INPLASY

Effects of Inspiratory Muscle Training on Respiratory Muscle Strength and Exercise Tolerance in Patients with Stable COPD: A MetaAnalysis and Systematic Review

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Lei, X; Qi, L.

Corresponding author:
Lei Xu

xulei58@126.com

Author Affiliation:
Department of General Medicine, Panzhihua Central Hospital, Sichuan Province 617067.

ADMINISTRATIVE INFORMATION

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Conflicts of interest - None declared.

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Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 8 May 2026 and was last updated on 8 May 2026.

INTRODUCTION

Review question / Objective Population (P): Adults (≥18 years) with stable chronic obstructive pulmonary disease (COPD) across GOLD stages I–IV, including post-exacerbation recovery patients.

Intervention (I): Structured inspiratory muscle training (IMT) using threshold or resistive devices (e.g., POWERbreathe, eBreather) at ≥30% maximal inspiratory pressure, performed ≥3 times/week for ≥3 weeks.

Comparator (C): Sham IMT, usual care/no intervention, pulmonary rehabilitation alone, or other non-IMT training; studies without a control group were excluded.

Outcomes (O): Primary: maximal inspiratory pressure (PImax), 6-minute walk distance (6MWD), and dyspnea (Borg/mMRC/TDI). Secondary: FEV_1.

Study Design (S): Randomized controlled trials (parallel, cross-over, or multi-center).

Objective: To systematically evaluate the effects of IMT on respiratory muscle strength, exercise tolerance, and dyspnea in patients with stable COPD, and to explore how the type of comparator influences treatment efficacy.

Condition being studied Chronic obstructive pulmonary disease (COPD) is a common, preventable, and treatable chronic respiratory disorder characterized by persistent respiratory symptoms and airflow limitation, primarily caused by chronic exposure to noxious particles or gases, such as tobacco smoke and air pollutants. COPD typically manifests with progressive dyspnea, chronic cough, sputum production, and exercise intolerance. Pathophysiologically, it involves small airway inflammation, structural remodeling, loss of alveolar elasticity, and destruction of lung parenchyma, leading to airflow obstruction, dynamic hyperinflation, and impaired gas

exchange. Even during stable phases, patients often experience fatigue, reduced exercise capacity, and impaired health-related quality of life, contributing to functional limitations and increased healthcare burden. Dyspnea and decreased respiratory muscle function, especially inspiratory muscle weakness, are central contributors to activity limitation in COPD. Managing these symptoms through non-pharmacological interventions, such as pulmonary rehabilitation and inspiratory muscle training, is essential for improving functional status, exercise tolerance, and overall well-being in patients with stable COPD.

METHODS

Participant or population The review focuses on adults aged 18 years and older diagnosed with chronic obstructive pulmonary disease (COPD) across all severity stages (GOLD I–IV), including patients in the stable phase (≥4 weeks after acute exacerbation) and those in early post-exacerbation recovery (≤2 weeks after hospital discharge). Participants may be from diverse geographic regions and healthcare settings. Individuals with comorbid conditions are included as long as COPD is the primary diagnosis. Studies excluding acute exacerbations, mechanically ventilated patients, or mixed populations where COPD-specific data cannot be extracted are not considered. The target population reflects typical clinical scenarios for evaluating the efficacy of inspiratory muscle training in stable COPD patients.

Intervention The review evaluates inspiratory muscle training (IMT) as the primary intervention. IMT involves structured exercises aimed at strengthening the inspiratory muscles using threshold or resistive devices, such as POWERbreathe or eBreather. Training protocols typically start at ≥30% of maximal inspiratory pressure (PImax or MIP), performed at least three times per week, for a minimum duration of three weeks. IMT may be delivered as a stand-alone intervention or combined with pulmonary rehabilitation or other exercise programs, but studies must report an IMT-specific arm to be eligible. Expiratory muscle training (EMT) alone or combined multi-modal respiratory interventions without a clear IMT component are excluded.

Comparator The review considers studies comparing inspiratory muscle training (IMT) with any of the following control conditions: sham or placebo IMT, usual care or health education, pulmonary rehabilitation (PR) alone, or other non-IMT exercise interventions such as endurance training. Studies without a control group, cross-sectional or mechanistic observational designs, or interventions not clearly distinguishable from IMT are excluded. Comparator type is also analyzed as a potential moderator of treatment efficacy, recognizing that IMT's incremental benefits may differ depending on the control condition.

Study designs to be included This review will include randomized controlled trials (RCTs)—parallel, cross-over, or multi-center designs—that evaluate inspiratory muscle training in adults with stable COPD. Non-randomized studies, observational studies, case reports, and reviews will be excluded, though non-RCTs may be used for narrative discussion only.

Eligibility criteria Inclusion: Studies must be randomized controlled trials involving adults (≥18 years) with stable COPD or early post-exacerbation recovery, using a structured inspiratory muscle training (IMT) protocol with ≥30% PImax, ≥3 sessions per week, and ≥3 weeks duration. IMT may be stand-alone or clearly reported as a specific arm in combination with other interventions.
Exclusion: Studies involving acute exacerbations, hospitalized/ICU or mechanically ventilated patients, non-COPD or mixed disease populations where COPD data cannot be extracted, interventions not involving structured respiratory muscle training, non-randomized designs, reviews, case reports, animal studies, or studies with insufficient data are excluded.

Information sources We will systematically search multiple electronic databases from inception to March 1, 2026, including PubMed, Embase, Cochrane Library, Web of Science, and Scopus. Additionally, clinical trial registries such as ClinicalTrials.gov and the WHO International Clinical Trials Registry Platform (ICTRP) will be screened to identify ongoing or unpublished trials. Reference lists of included studies and relevant systematic reviews will be manually checked for additional eligible articles. When necessary, corresponding authors will be contacted to obtain missing data or clarify study details. Grey literature sources, such as conference proceedings and dissertations, will also be considered to minimize publication bias.

Main outcome(s) The primary outcomes of this review are:

Maximal inspiratory pressure (PImax or MIP, cmH_2O): a measure of inspiratory muscle strength, assessed at the end of the intervention period.
Exercise tolerance (6-minute walk distance, 6MWD, meters): assessed at intervention completion, reflecting functional exercise capacity.
Dyspnea: measured using validated scales such as the Borg scale, mMRC, or TDI, evaluated at the end of the intervention.

Secondary outcomes include lung function (FEV_1, liters or % predicted). Where multiple time points are reported, the assessment immediately post-intervention will be prioritized. Effect measures include mean differences (MD) or standardized mean differences (SMD) with 95% confidence intervals to quantify treatment impact.

Quality assessment / Risk of bias analysis The methodological quality of included randomized controlled trials will be evaluated using the Cochrane Risk of Bias tool 2.0 (RoB 2.0). This tool assesses five domains: (1) bias arising from the randomization process, (2) bias due to deviations from intended interventions, (3) bias due to missing outcome data, (4) bias in measurement of the outcome, and (5) bias in selection of the reported result. Each domain will be rated as "low risk," "some concerns," or "high risk", and an overall risk-of-bias judgment will be assigned for each study. Two reviewers will independently perform the assessment, with disagreements resolved through discussion or consultation with a third reviewer. Outcome-specific judgments will be reported to allow nuanced interpretation, particularly for subjective measures such as dyspnea. Sensitivity analyses will consider study quality to evaluate the robustness of pooled effect estimates.

Strategy of data synthesis Continuous outcomes will be analyzed using mean differences (MD) when the same scale is applied across studies, or standardized mean differences (SMD) when different scales measure the same construct, each with 95% confidence intervals. Both change scores and post-intervention endpoint values will be considered, with preference given to change scores. A random-effects model will be used for meta-analysis to account for clinical and methodological heterogeneity; fixed-effect models will be reported when heterogeneity is low. Heterogeneity will be quantified using the I^2 statistic and Cochran Q test. Subgroup analyses will explore differences by comparator type, intervention strategy, training duration, and supervision method. Meta-regression may be performed to identify sources of heterogeneity. Sensitivity analyses (e.g., leave-one-out) will assess robustness of findings. Publication bias will be examined using funnel plots and statistical tests where feasible. When meta-analysis is not appropriate, narrative synthesis will summarize outcomes systematically. Effect sizes will be interpreted in the context of clinical relevance, e.g., minimal clinically important differences for 6MWD and dyspnea scales.

Subgroup analysis Planned subgroup analyses will be conducted to explore potential sources of heterogeneity and to determine how the effects of inspiratory muscle training (IMT) vary across different contexts. Subgroups will include:

Comparator type: sham IMT, usual care/no intervention, or pulmonary rehabilitation alone.
Intervention strategy: IMT alone versus IMT combined with pulmonary rehabilitation or exercise training.
Training duration: 12 weeks.
Supervision method: fully supervised versus unsupervised/home-based programs.

These analyses will help clarify whether the incremental benefits of IMT are influenced by control conditions, intervention intensity, or delivery methods. Meta-regression may also be applied to quantify the contribution of comparator type or other study-level variables to between-study heterogeneity. Subgroup results will guide interpretation of pooled effect estimates and inform individualized clinical recommendations for stable COPD patients.

Sensitivity analysis Sensitivity analyses will be performed to assess the robustness of the meta-analysis findings. This will include leave-one-out analyses, where each study is sequentially removed to evaluate its impact on pooled effect estimates. Analyses will also consider study quality by excluding trials rated as high risk of bias or with "some concerns" in key domains. The effects of using change scores versus post-intervention values will be examined to ensure methodological consistency. Additionally, the influence of outlier studies, small sample sizes, or extreme effect estimates will be explored. These analyses will help determine whether the main conclusions are stable across different assumptions, data-handling methods, and study characteristics, providing confidence in the reliability and interpretability of the results for inspiratory muscle training in stable COPD patients.

Country(ies) involved China - Department of General Medicine, Panzhihua Central Hospital, Sichuan Province 617067.

Other relevant information Studies and authors are from China, France, Taiwan, Canada, Belgium, Germany, Brazil, Turkey, Tunisia, Czech Republic, and Egypt.

Keywords Chronic obstructive pulmonary disease; COPD; inspiratory muscle training; IMT; respiratory muscle strength; exercise tolerance; dyspnea; 6MWD.

Contributions of each author
Author 1 - Lei Xu.
Author 2 - Qi Liao.