v. 5, n. 6, 2025

International Journal of Health Science

Acceptance date: 16/01/2025

IMPACT OF PHYSICAL ACTIVITY MODALITIES ON THE REHABILITATION OF PATIENTS AFTER CORONARY ARTERY BYPASS GRAFT SURGERY

Igor Nathan Isidoro Gomes

Hugo Deleon Carvalho

Bruna Sacagni Domingues

Larissa Rodrigues Michalsky

Acácio Queiroz Silva Neto

Helena Guedes Oliveira

Gustavo Cordeiro Daniel

Gabriel da Costa Silveira

Maria Helena Rocha Mendes Fraga

Gabriel Braga Mendes

Pedro Vinícius Araújo de Abreu

Abstract: Introduction: Physical exercise is essential for the recovery of patients after coronary artery bypass grafting (CABG), improving functional capacity and quality of life. The aim of this study was to analyze how different types of exercise impact this rehabilitation. Methods: A systematic review was carried out using the PICO strategy, with searches in PubMed, LILACS and SciELO. The PRISMA protocol was used to minimize bias, with two independent researchers selecting and collecting data and a third in case of disagreement. Original studies from the last 5 years in English were included, detailing the effects of physical activity in post-CABG patients. Case reports, literature reviews and studies that did not meet the established criteria were excluded. Methodological quality was assessed using the Jadad and Newcastle-Ottawa scales. Results/Discussion: Eight articles were selected. Respiratory muscle training combined with progressive aerobic exercises such as treadmills, cycle ergometers, aquatic training and walking were highlighted as improving physical performance, lung capacity, lipid profile, blood pressure, blood coagulation and cardiac function. Greater adherence to physical activity was observed in medical centers; other environments had interruptions due to discouragement and malaise. Combined resistance and aerobic training improved quality of life and reduced time in the Intensive Care Unit. In contrast, competitive exercise increased the risk of stent thrombosis in patients with Coronary Artery Disease. Aquatic training proved to be as effective as land-based training in improving exercise capacity and reducing NT-proBNP levels. Conclusion: Physical exercise after CABG improves cardiovascular health, but it is essential to adjust the intensity and type of exercise according to the patient. It is crucial that health centers offer suitable environments for physical activity in the rehabilitation phase, increasing adherence to treatment.
Keywords: rehabilitation; training; myocardium; postoperative.

INTRODUCTION

Cardiovascular diseases, especially coronary artery disease (CAD), are the leading cause of mortality in developed countries. In this context, coronary artery bypass grafting (CABG) represents an effective, albeit complex, intervention for patients with advanced CAD, providing a significant resolution to this condition[1, 2].

Coronary artery bypass grafting is a complex surgical procedure used to treat coronary artery disease: grafts are performed to divert blood flow around an obstruction in one or more coronary arteries, helping to restore proper blood flow to the heart muscle. Grafts can be performed using an autologous vein (usually the saphenous vein) or an autologous artery (usually the internal mammary artery or the radial artery). This procedure is only indicated for complex patients, such as those with three--vessel disease, left coronary artery stenosis, ischemic left ventricular dysfunction and severe angina. Despite significantly reducing the risk of adverse cardiac events in these patients, it is important to note that CABG is not without risks and complications, and the clinical success of the procedure depends on subsequent patient management, including cardiac rehabilitation programs and secondary prevention[1, 3].

In Brazil, the number of myocardial revascularization surgeries performed annually is on the rise: between 1995 and 2015, there was a 71% increase in the volume of these surgeries, while the hospital mortality rate declined from 7.6% to 5.9%[4]. This progress can be attributed to the refinement of surgical techniques, improvements in post-operative monitoring and better hospital care[5]. Despite this progress, complications such as atrial fibrillation, prolonged mechanical ventilation and the need for re-intervention still have an impact on patients' prognoses[3], and further observation and the inclusion of rehabilitation and prevention projects in treatment are always essential[6, 7].

In this sense, cardiac rehabilitation (CR) has emerged as a fundamental strategy in secondary prevention for patients undergoing coronary bypass. Exercise-based physical training has been shown to promote not only improved physical performance post-revascularization, but also improvements in circulatory function, muscle oxidative capacity and a reduction in low-density lipoproteins (LDL)[8]. Although both aerobic and resistance training are recognized as beneficial[9], the ideal intensity of physical training to optimize these benefits remains uncertain, given that vigorous exercise can increase the risk of acute coronary events in apparently healthy but untrained middle-aged men[10]. Therefore, it should be thought that the appropriate combination of these modalities, balancing the intensity, is recommended to improve muscle strength, functional capacity and quality of life post-CABG[11,12].

In this context, with a view to clarifying the nuances of this combination, this study aims to review the literature in order to discuss the impact of different types of physical activity on the rehabilitation of patients undergoing coronary bypass, with a view to corroborating a medical approach that efficiently promotes a better quality of life for the patient.

OBJECTIVE

To identify the effects of physical activities performed during the postoperative period of coronary artery bypass graft surgery on patient recovery.

METHODS

This is a systematic review which, using the PICO strategy (Population, Intervention Comparison, Outcome)[13], was based on the following guiding question: "For patients after coronary artery bypass graft surgery (population), what is the impact of different types of physical activity (intervention) - when compared to each other (control) - on their rehabilitation (outcome)?".

A search was conducted for articles available up to March 17, 2024 in the PubMed, LILACS and SciELO databases. In the PubMed and LILACS databases, the following descriptors from the Health Sciences Descriptors (DeCS) were used: "Cardiac Rehabilitation", "Myocardial Revascularization" and "Physical Activity", as well as the Boolean operator "AND". In the SciELO database, the MeSH descriptors "Myocardial Revascularization" and "Physical Activity" were used, as well as the Boolean operator "AND".

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses - The PRISMA Statement[14] - protocol was strictly followed and, in order to avoid bias, the selection of articles and data collection was carried out by two independent researchers and, in the event of disagreements regarding the content or relevance of the sources, a third researcher was called in to make the decision. To this end, the Jadad score[15] - for evaluating clinical trials - and the Newcastle-Ottawa scale[16] - for observational studies - were applied, which, as well as making the selection effective, ensured safety in the analysis of the methodological quality of the selected studies. The following inclusion criteria were established studies objectively detailing the effects and variables (such as intensity and duration) of physical activity in individuals after coronary artery bypass graft surgery using traditional or alternative methods, published in the last 5 years, available in full text and written in En-

glish Single case reports were excluded, literature reviews, duplicate articles or those not related to the guiding question, studies which included patients who had undergone procedures other than coronary artery bypass grafting and studies which did not include physical activity protocols or which did not identify their effects on these patients were excluded.

First, the titles and abstracts of the studies identified were read, discarding any articles that did not address the proposed theme. After this, a critical analysis of the resulting studies in their complete form was prioritized, so that articles that did not meet the inclusion criteria were excluded.

RESULTS

The search of databases based on the development and application of descriptors and eligibility criteria resulted in 42 articles. Of these, after critical analysis, 8 made up this systematic review due to the relevance of their content. Figure 1 shows the flowchart which, following the PRISMA protocol, outlines the process of selecting the studies.

Of the 8 articles, 1 was published in 2018, 3 were published in 2019, 1 was published in 2020, 1 was published in 2021, 1 was published in 2022 and 1 was published in 2023. The studies were carried out in the following countries: Russia (n=1), Brazil (n=2), Indonesia (n=1), France (n=1), China (n=1), Iran (n=1) and Slovenia (n=1). The data on the authors, the objectives, the number and characteristics of the participants, the physical activity carried out and the effects on post-procedure rehabilitation are shown in Table 1. The scores for each study according to the scale used are described in Table 2.

The articles, published over a five-year period, showed the positive effects of physical exercise as an adjunct to cardiac rehabilitation for hospitalized patients who have undergone myocardial revascularization. Among these studies, the most frequently recommended intervention was respiratory muscle training combined with progressive aerobic exercise.

In this respect, in order to monitor the clinical parameters of the groups under analysis, the methodology commonly used consisted of investigating the pathological history and comorbidities[19] associated with each patient, in addition to measuring vital signs and analyzing anthropometric characteristics[20] and electrocardiogram records.

The main result noted was an improvement in physical performance due to greater efficiency in cardiac functionality, which is characterized by improvements in cardiovascular structures in terms of functioning and the prevention of accumulations of atherogenic lipid fractions. As a result, the quality of life of the groups that received the health intervention was also improved in most cases

In addition, it is worth noting that a recurring observation among the collection of articles studied was that patients were more adherent to physical activities during the cardiac rehabilitation process[21,22] when they were carried out in medical centers. This finding contrasts with the interruptions often justified by discouragement and malaise when activities are carried out in other environments.

DISCUSSION

Based on an analysis of the selected studies, the use of physical activities in the post-operative period of coronary artery bypass graft surgery is proving to be incipient in improving the quality of life of these patients. Depending on their modality, they can have different forms and magnitudes of impact on functional rehabilitation. The most commonly used interventions were a variety of aerobic exercises, including treadmill ergometers, cycle ergometers, bicycle training, aquatic training, walking training, Cardiopulmonary Exercise Testing (CPET) and resistance exercises.

As for the impact on cardiovascular health, the studies compiled analyzed, among other factors, the effects of these post-operative exercises on the lipid profile (LDL, VLDL, PCSK9), on the values of the N-terminal pro-hormone B-type natriuretic peptide (NT-proBNP), blood pressure (BP), coagulation factors, left ventricular ejection fraction (LVEF/LVEF) and the incidence of various complications and Major Adverse Cardiac Events (MACE). The impacts on functional capacity - assessed by respiratory muscle strength, pulmonary function tests and lower limb muscular endurance - and on the length of stay in the Intensive Care Unit (ICU) and the overall length of hospital stay were also verified.

With regard to the effects of physical rehabilitation exercises in the post-operative period on the lipid profile, Aronov, David et al.[1] (n= 30) showed that the use of ergonomic bicycles, associated with breathing, strength and endurance exercises, as a method for cardiac rehabilitation resulted in a significant reduction in VLDL values after the first 4 months of training. There was also evidence of an improvement in physical endurance (a 32.6% increase in the intervention group - a value that was maintained after 12 months - compared to only 9.8% in the control group) and an improvement in cardiac efficiency, based on the LVEF value. At the same time, the study conducted by Dwiputra, Bambang et al.6 (n = 87), which analyzed the effects of muscular resistance training - in supervised biceps and quadriceps exercises - on mostly male individuals (88.5% on average), found that the action of the PCSK9 protein (Proprotein Convertase Subtilisin Kexin Type 9) is closely related to upper and lower limb resistance training exercises. This is due to the increase in lipid degradation under the influence of PCSK9, which is accentuated by resistance training. It has been found that a reduction in PCSK9 levels is associated with lower LDL levels and, consequently, a lower risk of cardiovascular disease. In this light, the results of the study indicated that resistance training may provide additional benefits for post-CABG patients by reducing PCSK9 levels, which potentially improves LDL profiles in these patients.

From another perspective, in relation to the maintenance of functional capacity and the incidence of anginal events, Zhang, Quan-Yu et al.[11] (n = 10,609), which included patients undergoing percutaneous coronary intervention for acute coronary syndrome, showed an improvement in quality of life as assessed by the Seattle Angina Questionnaire (SAQ) in the study group. Patients in the intervention group underwent the Cardiopulmonary Exercise Test (CPET), followed by systematic education - through medical and physiotherapeutic follow-up for medication adjustments and the execution of rehabilitation exercises, combined with psychological and nutritional care. The response rate to rehabilitation treatment was 37%, and propensity score matching analysis confirmed the absence of significant differences in baseline characteristics between the control groups and those undergoing cardiac rehabilitation, validating the comparison of results.

In addition, with regard to muscle/aerobic training combined with ventilatory training to improve functional capacity, two studies corroborate the positive impact of combining these two interventions. In the study by Windmoller, Pollyana et al.[5] (n = 31), which included predominantly male (71%) post-CABG patients, there was an analysis of a possible intervention using Continuous Positive Airway Pressure (CPAP) during intense physical activity on a cycle ergometer, with the aim of replacing the physiotherapy commonly used. The results of the study indicated that patients who exercised on a cycle ergometer with CPAP had a significantly shorter

length of stay in the Intensive Care Unit (ICU) and were able to maintain their functional capacity compared to those who followed the step protocol alone. Furthermore, Eibel, Bruna et al[9] (n = 15), who included patients aged between 60 and 75 in the post-operative period of CABG of ischemic origin, also showed similar results. During the assessment of the functional capacity of the groups, they noted that although the conventional training group and the isometric training group started with a higher baseline capacity, after the program the only group that increased functional capacity was the ventilatory training group, showing that cardiopulmonary rehabilitation is of paramount importance for increasing functional capacity after CABG surgery. In this sense, the rehabilitation program based on isometric and, especially, ventilatory training, associated with conventional training, improved the recovery of pulmonary functional capacity and can easily be implemented in a hospital setting, since it is a low-cost program[25]. However, the endothelial function and oxidative stress levels did not show results with the program.

As for the ideal level of exercise intensity for maintaining these benefits in patients, compared to the associated complications, two studies have shown divergent results. Ghardashi-Afousi et al.[17] (n=42) compared 3 groups, 2 of which were intervention groups: a low-volume, high-intensity interval training group (TIAI) and a moderate-intensity continuous training group (TCIM). TIAI training, lasting 6 weeks, was shown to improve heart rate variability (HRV) in post-CABG men. When compared to TCIM, TIAI showed more significant benefits in patients who had previously undergone CABG. These benefits include a reduction in resting heart rate; a greater reduction in diastolic and systolic blood pressure, resting heart rate and end-systolic volume. These factors indicate an improvement in cardiac autonomic modulation, attenuation of pathological remodeling and an increase in ventricular compliance. When combined, they promote a reduction in morbidity and mortality among these patients

In contrast, in a cohort study conducted by Guy, Jean-Michel et al.[10](n = 108), which included men undergoing percutaneous revascularization surgery, divided into 3 post--operative groups: one that would remain in moderate leisure sports (MLS), intense leisure sports (ILS), and competitive sports (CS), it was observed that Major Adverse Cardiac Events (MACE), such as stent thrombosis, were significantly more frequent in patients who practiced CS[23] compared to those who engaged in MLS. No other significant differences were observed in relation to coronary stenosis. Furthermore, the study suggests that in patients with CAD, the balance between fibrinolysis and coagulation during peak exercise seems to be disturbed in favor of coagulation. This is particularly evident during post-exercise recovery, which can increase the risk of stent occlusion[24]. However, moderate resistance training has been shown to have a beneficial effect on red blood cell deformability during exercise, both in sedentary individuals and in patients with CAD. In conclusion, a combination of disturbances in coagulation, increased stress on the arterial wall, dehydration and catecholergic alterations due to intensive exercise could favor the occurrence of stent thrombosis. Therefore, in these cases, intensive physical activity should be conditioned to the monitoring of cardiovascular risk factors.

In the article by Vasic, Danijela et al.[18], the effects of performing aerobic physical exercise were compared in 2 groups: one in a land environment, on a bicycle ergometer, and the other in an aquatic environment, in conditioning activities; both intervention groups underwent supervised aerobic resistance trai-

ning, complemented by calisthenic exercises, performed both in thermoneutral water and on land, at moderate intensity. The results showed that the efficacy and safety of aquatic exercises were comparable to those performed on land in terms of achieving cardiac rehabilitation. The results showed an increase in VpicoO2 in both intervention groups, which was more significant in the aquatic training group. In addition, levels of NT-proBNP, a marker of cardiac dysfunction, decreased in the aquatic training group. However, no significant changes were detected in biomarkers of inflammation, cell adhesion or hemostasis. Aquatic training resulted in a more significant increase in peak oxygen consumption and a reduction in N-terminal prohormone B-type natriuretic peptide levels. These factors are associated with a significant increase in exercise capacity and improved vascular function in patients with coronary artery disease, making aquatic training a beneficial exercise option for these patients.

FINAL CONSIDERATIONS

The practice of physical activity by patients undergoing coronary artery bypass grafting has been shown to have a positive impact on the postoperative period when considering light, moderate and intense interval exercise. Decreased anginal frequency, increased functional capacity, lower cholesterol levels and improved quality of life were the main aspects highlighted. Intense competitive exercise, however, was shown to have a higher risk of causing thrombotic complications in revascularized patients compared to moderate exercise, which is a negative clinical finding that is epidemiologically relevant.

This highlights the importance of having environments prepared to provide adequate support for the practice of physical activity during the rehabilitation phase in health centers, in order to increase adherence and obtain its benefits.

CONFLICT OF INTEREST

All the authors declare that there are no possible conflicts of interest regarding this work.

FINANCING

The article did not require funding.

AUTHORS' CONTRIBUTION

All the authors contributed significantly to the development of this work. Gomes INI, Silveira GC, Abreu PVA participated in the selection and collection of articles. Carvalho HD participated in the data analysis. Neto AQS, Domingues BS, Oliveira HG, Michalsky LR, Daniel GC took part in drafting and correcting the final text. Fraga MHRM, Mendes GB took part in revising and drafting the abstract. Gomes INI and Neto AQS took part in formatting the text according to the standards of the Brazilian Medical Student Journal. Corso RB guided all stages of this work.

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