Literature Review

Physiotherapeutic intervention in the postoperative period of myocardial revascularization: systematic review

Atuação fisioterapêutica no pós-operatório de revascularização miocárdica: revisão sistemática

André Rodrigues Carvalho[1]
Izabelle Macedo de Sousa[2]

[1]Corresponding author. Centro Universitário Mauricio de Nassau (Teresina). Piauí, Brazil. andre-dez@hotmail.com
[2]Centro Universitário Mauricio de Nassau (Teresina). Piauí, Brazil. izabelle_macedo@hotmail.com

ABSTRACT | INTRODUCTION: Myocardial revascularization surgery is the main treatment for advanced coronary artery disease and has proven to be effective, but its potential for postoperative complications directly interferes in the evolution of patients. To minimize the deleterious effects of the surgery, physiotherapy should be started as soon as possible. **OBJECTIVES:** To review the knowledge about the physiotherapeutic performance in the postoperative period of myocardial revascularization. **MATERIALS AND METHODS:** It consisted of a systematic review in the PubMed, SciELO, BHS and PEDro databases through the crossing of the key words myocardial revascularization, physical exercise and rehabilitation. Randomized clinical trials of Portuguese and English origin published between 2014 and 2019 that related the physiotherapeutic performance in the postoperative period of myocardial revascularization were included. Duplicate articles, studies that presented intervention only in the preoperative phase, studies which compared the use of pharmacological methods or other surgical procedures, research intentions, studies that showed inadequacy of the proposed subject and PEDro score below 5 were excluded. **RESULTS:** 12 studies were included because they met the eligibility criteria. The total sample included 435 adult patients of both sexes aged between 30 and 70 years. They were submitted to aerobic, anaerobic and respiratory exercises, electrotherapy, phototherapy and non-invasive mechanical ventilation. **CONCLUSION:** The procedures commonly performed by physiotherapy in the postoperative phase of myocardial revascularization include techniques related to respiratory physiotherapy and progressive mobilization. Among the interventions employed, aerobic exercise has been the most evident modality in terms of numbers regarding its benefits.

KEYWORDS: Myocardial revascularization. Physical exercise. Rehabilitation.

RESUMO | INTRODUÇÃO: A cirurgia de revascularização miocárdica é o principal tratamento para a doença arterial coronariana avançada e se mostra eficaz, porém seu potencial para complicações pós-operatórias interfere diretamente na evolução dos pacientes. Para minimizar os efeitos deletérios da cirurgia, a fisioterapia deve ser iniciada logo que possível. **OBJETIVOS:** Revisar os conhecimentos a respeito da atuação fisioterapêutica no pós-operatório de revascularização miocárdica. **MATERIAIS E MÉTODOS:** Constituiu-se de uma revisão sistemática nas bases de dados PubMed, SciELO, BVS e PEDro por meio do cruzamento das palavras-chave revascularização miocárdica, exercício físico e reabilitação. Foram incluídos ensaios clínicos randomizados de origem portuguesa e inglesa, publicados entre 2014 a 2019 que relacionassem a atuação fisioterapêutica no pós-operatório de CRM. Foram excluídos os artigos duplicados, estudos que apresentaram intervenção apenas na fase pré-operatória, que compararam a utilização de métodos farmacológicos ou outros procedimentos cirúrgicos, intenções de pesquisa, inadequação ao tema proposto e score PEDro inferior a 5. **RESULTADOS:** 12 estudos foram incluídos por preencherem os critérios de elegibilidade. A amostra total foi de 435 pacientes adultos, de ambos os sexos com idades entre 30 e 70 anos. Estes foram submetidos a exercícios aeróbios, anaeróbios e respiratórios, eletroterapia, fototerapia e ventilação mecânica não invasiva. **CONCLUSÃO:** As condutas comumente realizadas pela fisioterapia na fase de pós-operatório de revascularização miocárdica incluem técnicas relacionadas a fisioterapia respiratória e mobilização progressiva. Dentre as intervenções empregadas o exercício aeróbio tem sido a modalidade com maior número de evidências a respeito dos seus benefícios.

PALAVRAS-CHAVE: Revascularização miocárdica. Exercício físico. Reabilitação.

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Introduction

Coronary artery disease (CAD) is a major health problem and is one of the leading causes of death worldwide, in addition to generating disability and loss of quality of life[1-3]. According to the World Health Organization (WHO), 17.5 million people die each year from cardiovascular diseases, in which 75% of these deaths occur in low and middle income countries[4]. Risk factors for CAD are usually associated with lifestyle, environmental exposure, family history, hypertension, smoking and dyslipidemias[5].

Surgical myocardial revascularization (SMR) is the standard treatment for advanced CAD[6]. Its performance aims at improving survival, preventing acute myocardial infarction, reinfarction, improving ventricular function and relieving anginal symptoms[3]. However, despite its effectiveness, this surgery is a highly invasive procedure and often associated with a long period of bed rest, cardiorespiratory failure, loss of strength and muscle mass and postoperative complications[7,8].

Cardiopulmonary complications are the most frequent during the postoperative period of SMR and are usually related to intraoperative factors. It is believed that prolonged supine position, thoracic manipulation, pleural drainage, analgesic effects and cardiopulmonary bypass lead to changes in lung mechanics, which can negatively interfere with volumes, capacities and respiratory muscle strength[9-12]. To minimize the deleterious effects of SMR, the cardiopulmonary rehabilitation program is crucial in the recovery of patients and should be initiated as soon as possible[3].

Cardiopulmonary rehabilitation is a therapy developed by a multiprofessional team that offers support in physical, psychic, social, vocational and spiritual aspects. The physiotherapist as an integral part of this team that acts in the recovery of lost function, prevention of cardiopulmonary events and education on healthy living habits[9,13].

Recently, randomized clinical trials have reported the efficacy of cardiopulmonary rehabilitation programs during the postoperative period of SRM, however, systematic reviews related to the theme have not been identified in the current literature. Considering this context, the aim of this work is to review the knowledge regarding physiotherapeutic performance during the postoperative period of SRM.

Materials and methods

The present study is a systematic review, elaborated according to PRISMA recommendations, which consists of a checklist with 27 items and a four-step flowchart used to help the authors to improve the systematic review and meta-analysis reports[14].

The articles used in this review were selected from the PubMed, SciELO, BVS and PEDro databases by crossing the keywords myocardial revascularization, exercise and rehabilitation, which were related through the Boolean operators "AND" and "NOT" and followed the terms of the DeCS and MESH descriptors. The detailed search strategy for PubMed is illustrated in Chart 1.

Chart 1. PubMed database search strategy (October, 2019)

- 1 myocardial revascularization
- 2 myocardial revascularization AND exercise
- 3 myocardial revascularization AND exercise AND rehabilitation
- 4 myocardial revascularization AND exercise AND rehabilitation NOT pharmacology
- 5 myocardial revascularization AND exercise AND rehabilitation NOT pharmacology (filters: Clinical Trial)
- 6 myocardial revascularization AND exercise AND rehabilitation NOT pharmacology (filters: Clinical Trial, 5 years)

Eligibility Criteria

Randomized clinical trials published in English and Portuguese between the years 2014 and 2019 that related the physiotherapeutic performance in the postoperative period of SRM were included. The population studied was that of adult patients of both genders, without upper age limit, submitted to emergent, urgent or elective SRM who participated in any of the phases of a cardiopulmonary rehabilitation program.

Exclusion criteria: duplicate articles among the databases, studies that presented intervention only in the preoperative phase, studies that compared the use of pharmacological methods or other surgical procedures, research intentions, studies that showed inadequacy of the proposed subject and PEDro score below 5.

Assessment of methodological quality and risk of bias

The methodological quality of the studies was assessed according to the criteria of the PEDro[15] scale, which scores 11 items, namely: 1 - Eligibility criteria, 2 - Random allocation, 3 - Hidden allocation, 4 - Baseline comparability, 5 - Blind participants, 6 - Blind therapists, 7 - Blind assessors, 8 - Proper follow-up, 9 - Intent to treat analysis, 10 - Group comparisons, 11 - Point estimates and variability. Items are scored as present (1) or absent (0), generating a maximum sum of 10 points, and the first item is not counted.

The assessment of bias risk was performed through the Cochrane collaboration tool composed of seven domains: 1- Generation of random sequence, 2- Concealment of allocation, 3- Blinding of participants and professionals, 4- Blinding of outcome assessors, 5- Incomplete outcomes, 6- Selective outcome report, 7- Other bias sources. These areas have been classified into three categories: low risk of bias, high risk of bias or risk of uncertain bias[16].

Selection and analysis of studies

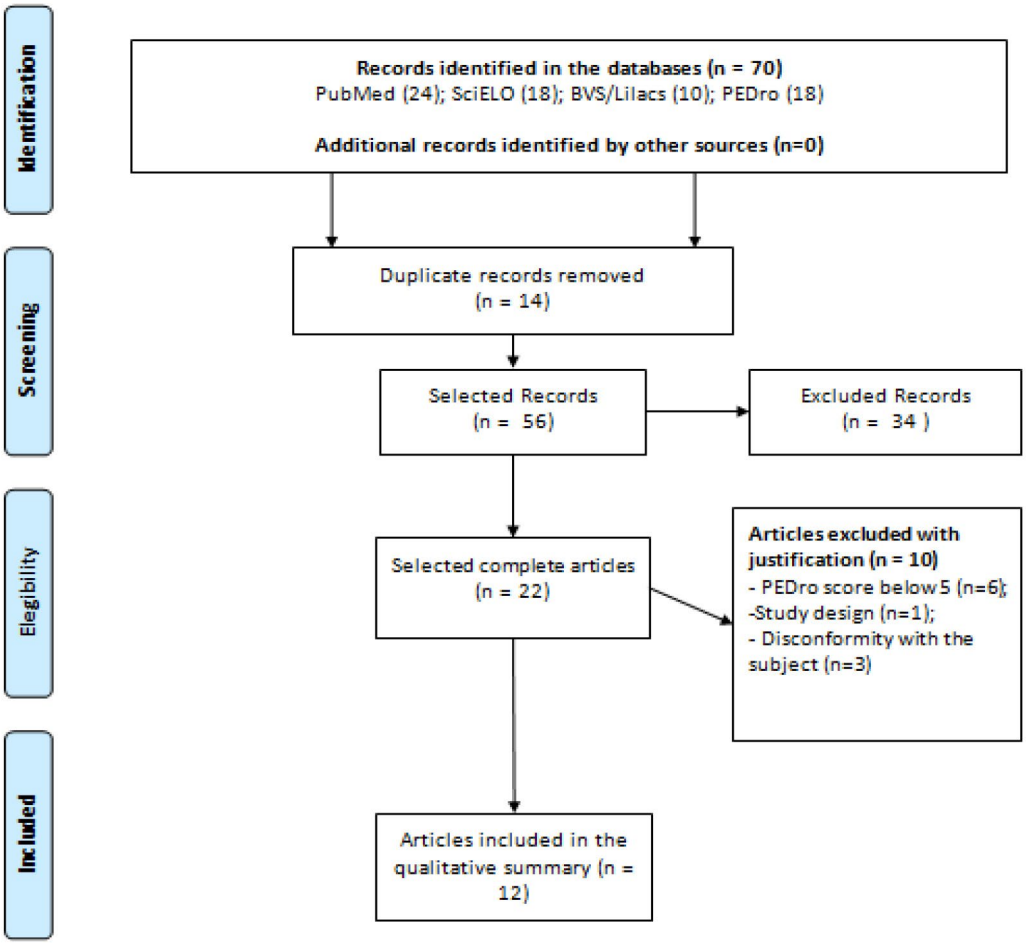
The database search was conducted in March and October 2019. The articles were initially selected by reading the title and abstract, then studies which are potentially relevant to the review were analyzed by reading the full text in order to confirm the eligibility criteria.

The analysis of the studies took place in two stages. The first step was to identify the general characteristics of the studies: Year of publication, objectives, sample and study design. In the second stage, the studies were analyzed in detail for extraction of the interventions employed, outcomes analyzed and results obtained. This information was summarized, compared and expressed in tables.

Results

In the initial research, 410 articles were identified: PubMed (339), BVS/LILACS (35), SciELO (18), PEDro (18). After applying the "clinical trial" and "last 5 years" filters, there were 70 studies potentially relevant to the review, of which 48 were excluded because they did not meet the eligibility criteria, resulting in 22 articles for detailed analysis. After analysis of the full texts, 6 were excluded because they had a PEDro score of less than 5, 1 because of the study design and 3 because they did not comply with the proposed review. The selection process of the studies is completely described in the flowchart of Figure 1.

Figure 1. Systematic search flowchart of studies with population undergoing SRM (March - October, 2019)



The included studies obtained a total of 435 adult participants, of both sexes aged between 30 and 70 years. They were submitted to aerobic, anaerobic and respiratory exercises, electrotherapy, phototherapy and non-invasive mechanical ventilation. These interventions were carried out in an isolated, comparative or associated manner.

The effects of aerobic exercises were the most investigated, and the results were used in seven studies[3,9,17,19-21,23], followed by respiratory exercises which were used in four studies[6,19,21,22] and non-invasive mechanical ventilation, used in three studies[17,22,24]; laser therapy, electrotherapy and anaerobic exercise were used in 1, 18 and 21 studies, respectively. Characterization of samples, the interventions employed and the main results obtained in the included studies are outlined in Table 1, the studies are organized in descending order according to the scores acquired in the PEDro score.

Table 1. Description of the randomized clinical trials included in the systematic review of the population undergoing SRM (March - October, 2019)

Authors	PEDro Score	Sample	Intervention	Results
Stein et al. [1]	8	15 male patients (60 ± 9 years).	Lasertherapy	Low power laser therapy did not improve functional capacity or oxidation markers after CRM.
Pantoni et al. [17]	7	27 patients of both sexes	Aerobic exercise + NIV (CPAP)	CPAP can positively influence exercise tolerance, ventilatory function and respiratory pattern after SRM.
Cipriano et al. [18]	7	38 patients	Electrotherapy	TENS in the region of the stellate ganglion positively impacted the femoral blood flow during a sympathetic stimulation maneuver, a beneficial effect associated with better clinical and functional results.
Miozzo et al. [19]	7	24 patients between the ages of 30 and 70.	Aerobic exercise + TMI	TMI was unable to provide additional benefits to aerobic training.
Borges et al. [20]	6	34 patients	Aerobic exercise	Aerobic exercise can promote maintenance of functional capacity, with no impact on lung function and respiratory muscle strength when compared to conventional physiotherapy.
Trevisan et al. [3]	6	24predominantly male patients with a mean age of 60 years	Aerobic exercise	There was an increase in the maximum distance covered at the TW6 in the intervention group compared to the control group.
Hermes et al. [21]	6	24 patients	Aerobic + anaerobic + TMI exercise	IMTcan complement the effects of aerobic exercise combined with anaerobic.
Graetz; Moreno22	6	15 male patients, between 30 and 60 years old	Respiratory exercises + PEEP	The protocols of respiratory physiotherapy were not able to reestablish the pulmonary capacity of patients after SRM.
Szylinska et al. [9]	5	104 adult patients of both sexes	Aerobic exercise	Hospital physiotherapy compared to home exercises is more effective.
Huang et al. [23]	5	49 patients	Aerobic exercise	Aerobic training decreases the absolute type I and II monocyte count and attenuates platelet heteroaggregation, which makes it effective in modulating thrombosis and inflammation.
Tashiro et al. [24]	5	66 patients of both sexes with an average age of 69 years.	Self-adaptive servo-ventilation	Adaptive servo-ventilation reduced the occurrence of atrial fibrillation during the postoperative period and the duration of hospitalization.
Cavalcante et al. [6]	5	39 patients of both sexes with a mean age of 61.95 ± 8.5 years	Respiratory exercises	Changes in pulmonary function did not differ significantly between groups. However, the same did not occur with neurocognitive function, which showed a decline in the intervention group, but not in the control group.

Key: NIV = Noninvasive ventilation; CPAP = Continuous positive airway pressure; TENS = Transcutaneous electrical nerve stimulation; IMT = Inspiratory muscle training; TW6 = 6-minute walk test; PO = Postoperative; PEEP = Positive end expiratory pressure; SRM = Surgical Myocardial revascularization.

The main parameters investigated were functional capacity, pulmonary function, respiratory muscle strength and hemodynamic status. Functional capacity was the main outcome evaluated, this was measured in four studies using the 6-minute walk test[3,18-20]; Stein et al.[1] used the incremental walk test, Pantoni et al.[17] used the exercise time in 300 seconds and Huang et al.[23] used the ergometric test. Pulmonary function was assessed in four studies[6,9,20,22] using spirometry; respiratory muscle strength was assessed in four studies[19-22] using manovacuometry and hemodynamic status was assessed in four studies[1,17,23,24]. The main hemodynamic variables observed were heart rate, arterial pressure and partial oxygen saturation. The parameters and evaluation measures used in the studies are expressed in Table 2.

Table 2. Parameters and evaluation measures used in the studies included in the systematic review of the population undergoing SRM (2019)

Authors	Evaluated Parameters	Evaluation measures
Stein et al. [1]	✓ Functional capacity ✓ Perceived effort ✓ hemodynamic state ✓ Tissue damage and oxidative stress marker	✓ Incremental walk test ✓ Borg effort scale ✓ Pulse oximetry ✓ PA ✓ Blood sample
Pantoni et al. [17]	✓ Functional capacity ✓ Perceived effort ✓ Respiratory pattern ✓ hemodynamic state	✓ Exercise time in 300 seconds ✓ Borg effort scale ✓ Plethysmography ✓ Pulse oximetry
Cipriano et al. [18]	✓ Sympathetic stimulation ✓ Functional capacity ✓ WFP ✓ Blood flow	✓ Cold pressure test ✓ TC6 ✓ Oscillometry ✓ Doppler ultrasound
Miozzo et al. [19]	✓ Functional capacity ✓ VO2 max ✓ Respiratory muscle strength ✓ Peripheral muscle strength ✓ Quality of Life	✓ TC6 ✓ Ergometric test ✓ Manovacuometry ✓ Test sit and stand ✓ Quality of Life Questionnaire - SF-36
Borges et al. [20]	✓ Pulmonary function ✓ Respiratory muscle strength ✓ Functional capacity	✓ Spirometry ✓ Manovacuometry ✓ TC6
Trevisan et al. [3]	✓ Functional capacity	✓ TC6 ✓ Pulse oximetry ✓ Blood pressure ✓ Borg effort scale
Hermes et al. [21]	✓ Respiratory muscle strength ✓ VO2 peak ✓ Quality of Life	✓ Manovacuometry ✓ Ergometric test ✓ *Minnesota Living with Heart Failure Questionnaire*
Graetz; Moreno22	✓ Pulmonary function ✓ Inspiratory muscle strength ✓ Radiological changes	✓ Spirometry ✓ Manovacuometry ✓ Chest radiography
Szylinska et al. [9]	✓ Pulmonary function	✓ Spirometry
Huang et al. [23]	✓ Functional capacity ✓ hemodynamic state ✓ Analysis of inflammatory biomarkers and platelet aggregation.	✓ Ergometric test ✓ Pulse oximetry ✓ PA ✓ Blood sample
Tashiro et al. [24]	✓ Hemodynamic state	✓ FC ✓ PA ✓ Echocardiogram
Cavalcante et al. [6]	✓ PO clinical complications ✓ Pulmonary function ✓ Cognitive function	✓ Analysis of medical records ✓ Spirometry ✓ *Digit Span Test* ✓ Benton Revised Visual Retention Test *Trail Making Test* ✓ Digit-Symbol Substitution subtest of the Wechsler Adult Intelligence Scale-Revised

Key: BP= Blood Pressure; MAP= Mean Blood Pressure; HR= Heart Rate; TW6= 6-minute walk test; VO2= Oxygen Volume; Minnesota *Living with Heart Failure Questionnaire=; Digit Span Test,* Trail Making Test.

The bias risk assessment showed that 75% of the studies exhibited little detail related to allocation or blinding, thus receiving the classification of "uncertain risk" for one or both of these domains. Two studies were rated "high risk" for random sequence generation, two studies for blinding professionals and participants, one for blinding outcome assessors and one for concealed allocation. Chart 2 represents the full assessment of the risk of bias.

Chart 2. Assessment of Bias risk of studies included in the systematic review according to the Cochrane collaboration tool (2019)

Authors/year / **Domains (Cochrane)**	Stein et al. [1]	Pantoni et al. [17]	Cipriano et al. [18]	Miozzo et al. [19]	Borges et al. [20]	Trevisan et al. [3]	Hermes et al. [21]	Graetz; Moreno [22]	Szylinska et al. [9]	Huang et al. [23]	Tashiro et al. [24]	Cavalcante et al. [6]
Random sequence generation	BR	BR	BR	BR	BR	AR	RI	RI	AR	RI	RI	BR
Concealed allocation	BR	BR	BR	BR	RI	AR	RI	RI	RI	RI	RI	RI
Blinding of participants and professionals	BR	AR	RI	RI	AR	RI	RI	RI	RI	RI	RI	RI
Blinding of outcome assessors	BR	RI	BR	BR	AR	RI	BR	RI	RI	RI	RI	RI
Incomplete outcomes	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR
Selective outcome report	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR
Other bias sources	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR

Key: AR= High risk of bias; BR= Low risk of bias; RI= Uncertain risk.

Discussion

Despite the evolution of surgical and anesthetic techniques, SRM still imposes a huge burden on the patient's homeostasis, which may lead to complications in the postoperative period and interfere in their recovery. The main complications found in this type of surgery are: decline in pulmonary and/or cognitive function, infections, arrhythmias, acute myocardial infarction, acute renal failure and reduced functional capacity[6,9].

All patients included in the studies demonstrated some degree of respiratory and/or physical impairment, which makes it necessary to use physiotherapeutic interventions that optimize lung and functional capacity in order to reduce post-surgical mortality and morbidity rates[24].

Studies such as Trevisan et al.[3], Pantoni et al.[17], Borges et al.[20] and Graetz and Moreno[22] described the protocols commonly employed in the hospital phase of cardiopulmonary rehabilitation. The respiratory techniques employed in these protocols included bronchial hygiene maneuvers, assisted coughing, pulmonary re-expansion techniques, respiratory functional re-education and breathing exercises. In concomitance the breathing techniques decubitus changes, sedation, orthostasis, active-assisted progressive exercises and walking were performed.

Some studies used as intervention for the control group, conventional protocols employed in the hospital phase in order to compare the effects of complementary therapies. Trevisan et al.[3] when comparing the effects of a cycle ergometer protocol in replacement of the standard hospital walking and stairway exercises observed that the group submitted to aerobic training with cycle ergometer had a better performance in TW[6].

A similar result to this was found by Borges et al.[20] when including aerobic training and cycle ergometer in the conventional physiotherapy protocol. This implies hospital phase of cardiopulmonary rehabilitation, since it is able to optimize the functional capacity of patients undergoing SRM.

Corroborating these results, Huang et al.[23] demonstrated that short-term intensive aerobic training can decrease the absolute type I and II monocyte count and attenuate platelet heteroaggregation, which makes it effective in modulating thrombosis and inflammation.

However, despite the benefits of aerobic training, many patients become intolerant to exercise in the early postoperative period. Pantoni et al.[17] associated aerobic training with CPAP and observed that there was a positive influence not only on exercise intolerance, but also on pulmonary function and respiratory pattern.

Following this same line of research, Hermes et al.[21] associated physical training with IMT. The results of this study found that an IMT program associated with aerobic and anaerobic exercise can reduce exercise intolerance and potentiate the effects of cardiopulmonary rehabilitation.

In contrast, the results obtained by Miozzo et al.[19] showed that IMT was not able to promote additional effects to aerobic training. However, the study displayed some limitations, such as the absence of a nonintervention group to compare results, nonbinding of participants and therapists, and a loss of approximately 30% of participants initially allocated to the intervention group. These factors may be strictly related to this unfavorable outcome.

Two studies used electrothermophototherapy aimed at maximizing functional capacity. Based on the assumption that phototherapic treatment with low intensity laser attenuates muscle fatigue and enhances muscle recovery after exercise, Stein et al.[1] proposed the use of laser therapy in order to optimize functional capacity. However, the use of laser therapy has not improved functional capacity or oxidation markers after SRM. However, this outcome may have been influenced by a small and heterogeneous sample of participants in the control and intervention groups.

On the other hand, Cipriano et al.[18] confirmed the hypothesis that TENS over the stellate ganglion region would reduce sympathetic over-stimulation and improve femoral blood flow after SRM, which has a positive impact on clinical and functional outcomes in this population.

Cavalcante et al.[6] were the only ones to evaluate the impact of intensive physiotherapeutic intervention on cognitive function. The protocol used in their study was based on respiratory kinesiotherapy techniques. The results of this study showed improvement in neurocognitive functions, especially in patients who received more sessions of respiratory physiotherapy per day, suggesting that more stimulated patients have better neurocognitive development.

This study has some limitations that should be pointed out: the heterogeneity of the interventions and evaluation measures employed made it difficult to compare the results obtained in the research. Some interventions, such as laser therapy and electrotherapy were investigated in only one study, which makes it necessary to do more research on the effects of electrothermophototherapy after SRM. In addition, most studies showed little detail regarding the allocation and blinding of participants, assessors and therapists, which implies an increased risk of bias in the studies.

Conclusion

The procedures commonly performed by physiotherapy in the postoperative phase of SRM include techniques related to respiratory physiotherapy and progressive mobilization. Among the interventions employed, aerobic exercise has been the most evident modality regarding its benefits.

Author contributions

Carvalho AR participated in the conception, design, search, analysis of research data and writing of the scientific article. Sousa IM supervised the research and participated in the writing and critical review of the manuscript.

Competing interests

No financial, legal, or political conflicts involving third parties (government, corporations, private foundations, etc.) have been declared on any aspect of the work submitted (including, but not limited to grants and funding, participation in advisory board, study design, preparation of manuscript, statistical analysis, etc.).

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