound or electromyographic assessment are warranted.

Within a well-defined cohort of patients with moderate COPD, this eight-week structured threshold IMT program elicited consistent, statistically significant, and clinically meaningful improvements in functional walking capacity, exertional breathlessness, health status, and inspiratory muscle strength. These findings support the clinical utility of targeted inspiratory muscle conditioning as an accessible component of outpatient respiratory physiotherapy.

CONCLUSION

Eight weeks of structured inspiratory muscle training improved functional exercise capacity and reduced dyspnea in patients with moderate COPD, with significant additional improvements in COPD-related health status and inspiratory muscle strength. These findings support

IMT as a useful component of physiotherapy management in moderate COPD. Larger randomized controlled trials with longer follow-up are needed to confirm these results.

Declaration by Authors

Ethical Approval: The study was approved by the Institutional Ethics Committee of the authors' institution.

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