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Effect of preoperative inspiratory muscle training on pulmonary complications after cardiothoracic surgery: a systematic review and meta-analysis

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Author Affiliation:The First Affiliated Hospital of
Guangxi Medical University.**ADMINISTRATIVE INFORMATION****Support** - No support.**Review Stage at time of this submission** - Completed but not published.**Conflicts of interest** - None declared.**INPLASY registration number:** INPLASY202680028**Amendments** - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 5 August 2026 and was last updated on 5 August 2026.**INTRODUCTION**

Review question / Objective To systematically evaluate the efficacy and safety of preoperative inspiratory muscle training (IMT) in patients undergoing cardiothoracic surgery regarding PPC incidence, duration of postoperative hospitalization, and postoperative MIP.

Rationale Cardiothoracic surgery carries a high incidence of postoperative pulmonary complications (PPC), exceeding 50% and leading to increased morbidity, prolonged hospitalization, and elevated mortality. Preoperative inspiratory muscle training (IMT) has emerged as a targeted prehabilitation intervention to improve respiratory muscle strength (maximal inspiratory pressure [MIP]) and functional recovery. Although individual trials have evaluated IMT, comprehensive meta-analytic synthesis incorporating recent trials (2016–2025) and detailed subgroup analyses across surgical types, loading intensities, and training durations remains necessary.

Condition being studied Postoperative pulmonary complications (PPC), length of postoperative hospital stay, and postoperative maximal inspiratory pressure (MIP) in patients undergoing cardiothoracic surgery.

METHODS**Search strategy** PubMed:

("Preoperative Exercise"[MeSH Terms] OR "Prehabilitation"[MeSH Terms] OR "Preoperative Rehabilitation" OR "Prehabilitation" OR "Pre-exercise" OR "Pre-surgical Rehabilitation" OR "Pre-surgical Exercise" OR "Preoperative Training" OR "Prehabilitation Program") AND ("Breathing Exercises"[MeSH Terms] OR "Respiratory Muscle Training" OR "Breathing Training" OR "Respiratory Muscle Exercise" OR "IMT")

Embase:

#1 'preoperative exercise'/exp OR 'prehabilitation'/exp OR 'preoperative rehabilitation':ti,ab OR prehabilitat*:ti,ab OR 'pre-exercise':ti,ab OR 'pre-

surgical rehabilitation':ti,ab OR 'pre-surgical exercise':ti,ab OR 'preoperative training':ti,ab OR 'prehabilitation program':ti,ab
 #2 'breathing exercise'/exp OR 'respiratory muscle training'/exp OR 'breathing training':ti,ab OR 'respiratory muscle exercise':ti,ab OR 'IMT':ti,ab
 #3 #1 AND #2

Web of Science:

TS=("Preoperative Exercise" OR "Prehabilitation" OR "Preoperative Rehabilitation" OR "Prehabilitation OR "Pre-exercise" OR "Pre-surgical Rehabilitation" OR "Pre-surgical Exercise" OR "Preoperative Training" OR "Prehabilitation Program") AND TS=("Breathing Exercises" OR "Respiratory Muscle Training" OR "Breathing Training" OR "Respiratory Muscle Exercise" OR "IMT").

Participant or population Adult patients (aged ≥ 18 years, predominantly ≥ 50 years) scheduled to undergo elective cardiothoracic surgery, including cardiac surgery (e.g., coronary artery bypass grafting, valve surgery), pulmonary resection for lung cancer, or esophagectomy.

Intervention Preoperative inspiratory muscle training (IMT) administered as standalone respiratory muscle exercise or integrated into multimodal prehabilitation (e.g., combined with aerobic endurance training, limb resistance training, or comprehensive pulmonary rehabilitation). Training devices include threshold loading, tapered flow resistance, or simple breathing devices.

Comparator Standard preoperative care, conventional usual care, chest physical therapy, or incentive spirometry without preoperative inspiratory muscle training.

Study designs to be included Original randomized controlled trials (RCTs) and prospective controlled clinical trials evaluating preoperative inspiratory muscle training (IMT) in adult patients undergoing cardiothoracic surgery. Reviews, systematic reviews, meta-analyses, case reports, editorials, conference abstracts, non-original studies, and non-controlled studies were excluded.

Eligibility criteria Inclusion Criteria: Original research articles (randomized controlled trials and prospective clinical trials) evaluating preoperative IMT in cardiothoracic surgery; reporting at least one outcome of interest (PPC incidence, hospital stay, or MIP); providing sufficient quantitative data

for calculating effect sizes (RR or WMD with 95% CIs).

Exclusion Criteria: Review articles, systematic reviews, case reports, conference abstracts, non-original studies, non-cardiothoracic surgery studies, or studies with insufficient reporting/duplicate cohorts.

Information sources PubMed, Embase, and Web of Science (WOS) databases searched from January 1, 2005 to January 24, 2025, supplemented by citation tracking of relevant references.

Main outcome(s) 1. Incidence of postoperative pulmonary complications (PPC), such as pneumothorax, pleural effusion, atelectasis, and pneumonia.
 2. Duration of postoperative hospitalization (length of hospital stay, in days).

Additional outcome(s) Postoperative maximal inspiratory pressure (MIP, measured in cmH₂O to evaluate respiratory muscle strength).

Quality assessment / Risk of bias analysis Methodological quality and risk of bias of included studies were independently assessed using the Cochrane Risk of Bias Tool across domains including random sequence generation, allocation concealment, performance bias, detection bias, attrition bias, and selective reporting.

Strategy of data synthesis Statistical analyses were conducted using STATA 17.0. Relative risks (RRs) with 95% CIs were calculated for dichotomous outcomes (PPC incidence). Weighted mean differences (WMDs) with 95% CIs were synthesized for continuous outcomes (hospital stay and MIP). Heterogeneity was assessed using the I^2 statistic and Q test. A fixed-effects model was used when $I^2 \leq 0.10$; otherwise, a DerSimonian-Laird random-effects model was applied ($I^2 \geq 50\%$ or $P \leq 0.10$).

Subgroup analysis Subgroup analyses were conducted based on:

1. Geographical region (Europe, Asia, South America);
2. Type of surgery (cardiac, pulmonary, esophageal surgery);
3. Intervention modality (IMT alone, IMT + aerobic endurance, IMT + limb endurance, IMT + pulmonary rehabilitation, IMT + sports training);
4. Training duration (≤ 1 week, 2–4 weeks, ≥ 4 weeks).

Sensitivity analysis Leave-one-out sensitivity analyses were performed by sequentially omitting individual studies to evaluate the stability of overall effect estimates.

Language restriction English.

Country(ies) involved China.

Keywords inspiratory muscle training; cardiothoracic surgery; postoperative pulmonary complications; meta-analysis; prehabilitation.

Contributions of each author

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