International Platform of Registered Systematic Review and Meta-analysis Protocols

INPLASY

INPLASY202610061

doi: 10.37766/inplasy2026.1.0061

Received: 18 January 2026

Published: 18 January 2026

Effects of Eccentric versus Concentric Cycling Training on Quadriceps Strength, Cardiopulmonary Exercise Testing, and Functional Performance in Cardiopulmonary Populations: A Systematic Review and Meta-analysis of Randomized Controlled Trials

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ADMINISTRATIVE INFORMATION

Support - None.

Review Stage at time of this submission - Data extraction.

Conflicts of interest - None declared.

INPLASY registration number: INPLASY202610061

Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 18 January 2026 and was last updated on 18 January 2026.

INTRODUCTION

Review question / Objective To compare the effects of eccentric versus concentric cycling training on quadriceps muscle strength, cardiopulmonary exercise testing outcomes, and functional performance in individuals with cardiopulmonary diseases, and to examine whether eccentric cycling training offers additional advantages over concentric cycling training.

Rationale Cardiopulmonary diseases represent a major global health burden, and exercise training is a core component of conservative management. Traditional concentric cycling training may impose substantial cardiovascular and ventilatory demands, limiting its feasibility in individuals with impaired cardiopulmonary function. In contrast, eccentric cycling training provides high mechanical loading with lower metabolic stress. However, whether it confers greater benefits than concentric cycling training remains unclear. Therefore, this systematic review and meta-analysis compared the effects of eccentric and concentric cycling training on cardiopulmonary exercise testing outcomes, muscle strength, and functional performance in individuals with cardiopulmonary diseases.

Condition being studied The population, intervention, comparison, and outcome framework of this meta-analysis was defined as follows: the population comprised individuals with cardiopulmonary diseases; the intervention was eccentric cycling training; the comparison consisted of control conditions that included concentric cycling training but did not involve eccentric cycling training; and the outcomes were changes in quadriceps muscle strength, cardiopulmonary exercise capacity, and functional performance. The population, intervention, comparison, and outcome framework of this meta-analysis was defined as follows: the population consisted of individuals with cardiopulmonary diseases; the intervention was eccentric cycling training; the comparison involved control conditions that included concentric cycling training

and did not include eccentric cycling training; and the outcomes were changes in quadriceps muscle strength, cardiopulmonary exercise capacity, and functional performance.

METHODS

Search strategy Two authors independently conducted electronic searches in PubMed, MEDLINE via Ovid, and Scopus using combinations of the following keywords: ("eccentric cycling" OR "eccentric ergometer bike" OR "eccentric cycle pedaling") AND ("chronic obstructive pulmonary disease" OR "respiratory disease" OR "lung diseases" OR "cardiovascular diseases" OR "coronary artery disease" OR "ischemic heart disease" OR "heart failure"). Searches covered all records from database inception through January2026.

Participant or population Cardiopulmonary diseases.

Intervention Eccentric cycling training.

Comparator Concentric cycling training.

Study designs to be included Randomized controlled trials.

Eligibility criteria (1) randomized controlled trials; (2) adult participants diagnosed with cardiopulmonary diseases; (3) intervention groups that incorporated eccentric cycling training, either as a standalone intervention or in combination with other therapeutic approaches; and (4) the inclusion of at least one comparison group that did not receive eccentric cycling training, such as concentric cycling training.

Information sources Two reviewers (L.-H.L. and K.-W.K.) conducted screenings across multiple databases, including PubMed, Medline-Ovid, and Scopus. The search employed the following keywords: ("eccentric cycling" OR "eccentric ergometer bike" OR "eccentric cycle pedaling") AND ("chronic obstructive pulmonary disease" OR "respiratory disease" OR "lung diseases" OR "cardiovascular diseases" OR "coronary artery disease" OR "ischemic heart disease" OR "heart failure").

Main outcome(s) The primary outcome was quadriceps muscle strength, evaluated by maximal isometric voluntary contraction. Strength was measured using validated instruments, including isokinetic dynamometers operated in isometric mode or strain-gauge-based systems during isometric knee extension testing.

Additional outcome(s) Cardiopulmonary exercise testing outcomes, including maximal oxygen uptake and peak power output, were analyzed as secondary outcomes, while functional performance was measured using the six-minute walking test.

Data management Data were independently extracted by two reviewers, including participant characteristics, study design, intervention and comparison protocols, and outcome measures. Particular care was taken to verify the directionality of outcome scales in each study to prevent misinterpretation of effect estimates.

Quality assessment / Risk of bias analysis The risk of bias of the included randomized controlled trials was assessed using the Risk of Bias 2 tool, which evaluates bias related to randomization, deviations from intended interventions, missing outcome data, outcome measurement, and selective reporting.

Strategy of data synthesis Because of heterogeneity in intervention protocols across studies, data were pooled using a random-effects model implemented in Comprehensive Meta-Analysis software (version 4; Biostat, Englewood, NJ, USA). Statistical significance was defined as a two-sided p value below 0.05. Standardized mean differences were estimated using Hedges' g and interpreted as small (0.2), moderate (0.5), or large (0.8). Statistical heterogeneity was evaluated with Cochran's Q test and the I^2 statistic, with I^2 values of approximately 25%, 50%, and 75% indicating low, moderate, and high heterogeneity, respectively.

Subgroup analysis Subgroup analyses were conducted according to types of population, including individuals with heart disease and pulmonary disease.

Sensitivity analysis The robustness of the pooled results was examined through leave-one-out sensitivity analyses, in which each study was sequentially excluded to evaluate its influence on the overall effect estimates.

Language restriction No language limit.

Country(ies) involved Taiwan (ROC).

Keywords Pulmonary Disease, Chronic Obstructive, Pulmonary Heart Disease, Eccentric Cycling.

Contributions of each author

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