v. 5, n. 11, 2025

International Journal of Health Science

Acceptance date: 18/02/2025

THE EFFECT OF EARLY MOBILIZATION AND BREATHING EXERCISES IN POST-CARDIAC SURGERY PATIENTS[1]

Giovana Laura Bernardini Sccoco
Fisioatividade, Unieduk

Maria Isabelle Neves de Oliveira
Fisioatividade, Unieduk

Luana Schneider Vianna
Fisioatividade, Unieduk

Jardiel Silva
Fisioatividade, Unieduk

1. Article presented to obtain the title of Postgraduate in Hospital Physiotherapy.

Abstract: Objective: The general objective of this study is to analyze the effects of early mobilization breathing exercises on post-cardiac surgery patients, comparing the techniques with each other. In addition, to carry out a correlation analysis between them. **Methods**: This is a systematic review study, with exploratory objectives, of the bibliographic type, with a qualitative approach. Initially, 330 articles were found in the various . After exclusion for more than five years of publication, the number of articles decreased to 125. 70 articles were excluded by title, 39 articles by abstract, 6 articles by full text, leaving 10 articles which were included in the research. **Results**: 4 studies showed an increase in Maximum Inspiratory Pressure after breathing exercises and one reported an improvement in Peak-VO2, SPO2 and respiratory rate. After early mobilization, 3 studies showed an increase in peripheral muscle strength and better performance in the 6-minute walk test. Another 2 studies reported a gain in functional capacity. 9 of the 10 studies stated that the combined techniques improved quality of life and vitality, thus reducing the length of hospital stay. **Conclusion:** Early Mobilization was found to be effective in the recovery of post-cardiac surgery patients, especially in terms of quality of life. Respiratory exercises promoted an increase in functional capacity and inspiratory muscle strength. The use of these techniques together demonstrated an effective improvement for the patient, with most studies showing a reduction in hospitalization time.
Keywords: Respiratory Therapy; Respiratory Muscles; Spirometry; Cardiac Rehabilitation; Thoracic Surgery; Intensive Care Unit.

INTRODUCTION

Early mobilization (EM) is a technique based on kinesiotherapy which includes: passive mobilization, active exercises, positioning in bed and the use of a cycle ergometer; with the aim of keeping the musculoskeletal system intact and, as a result, good lung capacity, since it is known that immobility has secondary aggravations such as pulmonary atelectasis, pneumonia, embolism, alterations to the cardiovascular system (volume of distribution of body fluids), among others.[1-3] PM is used to stimulate post-surgical patients who have been in the ICU for 72 hours or 48 hours on invasive (IMV) and non-invasive mechanical ventilation (NIMV).[4]

IMV is a resource that promotes artificial respiration by means of a device called a Mechanical Ventilator attached to the patient via a tube inserted into the oral cavity, nasal cavity or directly (tracheostomy) into the trachea, with the aim of totally or partially relieving the patient's work of breathing, i.e. reducing the energy needed to move a certain volume of gas through the airways and expand the lung, enabling gas exchange to occur at the alveolar level.[5]

NIMV also involves the use artificial ventilation, but without the need for endotracheal prostheses. The connection between the patient and the mechanical respirator is via special nasal or facial masks, thus maintaining the same principles and objectives as IMV.[6]

The best-known PM protocol is divided into 5 levels, which are defined as follows according to the conditions and characteristics each patient. **Level 1**: Unconscious patient. Stretches and passive mobilization are performed. **Level 2**: The patient by coming into contact with the medium, obeys simple commands. Active-assisted or free exercises and transfers are added. **Level 3**: The patient has grade 3 muscle strength in the upper limbs. Active exercises against gravity, transfer from lying to sitting and cycle ergometer for lower limbs. **Level 4:** The patient has grade 3 lower limb strength and trunk control. Transfer exercises from the armchair to the orthostatic position are added. **Level 5:** In this last stage, the patient must be trained balance and walking. [1, 7]

There are some barriers to the practice of MP, such as cardiovascular instability, the presence of drains, the level of sedation and muscle weakness, which are associated with invasive mechanical ventilation, especially when there is endotracheal or nasotracheal intubation. In patients with a tracheostomy, greater variations in mobilization are allowed, and complications should always be avoided during the technique.[7]

A number of scales are used to adapt PM to patient characteristics: MRC (Medical Research Council), Surgical Optimal Mobility Score (SOMS)[8], Glasgow Coma Scale[9], Manovacuometry[10, 11], Perme Intensive Care Unit Mobility Score - PERME[12], Hand Grip/Dynamometry, FSS-ICU.[11, 13]

There are several studies that prove the effectiveness of PM in relation to the length of ICU stay and the improvement of the clinical condition, thus reducing the rate of mortality and readmission after hospital discharge.[8]

With regard to the respiratory system, one of the main causes of complications after heart surgery is respiratory muscle weakness due to immobility. This weakness generates an inadequate inspiratory effort, which leads to slow mucociliary clearance, a loss of the sigh mechanism and subsequently to decreased lung volumes, which directly impairs gas exchange. There are also cases in which patients stay for a longer period of time, dependent on mechanical ventilation and drugs that are administered to maintain the condition, generating an even greater impairment to the systems, especially thinking about sarcopenia, which is the loss of muscle mass, and this is directly related to the longer length of hospitalization.[14]

Breathing exercises have been widely used around the world as a non-pharmacological therapy for the treatment of people with these disorders. Considering that the function of the respiratory muscles is affected, especially the diaphragm, the main function of respiratory muscle training is to increase muscle strength according to the patient's functional limitation, which is measured by certain tests and scales.[15]

In hospital settings, the main test that assesses muscle strength is the measurement of maximum inspiratory and expiratory pressures, using a device called a monovacuum meter. MIP is obtained through maximum inspiratory effort sustained for 2s from maximum expiration at the residual volume level. And MEP is obtained through maximum expiratory effort, sustained for at least 2s from maximum inspiration at the level of total lung capacity.[15, 16]

Several recent studies have proven the effectiveness of breathing exercises in post-cardiac surgery patients, reducing the loss of inspiratory (diaphragmatic) muscle strength, demonstrated by the increase in maximum inspiratory pressure, improving pulmonary gas exchange and oxygen saturation.[16]

Considering that one of the roles of the intensive care physiotherapist is to prevent muscle weakness the respiratory and motor systems, in order to reduce hospitalization time, optimize recovery of functionality and improve neuromuscular condition, it was necessary to carry out this research relating both techniques, in order to analyze the relevance and effectiveness of each.

The general aim of this study is to analyze the effects of PM as well as those of breathing exercises on post-cardiac surgery patients, comparing the techniques with each other. In, to carry out a correlation analysis between them.

METHOD

It is a systematic review study, with exploratory objectives, of the bibliographical type, with a qualitative approach.

Articles were searched in the following databases: Bireme, Cochrane, Lilacs, PEDro, PubMed and Scielo. The search strategy was based two clinical queries structured with the terms Health Science Descriptors (DeCS): "effect", "physical", "exercise, "respiratory", "therapy", "cardiac", surgery.

The descriptors were all cross-referenced with each other in the PEDro databases, and two searches were carried out, the first: "effect", "physical", "exercise", "respiratory", "therapy", "cardiac", "surgery", without the use of Boolean operators, while the second search was carried out without the descriptor "surgery".

Two searches were also carried in the Scielo database, the first for "effect", "physical", "exercise", "respiratory", "therapy", "cardiac", "surgery" and the second for "effect".

The other databases, Bireme and Lilacs, used all the descriptors and were , but without Boolean operators, just like the other searches.

In PUBMED, the descriptors were the same, "effect", "physical", "exercise", "respiratory", "therapy", "cardiac", "surgery", but a 5-year filter was used to select the articles, which the database itself provides, to refine the search and reduce the results.

The first search was carried out on the Bireme platform and found 67 articles, 3 studies on Scielo, 3 studies on Lilacs, 20 articles on PEDro and 237 articles on PubMed; however, by applying a 5-year filter, this last search decreased to 100 articles.

The inclusion criteria were articles from the last 5 years, in English, Spanish and Portuguese. With post-operative cardiac surgery patients, hospitalized in intensive care or outpatient. The exclusion criteria were patients with associated neurological pathologies, postoperative pulmonary surgery, participants under 18 years of age and pregnant women.

The articles were searched independently and blindly by two physiotherapist reviewers, strictly complying with the inclusion and exclusion criteria, and finally separating out the papers with potential relevance.

When the title and summary of the initial sample were unclear, we looked for the full article. Only papers whose full texts were available were considered for critical appraisal, as well as Portuguese, English and Spanish languages. The study designs selected were randomized clinical trials, controlled clinical trials, systematic reviews with or without meta-analysis.

RESULTS

Initially, 330 articles were found in the various databases. After exclusion for more than five years of publication, the number of articles decreased to 125. 70 articles were excluded by title, 39 articles by abstract, 6 articles by full text, leaving 10 articles which were included in the research.

DISCUSSION

The strength of this systematic review study is its affirmation of efficacy of PM and breathing exercises. It was possible to affirm that PM really does promote a better quality of life for the patient and a reduced length of stay, as confirmed by Zanini et al.4, who describe the different stages of early mobilization, from active exercise of the upper limbs and lower limbs to ambulation. This article also mentions bronchial hygiene procedures, which are beneficial for respiratory conditions.

Another study showing the effect of PM associated with breathing exercises was Chen et al.17, in which the efficacy was compared with improvement in the TUG and functional capacity, as well as an increase in strength. The control group received conventional physiotherapy, which did not show as much improvement compared to PM associated with breathing exercises.

DOI https://doi.org/10.22533/at.ed.1595112518028

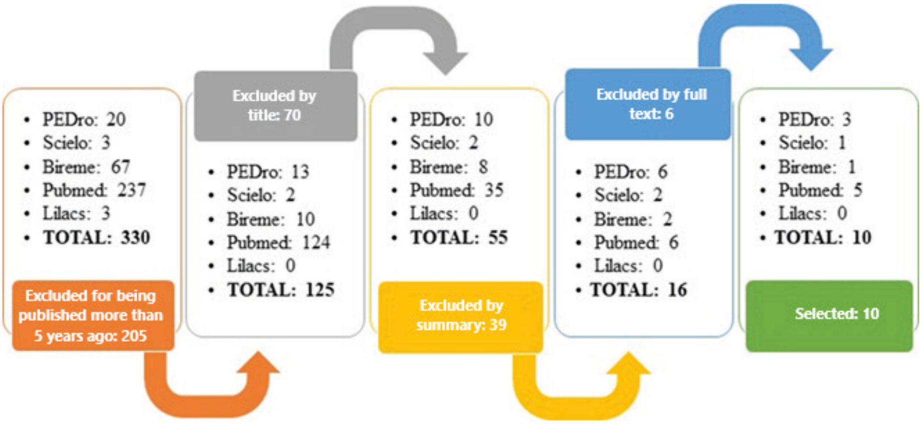

Image 1: Flowchart showing the article selection and exclusion processes.

AUTHORS	TYPE OF STUDY	METHODS	INTERVENTIONS	SCALES/ASSESSMENTS	RESULTS
Turky, K Afify, A	Randomized Clinical Trial	N=40, coronary bypass graft surgery. Intervention group N= 20 Control group N = 20	TMI with Powerbreathe Plus, Powerbreathe International, Warwickshire 3 sets of 10 repetitions, with deep inhalations for 30 to 60 seconds GC = early mobilization, but no respiratory muscle training.	Borg scale (fatigue) Muscle power	An increase in maximum inspiratory pressure was obtained in GI compared to CG. GI= 71.58 and GC = 37,44. In addition O2 saturation, which also showed improvement in GI= 98.85 and GC=97,85.
Aquino, T N Rosseto, S F Vaz, J L Alves, C F C Vidigal, F C Galdino, G	Randomized controlled clinical trial	N = 83, undergoing coronary artery bypass graft surgery Intervention group (RMT+ PMT) N= 42 Control group N= 41 (conventional physiotherapy)	Conventional physiotherapy RMT: Muscle strength training respiratory using Threshold IMT and PEP device (Respironics) PMT: knee flexion and extension exercise, digiflex in both hands, 3 sets of 10 repetitions	Manovacuometry (respiratory muscle strength) Dynamometry (peripheral muscle strength) 6MWT (physical conditioning) 36-item Short-Form Health Survey (SF-36, quality of life.) VAS (pain)	The intervention group showed less muscle weakness inspiratory (p < 0.025, 95% CI: 2,29 [1,9; 27,54]). The control group had worse physical functioning (p< 0.004, 95% CI: 3,03 [5,9; 29,52]), pain (< 0.004, 95% CI: 3,08 [5,21; 24,97]), vitality (p < 0.16, 95% CI: 2,51 [2,12; 19,53]) and social functioning (p < 0.15, 95% CI: 2.55 [3,07; 26,39]) with respect to the baseline.
Chen, J Zhang, T Bao, W Zhao, G Chen, Z	Randomized study	N = 34, undergoing heart valve surgery. Control group N= 16 Intervention Group N= 17	Individualized mobilization and ambulation. Breathing exercises (deep breathing 3 sets of 5 repetitions and cough stimulus).	Dynamometry (peripheral muscle strength) TUG (risk of falling)	There was an increase in peripheral muscle strength GC= 17.43 and GI=20,58. And a reduction the TUG time in the intervention group GC= 6.46s and GI= 6.32s.
Miozzo, A P	Randomized clinical trial	N = 20, undergoing heart valve surgery. Control group N= 10 (aerobic) Intervention Group N= 10 (aerobic + TMI)	Aerobic exercise. High-intensity IMT (five sets of 10 repetitions, progressing according to the week)	Stand and sit test (peripheral muscle strength) Manovacuometry (respiratory muscle strength) Life questionnaire, SF 36 6MWT (physical conditioning)	There was an improvement all outcomes in both groups, but high-intensity IMT was unable to provide additional benefit in most outcomes: Pins maximum: GAE= 100 and GAE + IMT= 120. Maximum Pexp: GAE = 130 and GAE + IMT 150.
Santos, T D	Randomized Clinical Trial	N = 24 Intervention group N= 12 Control group N= 12	TMI using the POWERbreathe Medic Plus device. Aerobic and resistance exercise.	Minnesota Living with Heart Failure Questionnaire (MLHFQ); Manovacuometry (respiratory muscle strength) 6MWT (physical conditioning) Spirometry (lung capacity)	In the intervention group, there were increases in VO2 peak (22.5%), in distance walked during the 6MWT (30.3%), in the MIP values (33.7%), FVC and FEV1, and quality of life (60.5% reduction in the scores of the MLHFQ), exceeding all the values of the control group. Only PEmax showed no statistical difference between the groups.

Tariq, M I Khan, A A Farheen, H Siddiqi, A Amjad, I	Randomized controlled trial	N = 174 patients undergoing heart valve surgery Intervention Group N = 87 Control group N= 87	Mobilization in bed (sitting on the edge of the bed for 5 minutes)+ exercises) Motor physiotherapy (stationary walking, 10 steps and 1-2 minutes standing next to the bed) Breathing exercises (breathing deep, incentive spirometry, blow bottle, cough)	Borg scale (fatigue)	SatO2: was better in the GI= 90 while in the GC= 86 FR: better in GI = 22 while in the CG= 26. In addition to reducing hospital stays.
Kanejima, Y Shimogai, T Kitamura, M Ishihara, K Izawa, K P	Systematic review and meta-analysis	N= 591 studies involving patients undergoing open heart surgery. N = 6 after exclusion of duplicates, exclusion by title, by abstract and by reading the full text.	Early mobilization (passive range of motion and ambulation) Respiratory physiotherapy (deep breathing exercises, incentive spirometry and IMT)	6MWT (physical conditioning)	Early mobilization led to a 54 m increase in the 6MWT result, according to the meta-analysis, GI= 299 to 433m, while GC= 272 to 331m.
Zanini, M Nery, R M Lima, JB Bühler, R P Silveira, A D Stein, R	Randomized clinical trial	N = 40, undergoing coronary artery bypass graft surgery. G1 N= 10 + active training upper limbs and lower + early ambulation G2 N= 10 + active training upper limbs and lower + early ambulation+ CPT G3 N = 10 TMI+ CPT G4 N= 10 Control group CPT	Early wandering MMSS and MMII active training TMI (Threshold Philips Respironics) CPT: Bronchial hygiene therapy, deep breathing EPAP: expiratory positive airway pressure	TC6 Spirometry (lung capacity) Manovacuometry (respiratory muscle strength)	Early mobilization interventions reduced loss of function in the hospital environment and the recovery of these patients after one month of surgery was faster.
Manapunsopee, S Thanakiatpinyo, T Wongkornrat, W Chuay-choo, B Thirapatarapong, W	Randomized clinical trial	N = 90, undergoing heart valve surgery. Intervention Group N= 47 (9 removed) Control Group N= 43 (10 withdrawn)	TMI (incentive spirometry: Pulmo-gain; Phartrillion Co. Ltd, Bangkok, Thailand) Coughing techniques DBE (deep breathing) Early wandering MMSS and MMII active training	Spirometry (lung capacity)	+incentive spirometry: improvement in inspiratory muscle strength compared only to the DBE group. No difference between pulmonary complications and length of stay in hospital.
Windmöller, P Bodnar, E T Casagrande, J Dallazen, F Schneider, J Berwanger, S A Borghi-Silva, A Winkelmann, E R	Randomized clinical trial	N= 59 patients undergoing coronary artery bypass graft surgery N = 42 were randomized N = 31 completed the program.	Cycle ergometry CPAP	6MWT (physical conditioning) Manovacuometry (respiratory muscle strength) 1-minute sit and stand test.	Cycle ergometry, combined with CPAP, reduced the length of stay in the ICU and helped with maintaining functional capacity. TC6: GC= 180.81 m GI= 216.47 m

Table 1: summary of the characteristics and results of each of the articles included in the literature review.

Caption: N= number participants MIP= maximal inspiratory pressure maximal expiratory pressure IMT= inspiratory muscle training CG= control group IG= intervention group RMT= respiratory muscle strength training VAS= visual analogue scale PMT= peripheral muscle training GAE= aerobic exercise group VO2= oxygen volume FVC= forced vital capacity 6MWT= 6-minute walk test TUG= Timed up and go FEV1= expired volume in the first minute RR= respiratory rate CPT= bronchial hygiene therapy, deep breathing EPAP= positive expiratory airway pressure DBE= deep breathing CPAP= continuous positive airway pressure ICU= intensive care unit.

When breathing exercises are included, there is a clinically significant improvement in physical function and in the inspiratory muscles for hospital discharge, reducing the length of stay in the ICU and helping to maintain functional capacity. The articles by Aquino et al[18] and Turky et al[19] addressed the effect of inspiratory muscle training breathing exercises in isolation, whether using powerbreath, threshold or incentive spirometry.

Aquino[18] used conventional physiotherapy in one intervention group (he didn't describe the procedure) and in another group inspiratory muscle training (IMT) with threshold and PEP device, associated with peripheral muscle exercises, without determining the volume and intensity of the training, as well as the use of digiflex for the hands. Turky[19] did not perform any type of early mobilization or peripheral muscle training exercise, but demonstrated the effectiveness of TMI / powerbreathe plus in increasing inspiratory pressure and saturation.

Another study that used inspiratory muscle training as an intervention was by Tamires Santos[20], but in this article aerobic and resistance training were used in addition to inspiratory muscle training. The study by Miozzo et al[15] also compared inspiratory muscle training and aerobic training. Both studies had positive results and improved inspiratory muscle strength. The finding of aerobic training was not the aim of our study, but it showed benefits anyway. Windmöller et al21 also associated aerobic training with the use of a cycle ergometer with aerobic training associated with CPAP, when necessary, and inspiratory muscle training with a monovacuum meter, obtaining a reduction in length of stay and maintenance of functional capacity according to the 6MWT result.

There were also studies that associated the two approaches: early mobilization and inspiratory muscle training. The first was by Muhammad Tariq[22] who used bed mobilization, sedation, motor physiotherapy (stationary walking) and breathing exercises (incentive spirometry and cough stimulation). The results showed an improvement in saturation, respiratory rate and a reduction in hospitalization time.

The second study by Kanejima et al[3] showed an improvement in the 6MWT after early mobilization and respiratory physiotherapy. An analysis of psychoeducation (sleep disturbance, stress) was carried out, an important point in this article, since none of the others selected observed the psycho-educational problems developed in patients during their hospitalization.

The third study by Manapunsopee et al[13] showed that the combination of early mobilization plus inspiratory muscle training exercises did not reduce the length of hospital stay as observed in other studies. This study used deep breathing exercises, which no previous study has mentioned.

In addition, there were findings that differed from what was expected in order to meet our objectives, such as the patient returning to their daily functions normally with a reduction in sequelae and deficits. Another finding was in the study by Aquino et al, where it was possible to find that breathing and muscle exercises have an effect on reducing patients' pain in the postoperative period.

There is a wide variety of exercises within early mobilization, as well as variations in intensity, training volume, training time and frequency of practice, as as different equipment for inspiratory muscle training, which can influence the outcome. However, at the same time, it possible to assess that the combination of the two approaches is beneficial for the patient and their prognosis, in terms of length of stay, functional improvement, and gain in muscle strength, which consequently influences length of stay.

The limitations present in this study are: years of publication of the articles, heterogeneity in the type of studies selected and the languages chosen, since 12 articles were selected, 9 are randomized clinical trials, 2 are systematic reviews and 1 is a cohort study.

CONCLUSION

Early Mobilization was found to be effective in the recovery of post-cardiac surgery patients, especially in terms of quality of life. Breathing exercises, on the other hand, promoted an increase in functional capacity and inspiratory muscle strength. The use of these techniques together has demonstrated an effective improvement for the patient, with most studies showing a reduction in hospitalization time.

REFERENCES

1. Fontela PC, Forgiarini LA, Friedman G. Clinical attitudes and perceived barriers to early mobilization of critically ill patients in adult intensive care units. Rev Bras Ter Intensiva. 2018;30:187–194. doi: 10.5935/0103-507X.20180037. Cited: in: : PMID: 29995084.

2. Fontela PC, Lisboa TC, Forgiarini-Júnior LA, Friedman G. Early mobilization practices of mechanically ventilated patients: A 1-day point-prevalence study in southern Brazil. Clinics. 2018;73. doi: 10.6061/CLINICS/2018/E241. Cited: in: PMID: 30379221.

3. Kanejima Y, Shimogai T, Kitamura M, Ishihara K, Izawa KP. Effect of early mobilization on physical function in patients after cardiac surgery: A systematic review and meta-analysis. Int J Environ Res Public Health. 2020;17:1–11. doi: 10.3390/ijerph17197091. Cited: in: : PMID: 32998202.

4. Zanini M, Nery RM, de Lima JB, Buhler RP, da Silveira AD, Stein R. Effects of Different Rehabilitation Protocols in Inpatient Cardiac Rehabilitation after Coronary Artery Bypass Graft Surgery: A RANDOMIZED CLINICAL TRIAL. J Cardiopulm Rehabil Prev. 2019;39:E19–E25. doi: 10.1097/HCR.0000000000000431. Cited: in: : PMID: 31343586.

5. Worraphan S, Thammata A, Chittawatanarat K, Saokaew S, Kengkla K, Prasannarong M. Effects of Inspiratory Muscle Training and Early Mobilization on Weaning of Mechanical Ventilation: A Systematic Review and Network Meta-analysis. Arch Phys Med Rehabil. W.B. Saunders; 2020. p. 2002–2014.

6. Perkins GD, Mistry D, Lall R, Gao-Smith F, Snelson C, Hart N, Camporota L, Varley J, Carle C, Paramasivam E, et al. Protocolised non-invasive compared with invasive weaning from mechanical ventilation for adults in intensive care: The Breathe RCT. Health Technol Assess (Rockv). 2019;23:vii–114. doi: 10.3310/hta23480. Cited: in: : PMID: 31532358.

7. Miranda Rocha AR, Martinez BP, Maldaner da Silva VZ, Forgiarini Junior LA. Early mobilization: Why, what for and how? Med Intensiva. Ediciones Doyma, S.L.; 2017. p. 429–436.

8. da Silva Maldaner VZ, de Araújo Neto JA, Cipriano G, Pinedo M, Needham DM, Zanni JM, Silva Guimarães F. Brazilian version of the functional status score for the ICU: Translation and cross-cultural adaptation. Rev Bras Ter Intensiva. 2017;29:34–38. doi: 10.5935/0103-507X.20170006. Cited: in: : PMID: 28444070.

9. Jain S ILM. Glasgow Coma Scale [Internet]. [cited 2022 Dec 21]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK513298/.

10. Costa D, Gonçalves HA, Peraro De Lima L, Ike D, Cancelliero KM, Imaculada M, Montebelo L. New reference values for maximal respiratory pressures in the Brazilian population [Internet]. J Bras Pneumol. 2010. Available from: www.jornaldepneumologia.com.br.

11. Schnaider J, Karsten M, de Carvalho T, Celso de Lima W. Influência da força muscular respiratória pré-operatória na evolução clínica após cirurgia de revascularização do miocárdio Influence of preoperative respiratory muscle strength on clinical evolution after myocardial revascularization surgery. 52 Fisioter Pesq. 2010.

12. Pereira CS, de Carvalho AT, Bosco AD, Forgiarini LA. The Perme scale score as a predictor of functional status and complications after discharge from the intensive care unit in patients undergoing liver transplantation. Rev Bras Ter Intensiva. 2019;31:113–121. doi: 10.5935/0103-507X.20190016. Cited: in: : PMID: 30970092.

13. Manapunsopee S, Thanakiatpinyo T, Wongkornrat W, Chuaychoo B, Thirapatarapong W. Effectiveness of Incentive Spirometry on Inspiratory Muscle Strength After Coronary Artery Bypass Graft Surgery. Heart Lung Circ. 2020;29:1180– 1186. doi: 10.1016/j.hlc.2019.09.009. Cited: in: : PMID: 31735684.

14. Sieck GC. Physiology in perspective: The importance of integrative physiology. Physiology. American Physiological Society; 2017. p. 180–181.

15. Miozzo AP, Stein C, Marcolino MZ, Sisto IR, Hauck M, Coronel CC, Plentz RDM. Effects of high-intensity inspiratory muscle training associated with aerobic exercise in patients undergoing CABG: Randomized clinical trial. Braz J Cardiovasc Surg. 2018;33:376–383. doi: 10.21470/1678-9741-2018-0053. Cited: in: : PMID: 30184035.

16. Kulkarni SR, Fletcher E, McConnell AK, Poskitt KR, Whyman MR. Pre- operative inspiratory muscle training preserves postoperative inspiratory muscle strength following major abdominal surgery - A randomised pilot study. Ann R Coll Surg Engl. 2010;92:700–705. doi: 10.1308/003588410X12771863936648. Cited: in: : PMID: 20663275.

17. Chen J, Zhang T, Bao W, Zhao G, Chen Z. The effect of in-hospital physiotherapy on handgrip strength and physical activity levels after cardiac valve surgery: A randomized controlled trial. Ann Palliat Med. 2021;10:2217–2223. doi: 10.21037/apm-20-2259. Cited: in: : PMID: 33725776.

18. de Aquino TN, de Faria Rosseto S, Lúcio Vaz J, de Faria Cordeiro Alves C, Vidigal F de C, Galdino G. Evaluation of respiratory and peripheral muscle training in individuals undergoing myocardial revascularization. J Card Surg. 2021;36:3166–3173. doi: 10.1111/jocs.15698. Cited: in: : PMID: 34085324.

19. Turky K, Afify AMA. Effect of Preoperative Inspiratory Muscle Training on Alveolar-Arterial Oxygen Gradients after Coronary Artery Bypass Surgery. J Cardiopulm Rehabil Prev. 2017;37:290–294. doi: 10.1097/HCR.0000000000000234. Cited: in: : PMID: 28169983.

20. Tamires Daros dos Santos. Efeitos do treinamento muscular inspiratório de alta intensidade associado ao exercício aeróbico e resistido pós revascularização do miocárdio. SANTA MARIA ; 2017.

21. Windmöller P, Bodnar ET, Casagrande J, Dallazen F, Schneider J, Berwanger SA, Borghi-Silva A, Winkelmann ER. Physical exercise combined with cpap in subjects who underwent surgical myocardial revascularization: A randomized clinical trial. Respir Care. 2020;65:150–157. doi: 10.4187/respcare.06919. Cited: in: : PMID: 31988253.

22. Muhammad Iqbal Tariq AAKZKHFFAS and IA. Effect of Early 3 Mets (Metabolic Equivalent of Tasks) of Physical Activity on Patient's Outcome after Cardiac Surgery. Journal of the College of Physicians and Surgeons Pakistan. 2017;27 (8):490– 494.