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IMPACT OF PREHABILITATION ON CARDIAC SURGERY OUTCOMES: AN INTEGRATIVE REVIEW OF SYSTEMATIC REVIEWS

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ABSTRACT

Introduction: Prehabilitation, comprising physical exercise protocols and inspiratory muscle training, aims to optimize a patient's functional reserve prior to cardiac surgery. This strategy seeks to mitigate pulmonary complications, reduce hospital stay, and accelerate functional and mental recovery. However, clinical application remains challenging due to the lack of standardized universal protocols. **Objective:** To verify the efficacy of prehabilitation programs on clinical outcomes in patients undergoing cardiac surgery. **Methodology:** This is an integrative literature review, with a search conducted in the PubMed database between 2021 and 2026. The descriptors "prehabilitation" and "cardiac surgery" were used. The exclusive inclusion criterion was the selection of systematic reviews, aiming to synthesize the highest level of evidence available on the subject. **Results:** A total of 48 articles were identified, of which 13 systematic reviews were selected for analysis, encompassing a total sample of 16,752 patients. The findings demonstrate that prehabilitation promotes significant improvement in functional capacity, an expressive reduction in postoperative complications, and a decrease in hospital costs associated with shorter lengths of stay. **Conclusion:** Scientific evidence confirms the feasibility and efficacy of prehabilitation, whether in in-hospital or home-based settings. The method proves to be a determinant in improving peri- and postoperative outcomes, consolidating itself as an essential strategy in the cardiovascular care continuum.

Keywords: Preoperative exercise, Thoracic surgery, Postoperative complications, Breathing exercises, Functional Status.

INTRODUCTION

Primary Cardiovascular diseases (CVDs) are the leading cause of global morbidity and mortality. According to the World Health Organization (WHO), CVDs accounted for 19.8 million deaths in 2022, with acute myocardial infarction and stroke representing 85% of this total. In addition to their epidemiological impact, a critical socioeconomic disparity is observed, as

more than three-quarters of these deaths occur in low- and middle-income countries.[1]

In this context, cardiac surgery emerges as a fundamental therapeutic intervention, although it is an invasive, high-cost procedure with significant systemic clinical repercussions. Globally, surgical volume has shown exponential growth; in the United States, the increase reached 484% over a 26-year period.[2] In Brazil, the reality reflects this trend: between 2008 and 2018, the Unified Health System (SUS) recorded more than 1.1 million cardiovascular procedures, with myocardial revascularization and valve surgeries being the most common.[3]

Despite its essential role, surgery imposes severe physiological stress, triggering inflammatory and catabolic responses that may exacerbate sarcopenia and functional decline.[4] Added to this are psychological challenges, such as anxiety and depression, particularly in patients with multiple comorbidities and low cardiorespiratory reserve, factors directly associated with increased perioperative morbidity and mortality.[4,5] Postoperative pulmonary complications are especially noteworthy, with a prevalence of up to 95%, increasing the length of stay in the Intensive Care Unit (ICU), hospital costs, and readmission rates.[6]

While postoperative exercise-based rehabilitation is a well-established strategy, prehabilitation has emerged as a proactive and promising approach. Defined as the active preparation of patients during the preoperative period, it aims to optimize functional capacity and physiological resilience through aerobic exercise, resistance training, and inspiratory muscle training (IMT).[6–9] However, the implementation of prehabilitation still lacks consensus protocols, and the strength of the current scientific evidence has frequently been questioned regarding its reliability and standardization.[7]

More recently, the integration of technology into prehabilitation has been explored to enhance equity and continuity of care, potentially improving patient-centered outcomes such as pain, fatigue, and quality of life.[10] Given the need to clarify the actual impact of these interventions and to support evidence-based clinical practice, the present study aims to analyze and synthesize the effectiveness of prehabilitation programs in cardiac surgery, evaluating their impact on functional capacity, postoperative complications, length of hospital stay, and psychofunctional well-being.

METHODOLOGY

The present study is characterized as an integrative literature review designed to synthesize high-impact evidence on the effectiveness of prehabilitation in the setting of cardiac surgery. The bibliographic search was conducted in the PubMed database covering the period from 2021 to 2026 in order to ensure the currency of the scientific evidence. The search strategy was structured through the combination of the Medical Subject Headings descriptors “prehabilitation” and “cardiac surgery” using the Boolean operator AND.

As a primary inclusion criterion, only systematic reviews addressing interventions based on aerobic exercise, resistance training, and inspiratory muscle training (IMT) performed during the preoperative period were selected. The selection of studies focused on the analysis of clinical and hospital outcomes, establishing functional capacity, predominantly assessed by the Six-Minute Walk Test (6MWT), and length of hospital stay in both the intensive care unit (ICU) and hospital ward as comparison variables.

The analysis process involved evaluating the maintenance of these outcomes from

the preoperative to the postoperative period, allowing for the extraction of data from an aggregated sample of 16,752 patients. The interpretative synthesis sought to identify the effectiveness of exercise modalities in mitigating pulmonary complications and accelerating the return to baseline functional status, consolidating evidence from studies that could support the clinical feasibility of prehabilitation.

RESULTS

The results are presented in Table 1, which describes the authors, year of publication, and number of participants included in each study. The table also presents the objectives, interventions performed in the prehabilitation programs, and the main findings/conclusions reported by each group of authors. The article selection flowchart is presented in Figure 1.

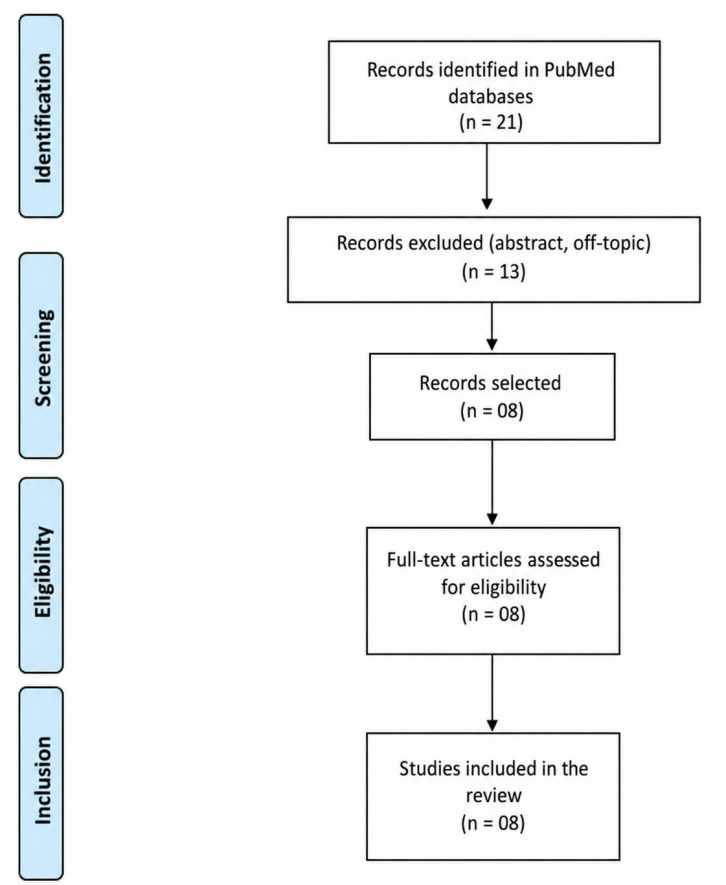

Figure 1. Flowchart for the selection and inclusion of articles in the present study.

Figure 2. (A) Patient positioning for pre-oxygenation. (B) Video laryngoscopy.

Table 1. Results of the search for articles addressing prehabilitation in cardiac surgery.

ARTICLE	AUTHOR/YEAR and Number of Patients Included	OBJECTIVE	TYPES OF PREHABILITATION INTERVENTIONS	MAIN FINDINGS/CONCLUSIONS
Efficacy of Prehabilitation Before Cardiac Surgery. A Systematic Review and Meta-analysis.[6]	Steinmetz *et al.*, 2020 (621 pacientes)	To evaluate the effect of prehabilitation involving functional exercise using the 6-Minute Walk Test (6MWT), Timed Up and Go (TUG), 5-meter gait speed, or the Short Physical Performance Battery (SPPB).	-Aerobic exercise; -Resistance training; -Respiratory exercises; -Health education; -Psychological support. †	Improvement in functional capacity (6MWT) during the preoperative and postoperative periods. Reduction in length of hospital stay and incidence of atrial fibrillation.
Prehabilitation Interventions for Cardiac Surgery to Prevent Postoperative Pulmonary Complications: Systematic Review and Meta-Analysis.[9]	Wang *et al.*, 2024 (2894 pacientes)	To investigate the effects of inspiratory muscle training (IMT), exercise, and health education on postoperative pulmonary complications (PPCs) and length of hospital stay.	-IMT; -Health education. †	Reduction in PPCs and length of hospital stay.
Exercise-Based Prehabilitation Before Cardiac Surgery: A Systematic Review, Meta-Analysis, Meta-Regression, and Proposal for a Clinical Implementation Model.[11]	Hurtado *et al.*, 2025 (873 patients)	To evaluate the effectiveness of prehabilitation programs on functional capacity and postoperative pulmonary complications through adapted exercise interventions.	- Resistance training; -Aerobic exercise; -IMT. †	Improvement in functional capacity. Reduction in length of hospital stay and PPCs.

Home-based prehabilitation: a systematic review and meta-analysis of randomized trials.[5]	D´Amico *et al.*, 2025 (3508 patients)	To evaluate adherence to home-based prehabilitation and its effects on postoperative pulmonary complications (PPCs).	- Aerobic exercise; -Resistance training; -IMT; -Nutrition; -Psychological support.†	Improvement in functional capacity. Reduction in PPCs, length of hospital stay, and levels of depression and anxiety.
Benefits from Implementing Low- to High-Intensity Inspiratory Muscle Training in Patients Undergoing Cardiac Surgery: A Systematic Review.[8]	Evangelodimou *et al.*, 2024 (815 patients)	To review and present the results of IMT and physical exercise in patients during the preoperative and/or postoperative period, as described over the last decade.	- IMT; -Aerobic exercise; -Resistance training. †	Improvement in inspiratory muscle strength, FC, and pulmonary function. Reduction in length of stay in the ICU.
Effect of preoperative prehabilitation on the 6-minute walk distance and postoperative outcomes in adult patients: meta-analysis.[4]	Díaz-Vidal *et al.*, 2026 (501 patients)	To determine the effect of exercise-based prehabilitation on preoperative functional capacity using the 6MWT.	- Aerobic exercise; -Resistance training; -Nutritional support; -Psychological support.†	Improvement in FC.
Prehabilitation in Patients Undergoing Cardiac Procedures: A Systematic Review and Meta-Analysis.[10]	Steinmetz *et al.*, 2026 (3.925 patients)	To consider the influence of prehabilitation on clinical recovery and the role of physical and mental preparation in functional capacity.	- Aerobic exercise; -Resistance training; -IMT; -Health education; -Nutritional support. †	Improvement in the distance covered during the 6MWT. Reduction in ICU and hospital length of stay.

Preoperative exercise training for adults undergoing elective major vascular surgery: A systematic review.[12]	Tew *et al.*, 2022 (197 patients)	To evaluate the benefits and harms of preoperative physical training in adults.	-Aerobic exercise; -Resistance training; -IMT †	Improvement in 6MWT distance. Reduction in ICU and hospital length of stay.

Prehabilitation exercise therapy before elective abdominal aortic aneurysm repair.[13]	Fenton *et al.*, 2021 (232 patients)	To evaluate the effects of physical exercise on morbidity and mortality in the prehabilitation and postoperative periods.	-Circuit training; -Aerobic exercise; -Resistance training; -HIIT. †	Reduction in mortality and PPCs.
Prevention and Reversal of Frailty in Heart Failure—A Systematic Review.[14]	Aili *et al.*, 2022 (41 patients)	To evaluate the effectiveness of cardiac rehabilitation and prehabilitation in reversing or preventing frailty.	- Balance exercises and resistance training. †	Improvement in frailty and quality of life.
Effects of Prehabilitation on Functional Capacity in Aged Patients Undergoing Cardiothoracic Surgeries: A Systematic Review.[15]	Costa *et al.*, 2021 (876 patients)	To evaluate the effectiveness of prehabilitation in improving functional capacity and physiological reserve during the preoperative and/or postoperative period in older patients.	- Physical exercise; -Nutrition; -Education; -Psychological support; -Aerobic and resistance training; -IMT. †	Improvement in physical fitness and return to preoperative functional status.

Post-Operative Outcomes of Pre-Thoracic Surgery Respiratory Muscle Training Vs. Aerobic Exercise Training: A Systematic Review and Network Meta-analysis.[16]	Kunadharaju *et al.*, 2023 (2070 patients)	To compare preoperative and postoperative outcomes using devices and aerobic exercise.	- IMT using a threshold loading device or respiratory muscle resistance device; -Aerobic and resistance exercises. †	Prevention of PPCs and pneumonia. Reduction in length of hospital stay.
Effect of Preoperative Respiratory Training on Perioperative Outcomes in Thoracic Surgery: A Systematic Review and Meta-Analysis.[17]	Zhu *et al.*, 2025 (199 patients)	To evaluate the effectiveness of preoperative respiratory training on pulmonary function, functional capacity, incidence of complications, and length of hospital stay.	- Pulmonary rehabilitation; -IMT. †	Improvement in the distance covered during the 6MWT. Reduction in PPCs.

6MWT: Six-Minute Walk Test; TUG: Timed Up and Go; SPPB: Short Physical Performance Battery; IMT: Inspiratory Muscle Training; PO: Postoperative; PPCs: Postoperative Pulmonary Complications; FC: Functional Capacity; RMT: Respiratory Muscle Training; PRT: Progressive Resistance Training; †: Compared with patients receiving standard preoperative care.

DISCUSSION

The literature demonstrates that patients undergoing cardiac surgery derive substantial benefits from diverse preoperative interventions. Such strategies range from circuit training and continuous moderate-intensity protocols to high-intensity interval training, in addition to inspiratory muscle training (IMT) using specific devices and aerobic and resistance exercises.[8,11] From a physiological perspective, physical exercise during this period enhances cardiorespiratory capacity and improves ventilatory efficiency. Furthermore, this preparation attenuates the inflammatory response resulting from surgical trauma, directly supporting the effectiveness of prehabilitation as a preventive measure.[17]

Regarding protocol design, a frequent integration of cardiovascular conditioning and strength training can be observed. In hospital settings, interventions usually prioritize aerobic, resistance, and high-intensity interval training protocols, although many publications lack detailed descriptions of exercise intensity or total intervention duration.[10,13] In contrast, data from the same review described outpatient and home-based practices more precisely, citing activities such as walking, running, or swimming performed three times per week. Strength training is generally prescribed three to five times weekly, using weights or elastic bands. This support is provided over a period ranging from one to twelve weeks before surgery, with the primary objective of building functional reserve to withstand surgical stress.[18]

Investigations conducted by Kunadharaju et al. reported programs lasting up to eight weeks, centered on preoperative aerobic exercise performed three to seven times per week, in sessions lasting between 30 and 60 minutes.[16] In a different approach, Fenton et al. described shorter interventions, ranging from one to six weeks, carried out predominantly in the home setting following an initial orientation phase.[13,16]

With regard to home-based practices, Aili et al. and Gimeno et al. detailed protocols lasting six weeks or longer, encompassing modalities such as balance training using the tandem position, backward walking for ten steps, and stair climbing. In terms of muscle strengthening, interventions included knee flexion exercises with ten repetitions and the functional sit-to-stand exercise, with progression based on increasing repetitions and reducing execution time.[14,19] Complementarily, Waite et al. found that an eight-week home-based protocol was capable of reducing frailty in patients, an outcome measured through improvements in handgrip strength and gait speed.[20]

Similarly, Rosenfeldt et al. described programs based on combined training, integrating aerobic and resistance exercises through the use of cycle ergometers, elastic bands, dumbbells, and body-weight exercises, with a target of 30 minutes per day.[21] Considerable methodological variability was observed between moderate continuous training and high-intensity interval training. Such variability reinforces that the adaptability of prehabilitation allows the transition between conservative approaches and protocols with greater metabolic demands, while always respecting the clinical profile of each individual.[2,11]

Costa et al. detailed an investigation involving 882 patients undergoing coronary artery bypass graft surgery under continuous moderate-intensity aerobic training or high-intensity interval training protocols. This individualized intervention, performed on a cycle ergometer or treadmill, lasted three weeks and consisted of sessions ranging from 10 to 30 minutes, administered two to three times daily, with a weekly frequency of up to seven days. Exercise intensity progressed from 60% to 80% of maximal work capacity or up to a score of 7 on the Borg Rating of Perceived Exertion scale. Participants were monitored for power output, distance, and exercise duration, with physical conditioning estimated through peak oxygen uptake and heart rate, demonstrating superiority in the 6-Minute Walk Test (6MWT) compared with the control group.[15] Additionally, the meta-analysis by Lai et al. demonstrated significant increases in forced expiratory volume in one second and forced vital capacity, further supporting the role of exercise in optimizing pulmonary function.[22]

In the same context, Diaz et al. and Steinmetz et al. reported that individuals participating in prehabilitation programs achieved an average increase of 30 meters in the 6MWT. This improvement is of considerable clinical relevance because it is directly associated with physical endurance and functional performance, also assessed by tests such as the Timed Up and Go (TUG) and gait speed.[4,6,11]

Interestingly, some findings suggest that shorter exercise programs may generate a greater clinical impact than prolonged interventions, possibly because of their closer temporal proximity to surgical stress. This phenomenon reinforces that the timing of intervention initiation is crucial and that even brief periods are capable of promoting substantial physiological adaptations.[16] Finally, D'Amico et al. and Steinmetz et al. demonstrated that early stabilization and reduced exposure to ICU-related stressors may decrease the incidence

of delirium and facilitate a faster transition to lower-complexity care settings.[5,6]

However, Wang et al.[2] and Hurtado-Borrego et al.[11] demonstrated that interventions involving physical exercise and inspiratory muscle training (IMT) are associated with improvements in dyspnea, increased maximal inspiratory pressure, and reductions in postoperative pulmonary complications (PPCs). A reduction in hospital length of stay was also observed, ranging from one to three days depending on the protocol.

According to Kunadharaju et al., prehabilitation reduced postoperative complications that may be related to procedural factors such as the type of surgery, incision site, operative time, and anesthetic technique. Patient-related factors include age over 60 years, ASA classification ≥ 2, the presence of chronic obstructive pulmonary disease, congestive heart failure, and functional dependence.[16] Yau et al. observed a reduction in postoperative atrial fibrillation, particularly among patients aged 65 years or younger. However, no significant results were identified in patients above this age range.[23]

Evidence suggests that IMT contributes favorably to surgical clinical outcomes. Steinmetz et al. observed reductions of 24 hours in hospital stay and six hours in ICU stay, whereas Hulzebos et al. reported reductions exceeding three days and 21 hours, respectively.[10,24] Such findings indicate earlier functional recovery and reduced exposure to nosocomial risks. Supporting this trend, a study involving 3,508 patients demonstrated that multimodal prehabilitation (IMT, resistance training, and cycle ergometry) reduced hospital stay by 0.3 days.[5] Additionally, Wang et al. found that ventilatory exercises and bronchial hygiene techniques not only mitigated postoperative pulmonary complications but also reduced ICU stay by 2.2 hours and total hospitalization by 1.8 days.[2]

Among the components of prehabilitation, inspiratory muscle training (IMT) also contributes to improved alveolar ventilation, reduced atelectasis, enhanced cough effectiveness, and pulmonary recruitment.[2] This modality has been widely investigated as a complement to physical exercise, especially in patients with limitations for aerobic activities. Studies such as that by Evangelodimou et al. demonstrated improvements in respiratory muscle strength and pulmonary function using progressively intensified protocols ranging from 30% to 80% of maximal inspiratory pressure, performed in two daily sessions.[8] Similarly, Hulzebos et al. employed daily 20-minute sessions using devices such as the Threshold IMT©, beginning at 30% of maximal inspiratory pressure with progression guided by the Borg scale. This resulted in increased inspiratory muscle strength and endurance during the first four preoperative weeks. In the postoperative period, the median length of hospital stay was reduced to 7 days (range: 5–41 days) compared with 8 days (range: 6–70 days) in the usual care group.[24] There are also shorter protocols lasting one week, involving incentive spirometry, emphasis on a 2–3 second inspiratory pause, and bronchial hygiene techniques such as controlled coughing. Another approach included 15-minute sessions performed six times per week, combining IMT with educational guidance and techniques such as the active cycle of breathing techniques and huffing.[7] High-intensity IMT is safe in this population provided that training load is progressed appropriately. However, a standardized protocol has not yet been established, and superiority among different intensity levels cannot currently be determined.[8]

Evidence has shown that resistance exercises contribute to improvements in functional capacity (assessed by the 6-Minute Walk Test) and reductions in hospital length of stay. These

effects are related to optimization of cardiorespiratory and musculoskeletal function, as well as attenuation of the impacts of general anesthesia and surgical trauma. Targeting large muscle groups also appears relevant in preventing preoperative sarcopenia and promoting functional autonomy during the immediate postoperative period.[11]

Despite the positive outcomes observed, this review identified limitations that warrant caution in interpreting the data. The main barrier lies in the marked heterogeneity of prehabilitation protocols, particularly regarding the lack of standardization of training variables such as intensity, total intervention duration, and weekly frequency. This disparity makes it difficult to establish an optimal dose-response relationship for patients awaiting cardiac surgery. In addition, a lack of detailed descriptions regarding the exercise modalities employed was observed. The absence of specifications concerning training volume, equipment used, and exercise progression severely compromises the reproducibility of studies in hospital or outpatient clinical practice. Another relevant issue is the selection bias present in some systematic reviews, which often fail to stratify patients according to frailty level or surgical complexity, potentially masking variations in intervention effectiveness among different cardiovascular risk profiles.

CONCLUSION

The scientific evidence compiled in this review demonstrates that prehabilitation programs based on inspiratory muscle training (IMT), aerobic exercise, and resistance training are effective in optimizing functional capacity, physical fitness, and distance covered during the 6-Minute Walk Test (6MWT), in addition to mitigating frailty and promoting improvements in quality of life. Such interventions were consistently associated with reductions in postoperative pulmonary complications (PPCs), mortality, and length of hospital and intensive care unit stays. Furthermore, a positive impact was observed on important psychological factors, including reductions in anxiety and depression levels. Prehabilitation is established as a feasible and highly relevant strategy in perioperative cardiac surgical care, contributing directly to improved clinical outcomes. However, the marked heterogeneity and lack of specificity in current protocols still limit the reliability and reproducibility of the findings. Future investigations establishing rigorous criteria regarding intervention dosage and outcome standardization are essential to support the systematic implementation of this approach in clinical practice.

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