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Original Article

Physiotherapy Section

Effectiveness of Leg Cycle Ergometry Exercise on Functional Capacity, Muscle Strength and Quality of Life in Post-CABG Patients: A Systematic Review

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ABSTRACT

Introduction: Coronary Artery Bypass Grafting (CABG) is performed to restore myocardial perfusion and reduce morbidity in patients with coronary artery disease. Postoperative patients commonly experience reduced functional capacity, respiratory muscle weakness and limited exercise tolerance, necessitating structured rehabilitation. Leg cycle ergometry has gained increasing interest as an early rehabilitation.

Aim: To systematically review Randomised Controlled Trials (RCT) evaluating the effectiveness of leg cycle ergometry in postoperative rehabilitation following CABG surgery. This systematic review was registered in PROSPERO. The review was structured according to the PICOTS framework: Population - adult CABG patients; Intervention - leg cycle ergometry; Comparator - standard physiotherapy, walking, or resistance training; Outcomes - functional capacity, muscle strength, pulmonary function and quality of life; Timing - immediate postoperative period; Study design - RCTs.

Materials and Methods: The present review was conducted in the Department of Cardiovascular and Respiratory Physiotherapy, Ravi Nair Physiotherapy College, Datta Meghe Institute of Higher Education and Research, Sawangi, Wardha, Maharashtra, India followed Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines and was registered in International Prospective Register of Systematic Reviews (PROSPERO). A comprehensive search was conducted in PubMed, Scopus and Nested Knowledge (2015-2025). Eligible studies were RCTs involving adult patients undergoing CABG who were also undergoing postoperative leg cycle ergometry. Data extraction followed a standardised format and the Cochrane RoB-2 tool was used to assess risk of bias. The review followed the Population, Intervention, Comparison, Outcome and Time (PICOTS) framework. The search strategy included combinations of keywords using Boolean operators ("CABG", "coronary artery bypass", "leg cycle ergometry", "aerobic training", "early mobilisation") across PubMed, Scopus and Nested Knowledge. Only RCTs involving adult CABG patients who received leg cycle ergometry were included. Studies involving other cardiac surgeries or non randomised designs were excluded.

Results: From 223 records, five RCTs met the inclusion criteria. Overall, the included RCTs demonstrated consistent improvements across major postoperative outcomes. Leg cycle ergometry performed for 1-3 weeks resulted in significantly greater gains in functional capacity and lower-limb strength compared with standard physiotherapy alone. Respiratory muscle strength was better preserved in studies measuring Maximal Inspiratory Pressure (MIP) and Maximal Expiratory Pressure (MEP), and additional benefits were noted in psychological outcomes {Patient Health Questionnaire-9 (PHQ-9), Generalised Anxiety Disorder 7 (GAD-7)}, sleep quality {Pittsburgh Sleep Quality Index (PSQI)} and overall quality of life {36-Item Short Form Survey (SF-36)}. However, heterogeneity in intervention duration, exercise intensity and outcome tools limited direct comparison of effect sizes. Three studies were rated as low-risk of bias, while two presented some concerns.

Conclusion: Leg cycle ergometry is an effective and safe adjunct in early post-CABG rehabilitation. Further standardised RCTs are warranted to strengthen evidence for widespread clinical implementation.

Keywords: Aerobic exercise, Cardiac rehabilitation, Coronary artery disease

INTRODUCTION

The CABG remains a standard surgical strategy for treating multivessel coronary artery disease. While saphenous vein grafts continue to be frequently used, arterial conduits such as the radial artery and internal thoracic artery demonstrate superior long-term patency and outcomes [1]. Despite improvements in surgical techniques, post-CABG patients commonly experience pain, reduced respiratory muscle strength, impaired pulmonary function and reduced exercise tolerance during the early recovery period [2]. These postoperative limitations highlight the need for structured rehabilitation strategies to improve recovery.

Early mobilisation within the Intensive Care Unit (ICU) is feasible and safe, supporting quicker functional recovery and reducing the risks associated with immobility [3]. Incorporating passive and active lower-limb activity in critically ill patients contributes to preserved muscle strength and improved physiological stability during early postoperative care [4]. Cardiac Rehabilitation (CR) is an individualised, multidisciplinary intervention designed to restore functional capacity and promote physical and psychological recovery after cardiac surgery [5]. Protocol-guided rehabilitation during Phase I hospitalisation has demonstrated benefits in promoting early ambulation and functional progress [6]. Exercise-based CR also improves haemodynamic responses and supports safer early postoperative recovery [7]. Participation in supervised CR following CABG is associated with enhanced functional capacity and better long-term health outcomes [8].

Lower-limb muscle strength is known to influence exercise tolerance and early postoperative functional recovery in cardiac patients [9]. However, CABG patients who undergo saphenous vein graft harvesting frequently experience donor-site discomfort, swelling

and early mobility limitations, which may hinder effective lower-limb rehabilitation [10]. In this context, leg cycle ergometry has gained interest as a feasible, low-impact intervention that promotes venous return, enhances peripheral circulation and supports early mobilisation after cardiac surgery [11]. The feasibility of cycle ergometer use in the immediate postoperative cardiac surgery period has also been demonstrated in pilot studies, supporting its early clinical applicability [12-14]. Passive and active cycling exercises have demonstrated improvements in quadriceps muscle strength, functional capacity and self-perceived physical performance in critically ill and postoperative patients [4]. Early use of a cycle ergometer after cardiac surgery has also shown improvements in mobility and functional capacity [12]. Additionally, structured cycle-ergometer training has been reported to positively influence cardiopulmonary function in elderly patients recovering from CABG [13].

Despite multiple trials evaluating leg cycle ergometry in post-CABG rehabilitation, the evidence remains fragmented due to variations in patient characteristics, intervention duration and outcome measures. Notably, no systematic review has exclusively synthesised RCTs examining the effects of leg cycle ergometry in adult CABG populations. Therefore, the present review systematically summarises current evidence from RCTs to clarify the impact of leg cycle ergometry on functional capacity, muscle strength, pulmonary function and quality of life following CABG, addressing an important gap in the literature.

MATERIALS AND METHODS

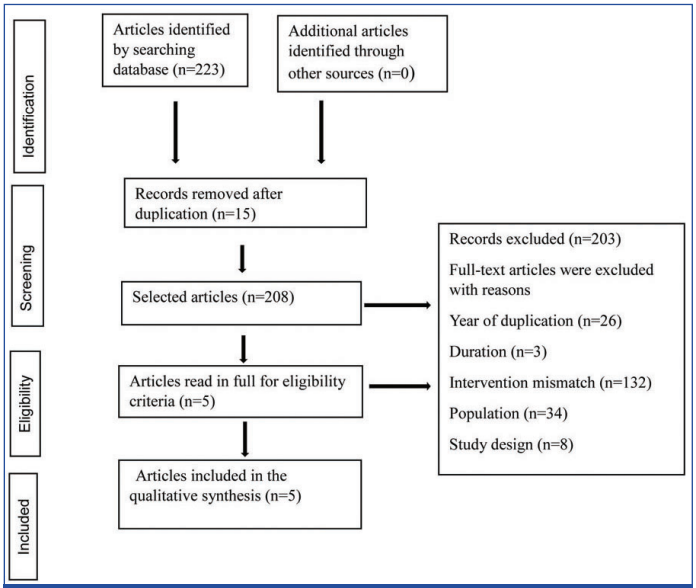
The present systematic review adhered to PRISMA guidelines and was prospectively registered in PROSPERO (CRD420251180594). Eligibility criteria were defined using the PICOTS framework. The population included adults who underwent isolated CABG surgery. The intervention of interest was postoperative leg cycle ergometry delivered during early CR. Eligible comparators included standard physiotherapy, walking programs, resistance training, or CR protocols that did not include leg cycle ergometry. The outcomes assessed across studies included functional capacity {Six-Minute Walk Test (6MWT), Functional Independence Measure (FIM)}, pulmonary function {vital capacity, peak expiratory flow, Maximal Inspiratory Pressure (MIP), Maximal Expiratory Pressure (MEP)}, lower-limb muscle strength, psychological parameters, sleep quality and overall quality of life. Studies conducted in the early postoperative period and published in English were included. Only RCTs were considered.

A systematic search was conducted in PubMed, Scopus and Nested Knowledge using Boolean combinations of the following terms: “early ambulation,” “aerobic training,” “early mobilisation,” “CABG,” “leg cycle ergometry,” and “leg ergometry.” Search limits included 2015-2025 and English-language RCTs. The database-wise search strings and article retrieval numbers are summarised in the [Table/Fig-1].

Database	Search string used	Boolean operators	Years covered	Hits retrieved
PubMed	(“Early Ambulation” OR “Ambulation” OR “Aerobic Training” OR “Early Mobilisation”) AND (“Coronary Artery Bypass” OR “CABG”) AND (“Leg Cycle Ergometry” OR “Leg Ergometry”)	AND, OR	2015-2025	85
Scopus	(“Early Mobilisation” OR “Aerobic Training”) AND (“CABG”) AND (“Leg Cycle Ergometry”)	AND, OR	2015-2025	98
Nested knowledge	(“Coronary Artery Bypass”) AND (“Cycling” OR “Ergometry”)	AND, OR	2015-2025	40
Manual reference search	Screening of reference lists of included RCTs	–	2015-2025	0

[Table/Fig-1]: Database-wise search strategy.

All titles and abstracts identified through the search were screened independently by two reviewers, followed by full-text assessment of potentially eligible studies. The study selection process is illustrated in the PRISMA flow diagram [Table/Fig-2]. Studies were excluded if patients underwent CABG combined with other cardiac surgeries or if they had major complications such as arrhythmias, myocardial infarction, or neuromuscular disorders.



[Table/Fig-2]: PRISMA flow diagram.

Data extraction was performed using a standardised template to record study characteristics, participant demographics, intervention protocols, comparator details, outcome measures and key findings.

Due to heterogeneity in intervention duration, intensity, outcome tools and rehabilitation settings across studies, a qualitative synthesis approach was adopted rather than a meta-analysis.

The risk of bias for each study was independently assessed using the Cochrane Risk of Bias 2 (RoB-2) tool across its five domains. The domain-wise and overall judgements for each included study are presented in [Table/Fig-4], Risk of Bias (RoB) assessment.

RESULTS

Study selection: A total of 223 records were identified from all databases. After removing 15 duplicates, 208 records were screened. Following title and abstract screening, 203 studies were excluded. Five RCTs met the eligibility criteria and were included in the qualitative synthesis. The PRISMA flow diagram summarising this process is presented in [Table/Fig-2].

Study characteristics: The studies were published between 2015 and 2024 and involved sample sizes ranging from 54 to 173. Intervention duration varied from Phase I (1 week) to Phase II (3 weeks) CR. All studies compared leg cycle ergometry with either standard physiotherapy, walking, or resistance training. The key characteristics of the five included RCTs are summarised in [Table/Fig-3].

Risk of Bias Assessment

Risk of bias was evaluated using the Cochrane RoB-2 tool across five domains. In Domain 1 (randomisation process), four studies adequately described random sequence generation and allocation concealment. They were therefore judged as low risk, while one study had insufficient detail, resulting in “some concerns.” Domain 2 (deviations from intended interventions) showed “some concerns” in two studies due to the inherent difficulty of blinding participants and therapists in exercise-based trials, which may introduce performance bias. Domain 3 (missing outcome data) was generally judged as low-risk, as most studies reported complete follow-up or provided reasons for attrition. Domain 4 (measurement of the

S. No.	Author/ Year	Country	Study design	Sample size	Population	Intervention (Duration/Intensity)	Comparator	Outcomes	Key findings
1.	Ma H et al., [15] 2024	China	RCT	80	Adult post-CABG patients	Early rehabilitation with leg cycle ergometry (2 weeks)	Progressive lower limb strengthening exercises	Lower limb function, PHQ-9, GAD-7, PSQI (sleep)	Improved lower limb function, shortened hospital stay, better psychological well-being and sleep quality
2.	Cordeiro R et al., [13] 2024	Brazil	RCT	122	Elderly post-CABG patients	Cardiac Rehabilitation (CR) with leg cycle ergometry (1 week)	Standard CR	Vital capacity, PEF, MIP, MEP, 6MWT	Reduced pulmonary function loss; improved muscle strength and functional capacity
3.	Skomudek A et al., [16] 2019	Poland	RCT	61	Post-CABG patients	Standard CR protocol with leg cycle (3 weeks)	Resistance training	BMI, dynamometer (muscle strength), FIM, SF-36	3-week intensive CR is most effective in restoring lower limb function compared to resistance training
4.	Hamid MF et al., 2022 [10]	Pakistan	RCT	54	Post-CABG patients (Phase 1 CR)	Phase 1 CR with paddling (1 week)	Phase 1 CR without paddling	FIM, SF-36, ABG, ejection fraction	Similar ABG and EF; improved quality of life with paddling
5.	Busch JC et al., 2017 [5]	Germany	RCT	173	Post-CABG patients	Aerobic exercise (walking+ergometry) (3 weeks)	Walking-only group	6MWT, cardiopulmonary strength, max isometric strength, QoL	Aerobic exercise significantly improved functional capacity and QoL

[Table/Fig-3]: Study characteristics of the included Randomised Controlled Trials (RCT) [5,10,13,15,16].
RCT: Randomised controlled trial; CABG: Coronary artery bypass grafting; PHQ-9: Patient health questionnaire-9; GAD-7: Generalised anxiety disorder-7; PSQI: Pittsburgh sleep quality index; PEF: Peak expiratory flow; MIP: Maximal inspiratory pressure; MEP: Maximal expiratory pressure; 6MWT: Six-minute walk test; BMI: Body mass index; FIM: Functional independence measure; SF-36: Short form (36) health survey; ABG: Arterial blood gas; EF: Ejection fraction; QoL: Quality of life

outcome) was considered low risk in all trials because validated and standardised instruments (e.g., 6MWT, MIP, MEP, SF-36) were used. Domain 5 (selection of reported results) identified concerns in one study where not all pre-specified outcomes were numerically reported. Overall, three studies were judged as having low-risk of bias and two were rated as presenting "some concerns," indicating acceptable methodological quality across trials. Risk of bias was evaluated using the Cochrane RoB-2 tool across five domains and it is mentioned in [Table/Fig-4].

[Table/Fig-4]: Risk of bias assessment.

Qualitative Synthesis

Due to methodological heterogeneity across intervention protocols and outcome measures, a qualitative synthesis was undertaken. All five RCTs demonstrated positive effects of leg cycle ergometry on functional recovery following CABG. Differences in rehabilitation setting (Phase I vs Phase II), ergometry duration (1-3 weeks) and outcome instruments justified narrative synthesis over meta-analysis.

Outcome-wise Result

Leg cycle ergometry demonstrated consistent benefits across functional, respiratory, muscular and psychosocial domains in post-CABG patients [Table/Fig-3]. Improvements in functional capacity, assessed using the 6MWT and FIM, were reported in four RCTs, with significantly greater gains observed in the leg cycle ergometry groups compared with standard rehabilitation or walking-based protocols [10,12,13]. Two studies reported attenuation of the expected postoperative decline in pulmonary function, particularly in MIP and MEP, indicating better preservation of respiratory muscle strength following ergometry-based training [11,13]. Enhanced lower-limb muscle strength, especially quadriceps performance and lower-limb endurance, was consistently demonstrated using dynamometry and isometric testing in patients receiving leg cycle ergometry [17]. Additionally, three trials reported significant improvements in quality of life and psychological outcomes, including SF-36 physical functioning and vitality domains, along with reductions in depressive symptoms (PHQ-9), anxiety levels (GAD-7) and improved sleep quality (PSQI), highlighting the multidimensional benefits of ergometry-based rehabilitation after CABG [10,13].

DISCUSSION

The present systematic review synthesised evidence from RCTs evaluating leg cycle ergometry as an adjunct to postoperative rehabilitation following CABG. Rather than reiterating outcome measures, the present discussion interprets the findings in relation to existing literature and explains how results from different included studies collectively support the clinical utility of leg cycle ergometry.

Improvements in functional capacity observed across the included trials are clinically relevant, as exercise intolerance remains a major barrier to early recovery after CABG [2]. In Phase I rehabilitation, Hamid MF et al., demonstrated that the addition of lower-limb paddling led to superior functional independence and quality-of-life outcomes compared with conventional rehabilitation alone, highlighting the benefit of early, structured lower-limb activation [10]. In contrast, Hirschhorn AD et al., showed that the mode of exercise itself influences functional recovery, supporting cycling-based interventions as an effective alternative to walking-based programs during early postoperative rehabilitation [12]. Together, these findings suggest that leg cycle ergometry provides a feasible method to enhance early mobility when traditional ambulation may be limited.

From a mechanistic perspective, targeting lower-limb muscle strength is essential in post-CABG rehabilitation, as peripheral muscle weakness limits exercise tolerance even after successful myocardial revascularisation [9]. The repetitive and cyclic nature of leg cycle ergometry enables early neuromuscular activation without

excessive joint loading, making it particularly suitable for patients recovering from saphenous vein graft harvesting [10]. Supporting this rationale, Busch JC et al., reported that structured aerobic and resistance-based rehabilitation programs yield superior functional outcomes compared with less intensive approaches, reinforcing the importance of adequate training stimulus during recovery [5].

Preservation of pulmonary function represents another important finding of the present review. Lordello GGG et al., reported that early implementation of cycle ergometry following cardiac surgery attenuated postoperative pulmonary function decline and improved respiratory mechanics [11]. These findings align with evidence indicating that early mobilisation and aerobic activity enhance ventilatory efficiency and reduce postoperative respiratory complications [18]. Vieira PJ et al., further demonstrated that cycle ergometer–based training improves ventilatory efficiency, providing physiological support for incorporating ergometry into post-CABG rehabilitation protocols [19].

Beyond physical recovery, several included studies highlighted the impact of leg cycle ergometry on psychological health and quality of life. Cordeiro R et al., observed significant improvements in health-related quality of life and cardiopulmonary function among elderly CABG patients undergoing cycloergometry training, suggesting that aerobic exercise contributes to both physical and emotional recovery [13]. These findings are consistent with previous CR literature, indicating that structured exercise programs improve psychological well-being by enhancing autonomy, reducing fear of movement and increasing patient engagement during recovery [8]. Additionally, improved physical function has been shown to positively influence perceived quality of life in older populations, further supporting the holistic benefits of ergometry-based rehabilitation [20].

The review is strengthened by adherence to PRISMA guidelines, prospective PROSPERO registration and inclusion of RCTs only. By specifically focusing on leg cycle ergometry, the present review contributes targeted evidence to the CR literature and supports its early integration into postoperative care following CABG.

Limitation(s)

The number of eligible RCTs was limited and heterogeneity existed in rehabilitation phase, intervention duration, exercise intensity and outcome measures. These factors precluded quantitative meta-analysis and necessitated a qualitative synthesis approach. Furthermore, most studies were conducted in single-centre settings with modest sample sizes, which may limit generalisability. Restriction to English-language publications may also have introduced selection bias.

CONCLUSION(S)

Leg cycle ergometry appears to be a safe and effective adjunct to postoperative rehabilitation in patients undergoing CABG surgery. Evidence from RCTs demonstrates consistent improvements in functional capacity, lower-limb muscle strength, pulmonary function preservation, psychological well-being and overall quality of life when leg cycle ergometry is incorporated into early CR programs.

However, variability in intervention duration and intensity, small sample sizes and limited follow-up periods restrict the generalisability of current evidence. Future research should focus on standardised ergometry protocols, longer-term outcome assessment and adequately powered multicentre randomised trials to strengthen the evidence base and support broader clinical integration of leg cycle ergometry in post-CABG CR.

Authors' contribution: DV: Conceptualisation, literature search, data extraction, analysis, manuscript writing, revision and final approval of the manuscript; VW: Quality assessment using RoB-2, critical review of the manuscript, editing and approval of the final version.

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