

Implementing Cardiac Prehabilitation in Brazil: Building an Evidence-based Framework for Surgical Outcomes

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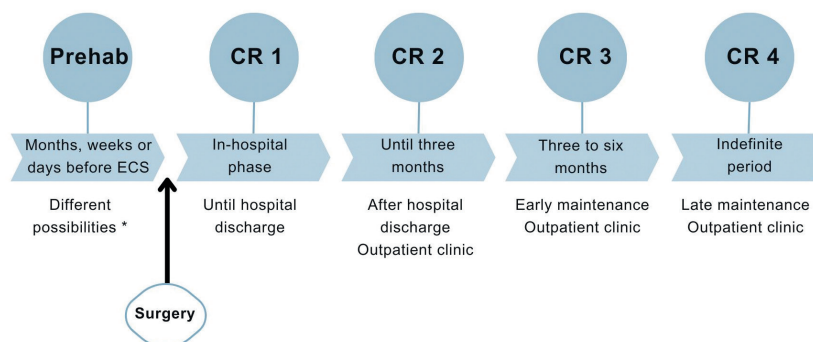
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Central Illustration: Implementing Cardiac Prehabilitation in Brazil: Building an Evidence-based Framework for Surgical Outcomes



MANAGEMENT FOR ELECTIVE CARDIAC SURGERY IN BRAZIL: HOW COULD IT BE?



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*Implementing Cardiac Prehabilitation in Brazil: Building an Evidence-Based Framework for Surgical Outcomes. The need for a national guideline recognition. The recognition of prehabilitation in the management of patients undergoing elective cardiac surgeries in the national guidelines of cardiovascular surgery and cardiac rehabilitation could be the first step. *Prehabilitation could be done in different scenarios, including in-hospital, outpatient clinic, or even through teleprehabilitation. Prehab: prehabilitation; ECS: elective cardiac surgeries; CR 1: phase 1 of cardiac rehabilitation; CR 2: phase 2 of cardiac rehabilitation; CR 3: phase 3 of cardiac rehabilitation; CR 4: phase 4 of cardiac rehabilitation.*

Keywords

Preoperative Exercise; Thoracic Surgery; Cardiac Rehabilitation

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Abstract

Patients undergoing cardiac surgery often face multiple challenges, including comorbidities, frailty, and psychosocial factors, which complicate recovery. Multimodal prehabilitation programs have emerged as a promising strategy to address these issues, aiming to reduce the length of hospital stay, mitigate pulmonary complications, and enhance functional recovery.

This Review Article examines the components and benefits of a comprehensive cardiac prehabilitation program, with a focus on exercise-based prehabilitation. Additionally, it underscores

the importance of integrating prehabilitation into Brazilian clinical guidelines as a valuable preoperative opportunity.

Emerging evidence, albeit of low to moderate quality, suggests that exercise-based prehabilitation, as a unimodal approach or integrating a multimodal program, can significantly improve functional capacity and postoperative outcomes in patients undergoing elective cardiac surgery. International guidelines have already supported cardiac prehabilitation as a valuable approach in this context. Globally, ongoing multicenter intervention trials seek to refine this evidence, pinpointing the ideal patient population and the most effective cardiac prehabilitation program. Given the growing burden of cardiovascular disease in Brazil, there is an unmet need for local research to assess the benefits of prehabilitation in patients undergoing cardiac surgery.

Introduction

Ischemic heart diseases and heart valve diseases are the first and fifth leading causes of mortality and morbidity worldwide, respectively, among cardiovascular diseases.¹ To treat these conditions, an annual global average of 36.7 coronary artery bypass grafts and 30.8 valvular surgeries is performed per 100,000 population.² Surgeries involving a major body cavity, as open-heart surgery, trigger a systemic neuroendocrine and inflammatory response, contributing to postoperative complications and increased mortality.³

Cardiac surgery patients generally present with advanced age, high burden of comorbidities, dietary risk factors, and significant perioperative morbidity and mortality risks, often compounded by frailty.^{1,4} Frailty affects up to 50% of older adults undergoing cardiac surgery and is strongly linked to adverse outcomes, including postoperative complications, high mortality rates, and prolonged hospitalization.^{4,5} Furthermore, convalescence may be complicated by delirium, anxiety, and depressive disorders.⁶ To mitigate these risks, prehabilitation has emerged as a key strategy to enhance physical resilience and optimize frail patients for surgical stress.⁶

To reduce postoperative complications and enhance functional recovery in cardiac surgery patients, further research is needed. This Review Article examines the components and benefits of comprehensive cardiac prehabilitation, with a focus on exercise-based programs. Additionally, it underscores the importance of integrating prehabilitation into Brazilian clinical guidelines as a valuable preoperative opportunity.

The prehabilitation concept

The concept of prehabilitation — also mentioned as preoperative rehabilitation⁵ — stems from the recognition that successful surgery depends not only on the procedure itself but also on the patient's rapid physical and psychological recovery.⁷ A groundbreaking 1981 study of 29 cardiac patients undergoing elective abdominal surgery was among the first to demonstrate that exercise-based prehabilitation (EBPrehab) could help assess and mitigate cardiac risk before surgery.⁸ This early finding laid the groundwork for prehabilitation to evolve into a critical element of surgical care.

In 2005, a significant advancement in perioperative care occurred with the development of the Enhanced Recovery After Surgery (ERAS) protocol for colorectal patients.⁹ This milestone catalyzed growing recognition in the scientific literature of prehabilitation's benefits across multiple surgical specialties. Subsequent systematic reviews and meta-analyses have demonstrated the effectiveness of multimodal prehabilitation in diverse patient populations, including orthopedic,¹⁰ abdominal,¹¹ cardiac,¹² bariatric,¹³ and cancer.¹⁴

Interestingly, the development of enhanced recovery programs for cardiac surgery progressed more slowly compared to non-cardiac procedures. This delay can be attributed to several challenges, including the high-risk nature of cardiac patients and the considerable diversity in cardiac surgical interventions. Nearly 15 years after the introduction of the ERAS protocol, enhanced recovery principles were formally established in cardiac surgery,¹⁵ culminating in the Enhanced Recovery After Cardiac Surgery (ERACS) Society's first comprehensive guidelines for perioperative care in this population.¹⁶

Through these years, prehabilitation evolved from a unimodal approach (focused on a single intervention like exercise or psychological support) to a multimodal strategy. As shown in Figure 1, this comprehensive model now integrates medical optimization, surgical planning, nutritional and psychological support, exercise training, and lifestyle modification.^{3,7,17-19} While current evidence remains limited, the ERACS guidelines recommend implementing such multimodal prehabilitation programs for elective cardiac surgery patients.^{5,16} As a fundamental intervention of prehabilitation, the exercise-based program represents a key strategy for optimizing outcomes in cardiac surgery.^{12,20}

Exercise-based prehabilitation: a key strategy for improving cardiac surgical outcomes?

EBPrehab, a fundamental intervention of cardiac prehabilitation involving the therapeutic application of exercise, has been increasingly incorporated into preoperative surgical care.²⁰ Figure 2 provides an overview of EBPrehab core components based on 16 randomized controlled trials²¹⁻³⁶ examining its effects in cardiac surgery, whether implemented as part of multimodal or unimodal prehabilitation programs. The EBPrehab interventions varied in design, ranging from single-component approaches to combined regimens incorporating at least two training modalities, breathing expansion exercises, or flexibility exercises, as detailed in Table 1. Notably, in 10 of these RCTs, EBPrehab was either conducted by physiotherapy professionals or implemented through structured physiotherapy sessions.^{23-28,30,31,35,36}

Current evidence shows considerable variability in exercise prescription for cardiac surgery patients, with no established consensus on optimal modality or dosage parameters. Existing programs demonstrate wide variations in duration (from 5 days to 16 weeks), frequency (2 to 7 sessions per week), session length (20 to 90 minutes), and intensity (low-moderate to high).²⁰ Despite the high

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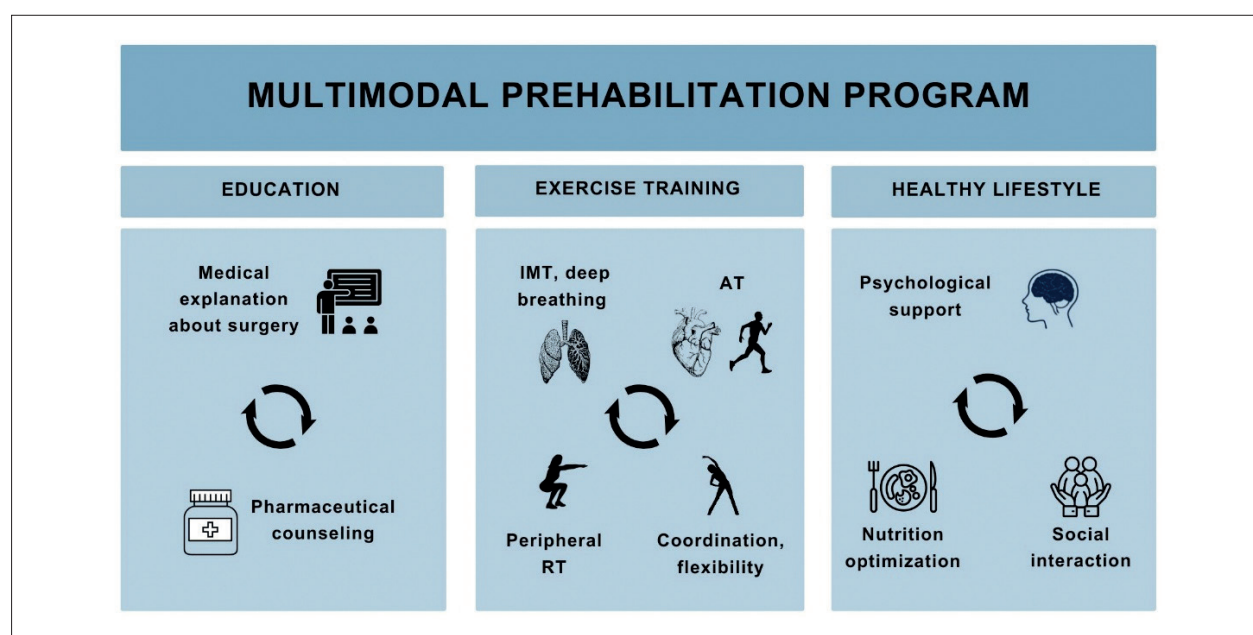


Figure 1 – Multimodal prehabilitation program. A multidisciplinary prehabilitation approach that could be included as an intervention before different surgeries, and should be individualized accordingly.^{2,12,15} IMT: inspiratory muscle training; AT: aerobic training; RT: resistance training.

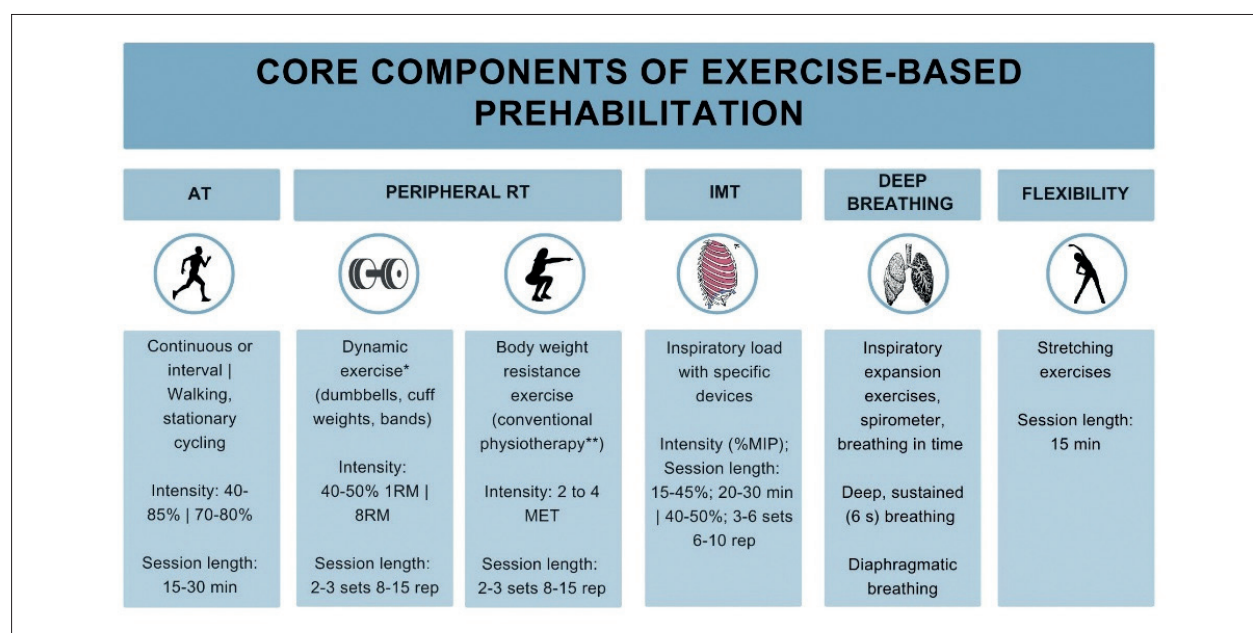


Figure 2 – Core components of exercise-based prehabilitation. * Major muscle groups of the upper and lower limbs. ** Conventional sessions of physiotherapy. AT: aerobic training; RT: resistance training; 1RM: one-repetition maximum; 8RM: eight-repetition maximum; rep: repetitions; MET: metabolic equivalent of task; IMT: inspiratory muscle training; MIP: maximum inspiratory pressure. Based on 16 previously published randomized controlled trials.²¹⁻³⁶

heterogeneity in intervention protocols, different systematic reviews and meta-analyses consistently support EBPrehab for enhancing postoperative functional capacity,^{12,20,37,38} reducing postoperative complications,^{12,20,37,39} and decreasing length of

hospital stay^{12,20,37-39} in patients undergoing cardiac surgery. The evidence suggests these benefits are reproducible across different program designs, underscoring the robustness of EBPrehab in elective cardiac surgical care.

Table 1 – Exercise-based prehabilitation in patients undergoing cardiac surgery

Study, Year	Country, Setting	Population, Sample size*	Prehab modality: components	Details of EBPrehab
Weiner, 1998 ²¹	Israel, Outpatient clinic	CABG, N=42	Unimodal: EBPrehab	<u>IMT</u> : 2-4 weeks, 6 times weekly, 30 minutes at 15% MIP with progressive increase up to 60% MIP
Arthur, 2000 ²²	Canada, Outpatient clinic	CABG [#] , N=123	Multimodal: Education EBPrehab	8 weeks, twice weekly <u>Flexibility</u> : 20 minutes, stretching <u>AT</u> : 30 minutes (stationary cycle, treadmill, arm ergometer, stair climber) at 40-70% of functional capacity
Hulzebos, 2006 ²³	The Netherlands, Outpatient clinic and Home	CABG [#] , N=14	Unimodal: EBPrehab	<u>IMT</u> : at least 2 weeks, 7 times weekly (1 at clinic and 6 at home), 20 minutes at 30% MIP, supervised by a physiotherapist
Hulzebos, 2006 ²⁴	The Netherlands, Outpatient clinic and Home	CABG [#] , N=140	Unimodal: EBPrehab	<u>IMT</u> : at least 2 weeks, 7 times weekly (1 at clinic and 6 at home), 20 minutes at 30% MIP, supervised by physiotherapists
Herdy, 2008 ²⁵	Brazil, Hospital	CABG, N=29	Unimodal: EBPrehab	At least 5 days, supervised by physiotherapists <u>Peripheral RT</u> : 2-4 METs based on CR phase I <u>Breathing expansion</u> : spirometer training and IPPB
Ferreira, 2009 ²⁶	Brazil, Home	CABG VRS, N=15	Unimodal: EBPrehab	<u>IMT</u> : at least 5 days, 2 times daily, 5 sets, 10 repetitions at 40% MIP (assessed by physiotherapists)
Rosenfeldt, 2011 ²⁷	Australia, Outpatient clinic	CABG [#] , N=60	Unimodal: EBPrehab	<u>AT</u> : 2 weeks, twice weekly, 40 minutes of cycle ergometry, treadmill walking, arm ergometry at 60% HRmax, supervised by physiotherapists
Savci, 2011 ²⁸	Turkey, Hospital	CABG, N=22	Unimodal: EBPrehab	<u>IMT</u> : 5 days, twice daily, 30 minutes at 15% MIP with progressive increase up to 45% MIP, supervised by physiotherapists
Sawatzky, 2014 ²⁹	Canada, Outpatient clinic	CABG [#] , N=8	Multimodal: Education EBPrehab Healthy lifestyle	<u>AT</u> : 4 weeks, twice weekly, 60 minutes walking at 85% VO ₂ peak (stretching and light exercise with body weight and bands were performed by only 2 participants)
Sobrinho, 2014 ³⁰	Brasil, Hospital	CABG, N=10	Unimodal: EBPrehab	Daily until surgery &, once a day, supervised by physiotherapists <u>IMT</u> : 3 sets, 10 repetitions at 40% MIP <u>Breathing expansion</u> : deep and sustained inspiration, diaphragmatic breathing together with upper limbs mobilization
Chen, 2019 ³¹	China, Hospital	CABG VRS, N=98	Multimodal: Education EBPrehab	<u>IMT</u> : 5 days, twice daily, 20 minutes (5 diaphragmatic breaths followed by 5-10 seconds rest) at 30% MIP, supervised by physiotherapists
Steinmetz, 2020 ³²	Germany, Outpatient clinic	CABG [#] , N=81	Unimodal: EBPrehab	2 weeks, 3 times weekly <u>AT</u> : 2 sets, 10-25 minutes cycle ergometer at 70% VO ₂ peak <u>Breathing expansion</u> : breathing techniques
Argunova, 2022 ³³	Russia, Outpatient clinic	CABG [#] , N=43	Unimodal: EBPrehab	<u>AT</u> : 5-10 days, 30 minutes at 80% VO ₂ peak
Akowuah, 2023 ³⁴	United Kingdom, Outpatient clinic and home	CABG [#] , N=91	Multimodal: Education EBPrehab	4 weeks, 7 times weekly (1 at clinic and 6 at home), 45-60 minutes <u>Peripheral RT</u> : exercise programme <u>IMT</u> : twice daily, at high intensity

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López-Hernández, 2024 ³⁵	Spain, Outpatient clinic	VRS, N=34	Multimodal: EBPrehab Healthy lifestyle	4-6 weeks, twice weekly, 60 minutes per session, supervised by physiotherapists AT: 5 bouts of 2 minutes, stationary bike at 70% to 90-100% PWR Peripheral RT: 2-3 sets, 8-12 repetitions, at 8RM (pectorals, latissimus dorsi, and quadriceps) Breathing expansion: twice daily, 1-2 sets, 10-15 breaths (chest expansions, diaphragmatic breaths, and deep inspirations)
Sahar, 2024 ³⁶	Pakistan, Outpatient clinic	CABG [#] , N=37	Unimodal: EBPrehab	Peripheral RT: 1-3 times daily, 10-15 repetitions per major muscle groups (upper and lower), with cuff weights/dumbbells at 40-50% 1RM, supervised by physiotherapists

AT: aerobic training; CABG: coronary artery bypass graft; CR: cardiac rehabilitation; EBPrehab: exercise-based prehabilitation; IMT: inspiratory muscle training; IPPB: intermittent positive pressure breathing; HRmax: maximum heart rate; MIP: maximum inspiratory pressure; Prehab: prehabilitation; PWR: peak workload; RT: resistance training; VO_{2peak}: peak oxygen consumption; VRS: valve replacement surgery; 1RM: one-repetition maximum; 8RM: eight-repetition maximum. *Participants included in the Prehabilitation intervention group. # Specified as elective CABG. & EBPrehab duration not specified in the study.

A recent European consensus statement proposes that the prescription of EBPrehab should incorporate physical exercise training and respiratory muscles training, individualized according to patient-specific needs and risk factors — particularly for frail populations.⁶ Notably, inspiratory muscle training has gained recognition as an effective, cost-efficient, and well-tolerated intervention. This modality works by applying resistance during inspiration to enhance inspiratory muscle strength and endurance.⁴⁰ When implemented as a standalone intervention, inspiratory muscle training has demonstrated a significant impact in reducing postoperative pulmonary complications (including atelectasis and pneumonia) and recovery time.⁴¹⁻⁴⁴

Existing evidence, albeit of low to moderate quality, indicates that EBPrehab improves functional capacity and facilitates postoperative recovery in elective cardiac surgery patients (Figure 3).^{12,37-39,41} A combined exercise approach incorporating breathing expansion exercises, inspiratory muscle training, peripheral resistance training, and general physical conditioning,^{41,42,44} appears particularly beneficial, underscoring the value of early and comprehensive EBPrehab implementation.

Currently, there is insufficient evidence to recommend a standardized intervention protocol or optimal combination of EBPrehab components. An individualized approach to EBPrehab is therefore warranted and often needed. For instance, it may not always be feasible or clinically necessary to incorporate all EBPrehab components within a single session, particularly for frail patients with marked muscular deconditioning, as they may lack the capacity to tolerate such extensive training volumes.

Although additional high-quality research is warranted, current international guidelines endorse prehabilitation as a valuable strategy for preoperative optimization in elective cardiac surgery.^{5,6,16} By targeting prevalent risk factors in this population^{4,6,45} — particularly frailty in the elderly — EBPrehab represents a clinically significant intervention for

enhancing surgical outcomes. Achieving these outcomes requires multiprofessional collaboration among all healthcare providers, with each discipline contributing to their specialized expertise. Physicians should assume responsibility for risk assessment and establish necessary clinical restrictions. For specific interventions such as nutritional counseling or smoking cessation, the involvement of other specialists — including nutritionists and psychologists — is essential.

Exercise-based cardiac prehabilitation in clinical practice in Brazil

EBPrehab — also known as preoperative physiotherapy^{24,26-28,30,31,35,36,41} — is becoming increasingly common in Brazil. The Brazilian Federal Council of Physiotherapy and Occupational Therapy (COFFITO) recognizes fifteen specialties in physiotherapy, two of which focus on cardiac care: cardiovascular physiotherapy and intensive care physiotherapy.⁴⁶⁻⁴⁸ Cardiovascular and intensive care physiotherapists can contribute to the EBPrehab component of cardiac prehabilitation programs across three distinct clinical scenarios.

First, high-risk patients necessitating intensive preoperative preparation receive multimodal care in intensive care units. Second, conventional cardiac rehabilitation centers serve as established sites for multimodal program delivery. In these two scenarios, the multimodal centralized approach is delivered through coordinated medical, physiotherapeutic, nutritional, and psychological interventions.^{3,7} Third, stable patients awaiting elective surgery may undergo EBPrehab in cardiac physiotherapy clinics following physician risk assessment and referral. In this case, the multimodal program can be delivered through a decentralized approach.⁴⁷ In all scenarios, physiotherapists autonomously assess functional capacity and functionality, establish diagnostic profiles, and design individualized EBPrehab programs based on each patient's risk factors and the time remaining before surgery.^{47,48}

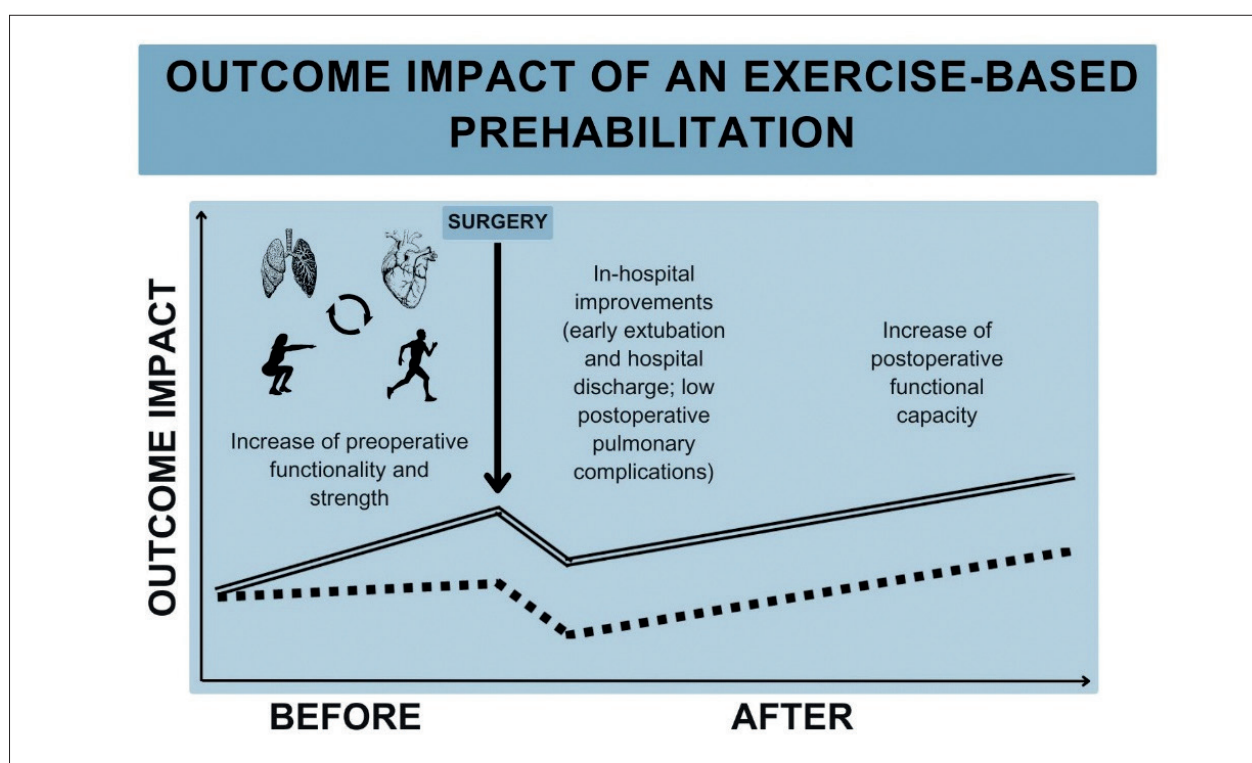


Figure 3 – Outcome impact of an exercise-based prehabilitation in elective cardiac surgery. Illustration about the outcome impact before and after cardiac surgery, in the presence (double line) or absence (dotted line) of an exercise-based prehabilitation. Based on ¹⁵.

However, these exercise interventions are so far usually based on individualized clinical prescriptions rather than standardized protocols, underscoring a disconnect between clinical practice and evidence-based research. Few Brazilian studies have investigated the benefits of EBPrehab within preoperative physiotherapy programs for patients undergoing coronary artery bypass grafting. A study conducted in Santa Catarina²⁵ demonstrated that EBPrehab (consisting of at least five days of bodyweight resistance exercises and breathing exercises) combined with Phase I cardiac rehabilitation significantly reduced hospital stays, time to extubation, and the incidence of postoperative complications — including pneumonia, pleural effusion, and atelectasis — compared to Phase I cardiac rehabilitation alone. Additionally, two studies from São Paulo revealed that an EBPrehab program incorporating inspiratory muscle training can shorten postoperative recovery time³⁰ and improve lung function.²⁶

Despite these promising findings, the preoperative cardiac rehabilitation (or “cardiac prehabilitation”) remains underutilized in Brazil.

Cardiac prehabilitation in Brazil: An emerging need

Despite over four decades of research supporting the benefits of prehabilitation,² — including its recommendation in international guidelines for patients undergoing elective cardiac surgery^{5,6,16} — prehabilitation has yet to be recognized as a valuable intervention opportunity in Brazilian guidelines.

The *South American Guideline for Cardiovascular Prevention and Rehabilitation (2014)*⁴⁹ recommends postoperative cardiac rehabilitation for procedures such as coronary artery bypass grafting and cardiac transplantation, yet makes no mention of preoperative interventions like prehabilitation. Similarly, Brazil’s most current comprehensive document on the subject, the *Brazilian Guideline for Cardiovascular Rehabilitation (2020)*,⁵⁰ omits prehabilitation as a recommended practice.

This oversight extends to other key guidelines:

- The *3rd Brazilian Guideline of Cardiac Transplantation (2018)*⁵¹ focuses solely on medical preoperative evaluation without referencing prehabilitation programs.
- The updated *Guideline for Perioperative Cardiovascular Evaluation (2024)* by the *Sociedade Brasileira de Cardiologia*⁵² emphasizes risk assessment but fails to include prehabilitation referrals — even for high-risk patients. Notably, its sole mention of physical rehabilitation applies exclusively to frail patients undergoing non-cardiac procedures.

This persistent exclusion in national guidelines represents a critical missed opportunity. Given the growing evidence demonstrating prehabilitation’s efficacy in improving surgical outcomes, Brazil stands to benefit significantly by aligning its clinical practice with international standards through the formal incorporation of prehabilitation protocols.

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Anticipated challenges and proposed solutions for implementation in clinical routine

The implementation of cardiac prehabilitation programs in Brazil will inevitably face challenges. Although specific barriers to cardiac prehabilitation participation are still unknown, the existing literature highlights systemic challenges in the delivery of cardiac rehabilitation services.

Cardiac rehabilitation services in low- and middle-income countries are insufficient to meet the growing cardiovascular disease burden, with low utilization even where available. While barriers exist across all settings, low- and middle-income countries face greater challenges due to resource constraints, weak health systems, and affordability issues.⁵³ Key implementation barriers include low patient motivation, environmental and dietary challenges, infrastructure gaps, and health literacy disparities. Limited insurance coverage further restricts access and long-term rehabilitation potential.^{54,55} For elderly frail patients, prehabilitation barriers include transportation limitations, lack of social support, and information overload.^{56,57}

Given Brazil's limited cardiac rehabilitation infrastructure for centralized multimodal prehabilitation programs, adaptive implementation strategies are essential. Challenges associated with center-based programs could be mitigated through decentralized models and/or teleprehabilitation, which not only address these barriers but may also enhance cost-effectiveness.^{58,59} Future research should explore locally adapted models leveraging interprofessional collaboration. For safety considerations, moderate-to-high-risk patients should be referred to a hospital or center-based programs, whereas low-risk patients awaiting elective surgery could receive coordinated, decentralized multidisciplinary care in community settings or via telerehabilitation. Such programs should integrate components from the medical, physiotherapeutic, nutritional, and psychological domains, depending on individual needs, to ensure comprehensive support.

Future perspectives: Advancing cardiac prehabilitation in Brazil

While gaps in evidence persist and no consensus exists on optimal prehabilitation programs, international medical societies increasingly recognize the urgent need for high-quality studies in this field.^{5,6}

Recent years have seen numerous multinational initiatives investigating effective prehabilitation strategies for cardiac patients. Notable programs include multimodal approaches (ERAS,⁵ PREHAB,⁶⁰ PREQUEL,⁶¹ PRECOVERY,⁶² PrEPS TRIAL,⁶³ Heart-ROCQ⁶⁴) and research in teleprehabilitation,^{65,59} which show promise in improving outcomes for cardiac surgical patients, including those undergoing heart transplantation.⁶⁶

To establish an evidence-based prehabilitation framework tailored to Brazil's population and healthcare realities, the following priorities should be advanced:

Key Recommendations for Brazil

1. Guideline Integration

Formal recognition of multimodal prehabilitation in national cardiovascular surgery and cardiac rehabilitation guidelines as a valuable intervention opportunity for elective cardiac surgery.

2. Population-Specific Research

Investigation of Brazil's unique epidemiological and cultural factors to ensure prehabilitation programs address local health disparities and resource constraints.

3. Multidisciplinary Implementation

Establishment of specialized prehabilitation teams (cardiologists, physiotherapists, nutritionists, psychologists) to design contextually adapted programs aligned with Brazil's healthcare infrastructure.

4. Pilot Programs in Academic Centers

Deployment of prehabilitation initiatives in university hospitals and cardiac rehabilitation centers to synergize clinical care with research while testing feasibility.

5. Expansion to Non-Open-Heart Procedures

Rigorous evaluation of prehabilitation's role in percutaneous coronary interventions, transcatheter aortic valve implantation, and other minimally invasive cardiac procedures.

6. Exercise Modality Optimization

Comparative studies to determine the safety and efficacy of various training components (aerobic, resistance, and/or inspiratory) within multimodal prehabilitation frameworks.

Conclusion: A call to action for cardiac prehabilitation in Brazil

Despite growing evidence supporting preoperative rehabilitation for cardiac surgery, Brazil's healthcare system has not fully implemented this approach. While international guidelines increasingly recognize prehabilitation as a valuable component of surgical preparation,^{5,6,16} its absence in Brazilian cardiovascular guidelines⁴⁹⁻⁵² represents a critical gap in patient care standards. The Brazilian medical community, together with the other health care professionals, stands at a pivotal moment, by:

1. **Formally incorporating** prehabilitation into national cardiac care guidelines.
2. **Development of evidence-based protocols** tailored to local population needs and healthcare infrastructure.
3. **Establishing multidisciplinary programs** in academic health centers.

By embracing these advances, Brazil has the potential to significantly improve cardiac surgical outcomes. The success of international multimodal programs⁶⁰⁻⁶⁴ and emerging teleprehabilitation models^{59,65,66} provides both

a roadmap and justification for this evolution. Future research should particularly focus on:

- standardizing outcome measures for Brazilian populations,
- evaluating cost-effectiveness in both public and private healthcare systems and
- exploring applications in minimally invasive cardiac procedures, in order to improve the existing knowledge and optimize the healthcare situation.

Author Contributions

Conception and design of the research, Acquisition of data and Analysis and interpretation of the data: Mazzoli-Rocha F, Schmidt T; Obtaining financing: Mazzoli-Rocha F; Writing of the manuscript and Critical revision of the manuscript for content: Mazzoli-Rocha F, Stein R, Steinmetz C, Sadlonova M, Borghi-Silva A, Schmidt T.

Potential conflict of interest

No potential conflict of interest relevant to this article was reported.

References

1. Mensah GA, Fuster V, Murray CJL, Roth GA; Global Burden of Cardiovascular Diseases and Risks Collaborators. Global Burden of Cardiovascular Diseases and Risks, 1990-2022. *J Am Coll Cardiol.* 2023;82(25):2350-473. doi: 10.1016/j.jacc.2023.11.007.
2. Vervoort D, Meuris B, Meyns B, Verbrugge P. Global Cardiac Surgery: Access to Cardiac Surgical Care Around the World. *J Thorac Cardiovasc Surg.* 2020;159(3):987-96.e6. doi: 10.1016/j.jtcvs.2019.04.039.
3. Durrand J, Singh SJ, Danjoux G. Prehabilitation. *Clin Med.* 2019;19(6):458-64. doi: 10.7861/clinmed.2019-0257.
4. Lee DH, Buth KJ, Martin BJ, Yip AM, Hirsch GM. Frail Patients are at Increased Risk for Mortality and Prolonged Institutional Care after Cardiac Surgery. *Circulation.* 2010;121(8):973-8. doi: 10.1161/CIRCULATIONAHA.108.841437.
5. Grant MC, Crisafi C, Alvarez A, Arora RC, Brindle ME, Chatterjee S, et al. Perioperative Care in Cardiac Surgery: A Joint Consensus Statement by the Enhanced Recovery after Surgery (ERAS) Cardiac Society, ERAS International Society, and The Society of Thoracic Surgeons (STS). *Ann Thorac Surg.* 2024;117(4):669-89. doi: 10.1016/j.athoracsur.2023.12.006.
6. Niebauer J, Bäck C, Bischoff-Ferrari HA, Dehbi HM, Szekely A, Völler H, et al. Preinterventional Frailty Assessment in Patients Scheduled for Cardiac Surgery or Transcatheter Aortic Valve Implantation: A Consensus Statement of the European Association for Cardio-Thoracic Surgery (EACTS) and the European Association of Preventive Cardiology (EAPC) of the European Society of Cardiology (ESC). *Eur J Prev Cardiol.* 2024;31(2):146-81. doi: 10.1093/eurjpc/zwad304.
7. Scheede-Bergdahl C, Minnella EM, Carli F. Multi-Modal Prehabilitation: Addressing the why, when, what, how, who and where Next? *Anaesthesia.* 2019;74(Suppl 1):20-6. doi: 10.1111/anae.14505.
8. Asoh T, Tsuji H. Preoperative Physical Training for Cardiac Patients Requiring Non-Cardiac Surgery. *Jpn J Surg.* 1981;11(4):251-5. doi: 10.1007/BF02468764.
9. Fearon KC, Ljungqvist O, Von Meyenfeldt M, Revhaug A, Dejong CH, Lassen K, et al. Enhanced Recovery after Surgery: A Consensus Review of Clinical Care for Patients Undergoing Colonic Resection. *Clin Nutr.* 2005;24(3):466-77. doi: 10.1016/j.clnu.2005.02.002.
10. Punnoose A, Claydon-Mueller LS, Weiss O, Zhang J, Rushton A, Khanduja V. Prehabilitation for Patients Undergoing Orthopedic Surgery: A Systematic Review and Meta-analysis. *JAMA Netw Open.* 2023;6(4):e238050. doi: 10.1001/jamanetworkopen.2023.8050.
11. Moran J, Guinan E, McCormick P, Larkin J, Mockler D, Hussey J, et al. The Ability of Prehabilitation to Influence Postoperative Outcome after Intra-Abdominal Operation: A Systematic Review and Meta-Analysis. *Surgery.* 2016;160(5):1189-201. doi: 10.1016/j.surg.2016.05.014.
12. Steinmetz C, Bjarnason-Wehrens B, Walther T, Schaffland TF, Walther C. Efficacy of Prehabilitation Before Cardiac Surgery: A Systematic Review and Meta-Analysis. *Am J Phys Med Rehabil.* 2023;102(4):323-30. doi: 10.1097/PHM.0000000000002097.
13. Durey BJ, Fritche D, Martin DS, Best LMJ. The Effect of Pre-Operative Exercise Intervention on Patient Outcomes Following Bariatric Surgery: A Systematic Review and Meta-Analysis. *Obes Surg.* 2022;32(1):160-9. doi: 10.1007/s11695-021-05743-w.
14. Michael CM, Lehrer EJ, Schmitz KH, Zaorsky NG. Prehabilitation Exercise Therapy for Cancer: A Systematic Review and Meta-Analysis. *Cancer Med.* 2021;10(13):4195-205. doi: 10.1002/cam4.4021.
15. Gregory AJ. Enhanced Recovery after Cardiac Surgery: More Than a Buzzword. *J Cardiothorac Vasc Anesth.* 2019;33(6):1495-7. doi: 10.1053/j.jvca.2018.11.046.
16. Engelman DT, Ben Ali W, Williams JB, Perrault LP, Reddy VS, Arora RC, et al. Guidelines for Perioperative Care in Cardiac Surgery: Enhanced Recovery after Surgery Society Recommendations. *JAMA Surg.* 2019;154(8):755-66. doi: 10.1001/jamasurg.2019.1153.
17. Le Roy B, Selvy M, Slim K. The Concept of Prehabilitation: What the Surgeon Needs to Know? *J Visc Surg.* 2016;153(2):109-12. doi: 10.1016/j.jvisurg.2016.01.001.
18. Zhao B, Zhang T, Chen Y, Zhang C. Effects of Unimodal or Multimodal Prehabilitation on Patients Undergoing Surgery for Esophagogastric

Review Article

- Cancer: A Systematic Review and Meta-Analysis. *Support Care Cancer*. 2023;32(1):15. doi: 10.1007/s00520-023-08229-w.
19. McCann M, Stamp N, Ngui A, Litton E. Cardiac Prehabilitation. *J Cardiothorac Vasc Anesth*. 2019;33(8):2255-65. doi: 10.1053/j.jvca.2019.01.023.
20. Yamikan H, Ahiskali GN, Demirel A, Kütükcü EC. The Effects of Exercise-Based Prehabilitation in Patients Undergoing Coronary Artery Bypass Grafting Surgery: A Systematic Review of Randomized Controlled Trials. *Heart Lung*. 2025;69:41-50. doi: 10.1016/j.hrtlng.2024.09.007.
21. Weiner P, Zeidan F, Zamir D, Pelled B, Waizman J, Beckerman M, et al. Prophylactic Inspiratory Muscle Training in Patients Undergoing Coronary Artery Bypass Graft. *World J Surg*. 1998;22(5):427-31. doi: 10.1007/s002689900410.
22. Arthur HM, Daniels C, McKelvie R, Hirsh J, Rush B. Effect of a Preoperative Intervention on Preoperative and Postoperative Outcomes in Low-Risk Patients Awaiting Elective Coronary Artery Bypass Graft Surgery. A Randomized, Controlled Trial. *Ann Intern Med*. 2000;133(4):253-62. doi: 10.7326/0003-4819-133-4-200008150-00007.
23. Hulzebos EH, van Meeteren NL, van den Buijs BJ, de Bie RA, de la Rivière AB, Helder PJ. Feasibility of Preoperative Inspiratory Muscle Training in Patients Undergoing Coronary Artery Bypass Surgery with a High Risk of Postoperative Pulmonary Complications: A Randomized Controlled Pilot Study. *Clin Rehabil*. 2006;20(11):949-59. doi: 10.1177/0269215506070691.
24. Hulzebos EH, Helder PJ, Favié NJ, De Bie RA, Brutel de la Rivière A, Van Meeteren NL. Preoperative Intensive Inspiratory Muscle Training to Prevent Postoperative Pulmonary Complications in High-Risk Patients Undergoing CABG Surgery: A Randomized Clinical Trial. *JAMA*. 2006;296(15):1851-7. doi: 10.1001/jama.296.15.1851.
25. Herdy AH, Marcchi PL, Vila A, Tavares C, Collaço J, Niebauer J, et al. Pre- and Postoperative Cardiopulmonary Rehabilitation in Hospitalized Patients Undergoing Coronary Artery Bypass Surgery: A Randomized Controlled Trial. *Am J Phys Med Rehabil*. 2008;87(9):714-9. doi: 10.1097/PHM.0b013e3181839152.
26. Ferreira PE, Rodrigues AJ, Evora PR. Effects of an Inspiratory Muscle Rehabilitation Program in the Postoperative Period of Cardiac Surgery. *Arq Bras Cardiol*. 2009;92(4):275-82. doi: 10.1590/s0066-782x2009000400005.
27. Rosenfeldt F, Braun L, Spitzer O, Bradley S, Shepherd J, Bailey M, et al. Physical Conditioning and Mental Stress Reduction--A Randomised Trial in Patients Undergoing Cardiac Surgery. *BMC Complement Altern Med*. 2011;11:20. doi: 10.1186/1472-6882-11-20.
28. Savci S, Degirmenci B, Saglam M, Arikan H, Inal-Ince D, Turan HN, et al. Short-Term Effects of Inspiratory Muscle Training in Coronary Artery Bypass Graft Surgery: A Randomized Controlled Trial. *Scand Cardiovasc J*. 2011;45(5):286-93. doi: 10.3109/14017431.2011.595820.
29. Sawatzky JA, Kehler DS, Ready AE, Lerner N, Boreskie S, Lamont D, et al. Prehabilitation Program for Elective Coronary Artery Bypass Graft Surgery Patients: A Pilot Randomized Controlled Study. *Clin Rehabil*. 2014;28(7):648-57. doi: 10.1177/0269215513516475.
30. Sobrinho MT, Guirado GN, Silva MA. Preoperative Therapy Restores Ventilatory Parameters and Reduces Length of Stay in Patients Undergoing Myocardial Revascularization. *Rev Bras Cir Cardiovasc*. 2014;29(2):221-8. doi: 10.5935/1678-9741.20140021.
31. Chen X, Hou L, Zhang Y, Liu X, Shao B, Yuan B, et al. The Effects of Five Days of Intensive Preoperative Inspiratory Muscle Training on Postoperative Complications and Outcome in Patients Having Cardiac Surgery: A Randomized Controlled Trial. *Clin Rehabil*. 2019;33(5):913-22. doi: 10.1177/0269215519828212.
32. Steinmetz C, Bjarnason-Wehrens B, Baumgarten H, Walther T, Mengden T, Walther C. Prehabilitation in Patients Awaiting Elective Coronary Artery Bypass Graft Surgery - Effects on Functional Capacity and Quality of Life: A Randomized Controlled Trial. *Clin Rehabil*. 2020;34(10):1256-67. doi: 10.1177/0269215520933950.
33. Argunova Y, Belik E, Gruzdeva O, Ivanov S, Pomeskhina S, Barbarash O. Effects of Physical Prehabilitation on the Dynamics of the Markers of Endothelial Function in Patients Undergoing Elective Coronary Bypass Surgery. *J Pers Med*. 2022;12(3):471. doi: 10.3390/jpm12030471.
34. Akowuah EF, Wagnild JM, Bardgett M, Prichard JG, Mathias A, Harrison SL, et al. A Randomised Controlled Trial of Prehabilitation in Patients Undergoing Elective Cardiac Surgery. *Anaesthesia*. 2023;78(9):1120-8. doi: 10.1111/anae.16072.
35. López-Hernández A, Gimeno-Santos E, Navarro-Ripoll R, Arguis MJ, Romano-Andrioni B, López-Baamonde M, et al. Differential Response to Preoperative Exercise Training in Patients Candidates to Cardiac Valve Replacement. *BMC Anesthesiol*. 2024;24(1):280. doi: 10.1186/s12871-024-02671-x.
36. Sahar W, Waseem M, Riaz M, Nazeer N, Ahmad M, Haider Z. Effects of Prehabilitation Resistance Training in Mild to Moderate Clinically Frail Patients Awaiting Coronary Artery Bypass Graft Surgery. *J Investig Med*. 2024;72(1):151-8. doi: 10.1177/10815589231207795.
37. Marmelo F, Rocha V, Moreira-Gonçalves D. The Impact of Prehabilitation on Post-Surgical Complications in Patients Undergoing Non-Urgent Cardiovascular Surgical Intervention: Systematic Review and Meta-Analysis. *Eur J Prev Cardiol*. 2018;25(4):404-17. doi: 10.1177/2047487317752373.
38. Yau DKW, Underwood MJ, Joynt GM, Lee A. Effect of Preparative Rehabilitation on Recovery after Cardiac Surgery: A Systematic Review. *Ann Phys Rehabil Med*. 2021;64(2):101391. doi: 10.1016/j.rehab.2020.03.014.
39. Snowden D, Haines TP, Skinner EH. Preoperative Intervention Reduces Postoperative Pulmonary Complications but Not Length of Stay in Cardiac Surgical Patients: A Systematic Review. *J Physiother*. 2014;60(2):66-77. doi: 10.1016/j.jphys.2014.04.002.
40. Bjarnason-Wehrens B, Predel HG. Inspiratory Muscle Training - An Inspiration for More Effective Cardiac Rehabilitation in Heart Failure Patients? *Eur J Prev Cardiol*. 2018;25(16):1687-90. doi: 10.1177/2047487318798917.
41. Hulzebos EH, Smit Y, Helder PJ, van Meeteren NL. Preoperative Physical Therapy for Elective Cardiac Surgery Patients. *Cochrane Database Syst Rev*. 2012;11(11):CD010118. doi: 10.1002/14651858.CD010118.pub2.
42. Gomes M Neto, Martinez BP, Reis HF, Carvalho VO. Pre- and Postoperative Inspiratory Muscle Training in Patients Undergoing Cardiac Surgery: Systematic Review and Meta-Analysis. *Clin Rehabil*. 2017;31(4):454-64. doi: 10.1177/0269215516648754.
43. Karanfil EOT, Møller AM. Preoperative Inspiratory Muscle Training Prevents Pulmonary Complications after Cardiac Surgery - A Systematic Review. *Dan Med J*. 2018;65(3):A5450.
44. Kendall F, Oliveira J, Peleteiro B, Pinho P, Bastos PT. Inspiratory Muscle Training is Effective to Reduce Postoperative Pulmonary Complications and Length of Hospital Stay: A Systematic Review and Meta-Analysis. *Disabil Rehabil*. 2018;40(8):864-82. doi: 10.1080/09638288.2016.1277396.
45. Ambrosetti M, Abreu A, Corrà U, Davos CH, Hansen D, Frederix I, et al. Secondary Prevention Through Comprehensive Cardiovascular Rehabilitation: From Knowledge to Implementation. 2020 Update. A Position Paper from the Secondary Prevention and Rehabilitation Section of the European Association of Preventive Cardiology. *Eur J Prev Cardiol*. 2021;28(5):460-95. doi: 10.1177/2047487320913379.
46. Mendonça ME, Coelho TRP, Alexandre DJA, Pantaleão TU, Araújo LD, Botelho AP, et al. How COVID-19 Elucidated Challenges in the Pedagogy of Physiotherapy Entry-Level Education in Brazil and Directions for Their Remediation with Special Attention to Digital Teaching and Learning. *Physiother Theory Pract*. 2024;40(5):887-99. doi: 10.1080/09593985.2022.2147409.
47. Conselho Federal de Fisioterapia e Terapia Ocupacional. Resolução nº 454, de 25 de abril de 2015. Reconhece e Disciplina a Especialidade Profissional de Fisioterapia Cardiovascular. *Diário Oficial da União*. 2015 maio 14;Seção1:96-7.

48. Conselho Federal de Fisioterapia e Terapia Ocupacional. Resolução nº 392, de 18 de agosto de 2011. Reconhece a Fisioterapia em Terapia Intensiva como Especialidade do Profissional Fisioterapeuta e dá Outras Providências. Diário Oficial da União. 2011 out 5;Seção1:160.
49. Herdy AH, López-Jiménez F, Terzic CP, Milani M, Stein R, Carvalho T, et al. South American Guidelines for Cardiovascular Disease Prevention and Rehabilitation. Arq Bras Cardiol. 2014;103(2 Suppl 1):1-31. doi: 10.5935/abc.2014s003.
50. Carvalho T, Milani M, Ferraz AS, Silveira ADD, Herdy AH, Hossri CAC, et al. Brazilian Cardiovascular Rehabilitation Guideline - 2020. Arq Bras Cardiol. 2020;114(5):943-87. doi: 10.36660/abc.20200407.
51. Bacal F, Marcondes-Braga FG, Rohde LEP, Xavier JL Jr, Brito FS, Moura LAZ, et al. 3ª Diretriz Brasileira de Transplante Cardíaco. Arq Bras Cardiol. 2018;111(2):230-89. doi: 10.5935/abc.20180153.
52. Gualandro DM, Fornari LS, Caramelli B, Abizaid AAC, Gomes BR, Tavares CAM, et al. Guideline for Perioperative Cardiovascular Evaluation of the Brazilian Society of Cardiology - 2024. Arq Bras Cardiol. 2024;121(9):e20240590. doi: 10.36660/abc.20240590.
53. Ragupathi L, Stribling J, Yakunina Y, Fuster V, McLaughlin MA, Vedanthan R. Availability, Use, and Barriers to Cardiac Rehabilitation in LMIC. Glob Heart. 2017;12(4):323-34.e10. doi: 10.1016/j.gheart.2016.09.004.
54. Makita S, Yasu T, Akashi YJ, Adachi H, Izawa H, Ishihara S, et al. JCS/JACR 2021 Guideline on Rehabilitation in Patients with Cardiovascular Disease. Circ J. 2022;87(1):155-235. doi: 10.1253/circj.CJ-22-0234.
55. Fukumoto Y. Barriers to Participation in Cardiac Rehabilitation. Eur J Prev Cardiol. 2025;zwaf225. doi: 10.1093/eurjpc/zwaf225.
56. Fuchs TI, Pfab C, Kiselev J, Schaller SJ, Spies C, Rombey T. Barriers and Facilitators to the Implementation of Prehabilitation for Elderly Frail Patients Prior to Elective Surgery: A Qualitative Study with Healthcare Professionals. BMC Health Serv Res. 2024;24(1):536. doi: 10.1186/s12913-024-10993-2.
57. Sontag AF, Kiselev J, Schaller SJ, Spies C, Rombey T. Facilitators and Barriers to the Implementation of Prehabilitation for Frail Patients into Routine Health Care: A Realist Review. BMC Health Serv Res. 2024;24(1):192. doi: 10.1186/s12913-024-10665-1.
58. Wu F, Laza-Cagigas R, Rampal T. Understanding Patients' Experiences and Perspectives of Tele-Prehabilitation: A Qualitative Study to Inform Service Design and Delivery. Clin Pract. 2022;12(4):640-52. doi: 10.3390/clinpract12040067.
59. Scheenstra B, van Susante L, Bongers BC, Lenssen T, Knols H, van Kuijk S, et al. The Effect of Teleprehabilitation on Adverse Events after Elective Cardiac Surgery: A Randomized Controlled Trial. J Am Coll Cardiol. 2025;85(8):788-800. doi: 10.1016/j.jacc.2024.10.064.
60. Stammers AN, Kehler DS, Afilalo J, Avery LJ, Bagshaw SM, Grocott HP, et al. Protocol for the PREHAB Study-Pre-Operative Rehabilitation for Reduction of Hospitalization after Coronary Bypass and Valvular Surgery: A Randomised Controlled Trial. BMJ Open. 2015;5(3):e007250. doi: 10.1136/bmjopen-2014-007250.
61. Yau DKW, Wong MKH, Wong WT, Gin T, Underwood MJ, Joynt GM, et al. PREhabilitation for Improving QUality of Recovery after Elective Cardiac Surgery (PREQUEL) Study: Protocol of a Randomised Controlled Trial. BMJ Open. 2019;9(5):e027974. doi: 10.1136/bmjopen-2018-027974.
62. Steinmetz C, Heinemann S, Kutschka I, Hasenfuß G, Asendorf T, Rempis BA, et al. Prehabilitation in Older Patients Prior to Elective Cardiac Procedures (PRECOVERY): Study Protocol of a Multicenter Randomized Controlled Trial. Trials. 2023;24(1):533. doi: 10.1186/s13063-023-07511-w.
63. Akowuah E, Mathias A, Bardgett M, Harrison S, Kasim AS, Loughran K, et al. Prehabilitation in Elective Patients Undergoing Cardiac Surgery: A Randomised Control Trial (THE PrePS TRIAL) - A Study Protocol. BMJ Open. 2023;13(1):e065992. doi: 10.1136/bmjopen-2022-065992.
64. Hartog J, Blokzijl F, Dijkstra S, DeJongste MJL, Reneman MF, Dieperink W, et al. Heart Rehabilitation in Patients Awaiting Open Heart Surgery Targeting to Prevent Complications and to Improve Quality of Life (Heart-ROCQ): Study Protocol for a Prospective, Randomised, Open, Blinded Endpoint (PROBE) Trial. BMJ Open. 2019;9(9):e031738. doi: 10.1136/bmjopen-2019-031738.
65. Scheenstra B, Mohansingh C, Bongers BC, Dahmen S, Wouters YIMS, Lenssen TF, et al. Corrigendum to: Personalized Teleprehabilitation in Elective Cardiac Surgery: A Study Protocol of the Digital Cardiac Counselling Randomized Controlled Trial. Eur Heart J Digit Health. 2021;3(1):114. doi: 10.1093/ehjdh/ztob094.
66. López-Baamonde M, Arguis MJ, Navarro-Ripoll R, Gimeno-Santos E, Romano-Andrioni B, Sisó M, et al. Multimodal Prehabilitation in Heart Transplant Recipients Improves Short-Term Post-Transplant Outcomes without Increasing Costs. J Clin Med. 2023;12(11):3724. doi: 10.3390/jcm12113724.



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