REVIEW ARTICLE

EVALUATION OF PREOPERATIVE BREATHING TECHNIQUES ON FUNCTIONAL MOBILITY IN ON-PUMP VERSUS OFF-PUMP CORONARY ARTERY BYPASS GRAFT PATIENTS: A COMPREHENSIVE REVIEW

Wajeeha Sahar[1], Asita Elengoe[1], Anjum Jalal[2], Syeda Aiman Batool[3], Zulfiqar Haider[2], Hafiza Madiha Jaffar[3]

[1]Lincoln University College, Malaysia, [2]Punjab Institute of Cardiology, Pakistan, [3]The University of Lahore, Pakistan

This review investigates and contrasts the effects of various preoperative chest rehabilitation techniques in patients undergoing coronary artery bypass graft (CABG) surgery, both on-pump and off-pump. Utilizing databases such as Pedro, Cochrane, and PubMed, a comprehensive literature review was conducted, focusing on studies published between 2017 and 2023. We identified 14 relevant articles that met specific inclusion and exclusion criteria, examining the effects of preoperative physiotherapy in adult patients undergoing CABG surgery. Preoperative physiotherapy encompasses a variety of approaches, including counselling, cardiovascular exercise, instruction on breathing techniques, and inspiratory muscle training (IMT). Numerous studies have highlighted the benefits of integrating these methods, such as reducing the risk of postoperative pulmonary complications, shortening hospital stays, achieving earlier extubation, and decreasing anxiety. Despite these findings, further research is needed to evaluate the effectiveness of combination therapies, particularly those involving IMT, in preoperative physical therapy. The goal is to develop a comprehensive understanding of the mechanisms through which these treatments reduce pulmonary complications post-surgery.

Keywords: Coronary artery bypass graft, chest physiotherapy, breathing exercises, preoperative treatment, on-pump CABG, off-pump CABG, pulmonary complications

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INTRODUCTION

Coronary artery disease (CAD) remains a leading cause of death worldwide, affecting both developed and developing nations. Its prevalence is largely attributed to factors such as poor dietary habits, obesity, tobacco use, and insufficient physical activity.[1] Coronary artery bypass graft (CABG) surgery is a well-established intervention for improving ventricular function and survival rates in patients with CAD. However, this procedure carries a risk of postoperative pulmonary complications (PPCs), including pneumonia, atelectasis, respiratory failure, pneumothorax, and bronchospasm.[2] While advancements have reduced mortality associated with PPCs, these complications still pose significant challenges, leading to prolonged hospital stays, increased healthcare costs, and psychological impacts such as anxiety.[3]

Physical therapy plays a crucial role in the preoperative and postoperative care of CABG patients by providing targeted exercises, education, and emotional support. Despite its importance, preoperative physical therapy is not always administered, nor consistently recommended. This review aims to explore recent literature to identify and characterize various preoperative physiotherapy interventions for patients undergoing CABG surgery.[4]

CABG surgery is integral in treating complex CAD by enhancing myocardial perfusion and alleviating symptoms. Two primary techniques are employed in CABG: the traditional on-pump method and the off-pump method. Each technique has distinct advantages and drawbacks. Enhancing pulmonary function preoperatively to reduce the risk of PPCs is a critical component of care for these patients. Preoperative chest physical therapy, encompassing techniques like incentive spirometry, deep breathing exercises, and airway clearance methods, is now standard practice in many cardiac surgery programs.[5] This review aims to provide a comprehensive analysis of preoperative chest physical therapy techniques and their impact on

patient outcomes, with a focus on both on-pump and off-pump CABG procedures.[6]

The choice between on-pump and off-pump CABG remains a topic of ongoing debate.[7] On-pump CABG provides a stable surgical field and precise coronary artery anastomosis but is associated with higher risks of complications, including potential neurological impairments and systemic inflammatory response syndrome.[8] Conversely, off-pump CABG eliminates the need for cardiopulmonary bypass, potentially reducing these risks, though it can be more challenging to graft smaller coronary arteries and maintain a clear operative field.[9]

Uses of Chest Physiotherapy: Preoperative chest physical therapy is well-established as a beneficial adjunct to CABG, correlating with improved lung function, reduced atelectasis, and lower incidences of PPCs.[10] However, research comparing the effectiveness of preoperative chest physical therapy in on-pump versus off-pump CABG patients is still emerging. This review critically assesses the current literature on various preoperative chest physical therapy techniques and their impact on outcomes for CABG patients treated with both surgical methods.[11]

Coronary Artery Bypass Graft: CABG surgery is a common treatment for complex CAD, improving myocardial perfusion, reducing angina, and extending patient survival. Improving lung function preoperatively is especially crucial for patients undergoing on-pump procedures to minimize the risk of postoperative lung complications. Preoperative chest physical therapy has thus become a critical component of the overall treatment strategy.[12]

On-pump CABG, which relies on cardiopulmonary bypass (CPB), is a cornerstone of cardiac surgery.[13] This method allows precise coronary artery anastomosis without compromising systemic circulation, but it poses risks of pulmonary dysfunction and postoperative atelectasis, particularly in elderly patients or those with pre-existing lung conditions.[14]

Significance of Chest Physical Therapy: Given the importance of preoperative chest physical therapy, various techniques are employed to enhance pulmonary function and mitigate respiratory issues. These include incentive spirometry, airway clearance techniques, and deep breathing exercises. Preoperative chest physical therapy not only reduces the risk of pulmonary complications but also enhances overall patient outcomes and surgical experiences.[15]

Despite its recognized importance, preoperative chest physical therapy is still evolving, with continuous advancements necessitating a comprehensive evaluation to identify best practices.[16] This review aims to synthesize current knowledge and provide insights into optimizing preoperative chest physical therapy to improve patient outcomes, reduce healthcare costs, and enhance care for on-pump CABG patients.[17]

Scope of Literature Search: This review conducted a literature search spanning from 2017 to 2023 across several databases, including Pedro, Cochrane, and PubMed. Search terms included exercise treatment, rehabilitation, physical therapy modalities, breathing exercises, cardiac surgery procedures, and coronary artery bypass graft. The review focused on studies involving adult patients undergoing stand-alone CABG surgery who received preoperative physiotherapy interventions. Excluded were studies on pediatric populations, other types of cardiac surgery, and articles exclusively focusing on postoperative physiotherapy. The goal is to provide a detailed analysis of preoperative chest physical therapy's impact on CABG patient outcomes.

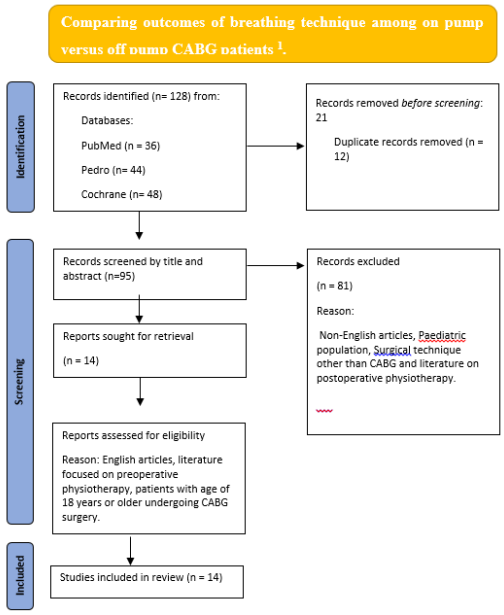

Figure 1: Prisma Flow Diagram

Through a rigorous methodological process, an initial pool of 128 studies was identified. By meticulously applying predefined inclusion and exclusion criteria, this selection was narrowed down to 14 articles, which form the basis of our subsequent discussion (Table 1). The selected studies include 9 randomized controlled trials, 2 systematic reviews, 1 cohort study, 1 observational follow-up study, and 1 descriptive case study. To assess the quality and reliability of these

studies, we employed the evaluation criteria from the Scottish Intercollegiate Guidelines Network (SIGN).

Both systematic reviews included in the analysis provided valuable insights for clinical practice and established a foundation for future research. However, a limitation of the first review was the lack of a graded assessment of the level of evidence for various outcomes, particularly concerning small clinical trials.[18] Additionally, the relatively limited number of studies available for inclusion in the first review presented another significant constraint.[19]

The quality of the selected studies varied widely, from good to poor, as noted in another review that encompassed a larger number of studies but showed substantial heterogeneity. Some articles provided detailed insights into their study design and data analysis, enhancing our understanding of the intervention outcomes.[20] For example, one study reported results related to PPC with a 95% confidence interval [0.30–0.92], noting that both groups were similar at baseline. However, such detailed reporting was not possible in other studies due to differences in gender composition within the domiciliary program groups.[21]

Table 1: Characteristics of selected studies

Author and year of publication	Number of participants	Study design	Intervention	Results
Gomes Neto et al., 2017 [22]	1	Descriptive – Case study	Analysis of a descriptive case by applying the broad suggestions based on earlier review research.	The majority of the recommendations proved advantageous for the particular case under examination, it is essential to underscore the significance of customizing these interventions to align with the unique condition of each individual patient. Preoperative care should encompass both aerobic exercises and respiratory exercises like Inspiratory Muscle Training (IMT).
Perelló-Díez & Paz-Lourido, 2018 [19]	60	Randomized controlled trial	Breathing exercises, instruction on how to use an incentive spirometer properly, and teaching coughing techniques that work. These activities also encompass mobility exercises, muscle strengthening through low-intensity aerobic workouts, and carried out once daily in the 15 days leading up to the cardiac surgery.	Preoperative respiratory physiotherapy can positively impact and enhance respiratory performance, leading to improvements in parameters like Forced Vital Capacity (FVC) and overall respiratory quality.
Yau et al., 2021 [23]	2689	Systematic review	A total of 17 studies incorporated a combination of approaches, including education, physical exercise, counseling, Inspiratory Muscle Training (IMT), and complex interventions involving elements such as breathing exercises and multidisciplinary interventions.	Utilizing a preoperative intervention, specifically IMT, leads to a decrease in postoperative pulmonary complications (PPC) and a shorter hospitalization duration among elderly patients.
Sobrinho et al., 2017 [24]	70	Randomized controlled trial	Engaging in daily preoperative respiratory exercises and 40% of the initial maximum inspiratory pressure is the threshold-IMT intensity. (MIPc). This regimen includes completing 3 sets of 10 repetitions with 2-minute rest intervals between each set.	The pulmonary physiotherapy regimen enhances preoperative MIPc and MEPd levels while concurrently reducing the length of hospitalization following surgery.
Cook et al., 2023 [25]	346	Cohort study	Participating in daily Inspiratory Muscle Training (IMT) for 20 minutes, commencing with an initial inspiratory load set at 30% and progressively augmenting it by 5% according to the Borg's scale. Simultaneously, patients are provided with instruction on postoperative techniques. This regimen is adhered to once daily during the fortnight preceding cardiac surgery.	Incorporating IMT as a part of preoperative physiotherapy for CABG patients is a viable option. Nevertheless, its effectiveness in preventing pneumonia among individuals at high risk remains uncertain.
Hulzebos et al., 2018 [26e]	856	Systematic review	A total of 8 studies that incorporated a combination of breathing exercises, aerobic exercise, and Inspiratory Muscle Training (IMT).	Engaging in physiotherapy preoperatively leads to a decrease in postoperative pulmonary complications, including atelectasis and pneumonia, as well as a shorter hospitalization duration.

Chen et al., 2019 [27]	117	Randomized controlled trial	A holistic treatment approach that combines mild physical exercise with a program designed to alleviate psychological stress.	In light of the modest effects noted according to this study, it is advised to contemplate an intervention duration that extends beyond two weeks prior to surgery.
Bano et al., 2023 [28]	64	Prospective screening	Engage in cycling times a day on an ergometer for cycling for a duration of 10 minutes each session. Maintain a BORG rating of 3 during the first session and increase it to 4 during the second session. Additionally, incorporate till the time of hospital discharge, use breathing techniques and follow conventional clinical musculoskeletal motions.	The 6-Minute Walk Test did not reveal any statistically significant differences between the groups with cyclists covering 402 ± 93 meters and walkers covering 417 ± 86 meters (P = 0.803). Additionally, there was no significant difference in the 6-Minute Cycle Ergometer Test (6MCA) results, as cyclists achieved 15.0 ± 6.4 kJ compared to walkers with 14.0 ± 6.3 kJ (P = 0.798). Similarly, there was no significant distinction in health-related quality of life between the groups.
Moradian et al., 2017 [29]	98	RCT	On the first postoperative day (1st POD), spend 15 minutes sitting at the bedside with legs hanging. On the second postoperative day (2nd POD), sit at the bedside for 5 minutes, followed by a 10-meter walk and a 30-meter night walk. On the third postoperative day (3rd POD), walk 30 meters both prior to and following the chest tube's removal.	The treatment group exhibited higher PaO2 levels on the third day postoperative (3DPO) and a higher percentage of SaO2 on the fourth day postoperative (4DPO) with a significance level of $P < 0.05$, in contrast to the control group. Overall, there was a reduction in the therapy group's incidence of pleural effusion and atelectasis.
Turky & Afify, 2017 [7]	40	RCT	Perform inspiratory muscle training (IMT) twice a day, with each session consisting of three sets lasting 10 minutes each. Apply a load of 30% of Maximum Inspiratory Pressure (MIP), introducing a pause of 30 to 60 seconds between sets. Adjust the resistance incrementally based on the Borg scale; increase by 2 cmH2O or half a turn if the Borg score is below 5, and decrease by 1 to 2 cmH2O in cases where the Borg score is between 9 and 10. Additionally, engage in early mobilization (EM) by strolling around the hallways and around the bed.	The intervention group demonstrated notable enhancements ($P < 0.05$) in inspiratory muscular power and arterial oxygen gradients in alveoli throughout all measurement points.
Zanini et al., 2019 [30]	30 G1, G2, G3 (10,10,10)	RCT	Group 1 (G1) follows a regimen involving inspiratory muscle training (IMT) with a load set at 20% of Maximum Inspiratory Pressure (MIP), consisting of 10 sets of 10 breaths each. This is complemented by active upper and lower limb exercise, including twice-daily early walks, conventional pulmonary therapy, and adherence to the Borg scale at an intensity of 11. Group 2 (G2) adheres to the same protocol as G1, excluding the IMT sessions. Instead, they engage in conventional pulmonary therapy and maintain a Borg scale intensity of 11. Group 3 (G3) undertakes targeted muscle training for inspiration (TMI) with a load equivalent to 20% of MIP, involving 10 sets of 10 breaths twice a day. Additionally, they incorporate conventional pulmonary therapy into their routine.	Both G1 and G2 exhibited a more efficient recovery of functional capacity (FC) by the 6th day postoperative, and this superiority persisted for more than 30 days following discharge, with a statistically significant difference between the groups ($P < 0.001$).

Cui et al., 2020 [31]	194	RCT	On the first postoperative day (1st POD), transition from sitting on the bed to sitting on a chair at the bedside with legs hanging, followed by a 10-minute session, and incorporate standing for 3 to 5 minutes, repeated five times. On the second postoperative day (2nd POD), continue the activities from the 1st POD, and additionally include a minimum 20-minute walk with encouragement to increase intensity and frequency up to five times. On the third postoperative day (3rd POD), extend the activities to sitting out of bed for 10 minutes, standing for 5 minutes, and walking for a minimum of 20 minutes with assistance. Encourage increased intensity and frequency up to five times.	The intervention group (IG) experienced a significant decrease in hospital stay following surgery in comparison to the control group (CG) ($P = 0.031$). There was no notable the two groups' differences in atelectasis and pulmonary infection ($P > 0.05$). The intervention group demonstrated a quicker return to physiological functional capacity and a more rapid recovery compared to the control group ($P < 0.001$), as well as superior PO_2 values between the intervention and control groups ($P = 0.001$). Additionally, the incidence of post-traumatic stress disorder (PTSD) was considerably lower in the intervention group than in the control group ($P < 0.001$).
Steinmetz et al., 2020 [32]	230	RCT	Engage in a preoperative exercise program over two weeks, with supervised sessions on the exercise bike three times a week. Maintain an intensity at 70% of VO2peak. Each training session consists of two aerobic exercises with cycling durations progressing from 10 minutes in the first session to 25 minutes in the sixth session. The program also incorporates 15 minutes of light gymnastics between the aerobic exercises, featuring breathing techniques and chair coordination exercises. The progression includes two sessions of 15 minutes each in the second and third sessions, followed by two sessions of 20 minutes each in the fourth and fifth sessions.	A total of 171 patients 81 participants in the intervention group (IG) and 90 participants in the control group (CG) finished the trial. Preoperative functional capacity (FC) showed significant improvement in the IG compared to the CG, as indicated by the 6-Minute Walk Test (6MWTIG: from 443.0 ± 80.1 m to 493.5 ± 75.5 m, $P = 0.003$) and the Timed Up and Go test (TUGIG: from 6.9 ± 2.0 s to 6.1 ± 1.8 s, $P = 0.018$). Quality of life (QoL) also saw a significant improvement in the IG (from 5.1 ± 0.9 to 5.4 ± 0.9, $P < 0.001$) compared to the CG. Furthermore, postoperatively, the IG exhibited additional improvements in FC, including a decrease in the 6-Minute Walk Distance (6MWDIG: Δ-64.7 m, pT1 - T3 = 0.013; Δ + 47.2 m, pT1 - T4 < 0.001) and a reduction in the Timed Up and Go test duration (TUGIG: Δ + 1.4 s, pT1 - T3 = 0.003).
Windmöller et al., 2020 [33]	31	RCT	Utilize an exercise bike in conjunction with Positive Expiratory Pressure Therapy (PEPPA) at a pressure of 10 cmH2O. Conduct a single daily session on the second postoperative day (2POD) for a maximum duration of 20 minutes, and on the third (3POD) and fourth (4POD) postoperative days, extend each session to a maximum of 30 minutes. The exercise intensity is estimated to reach up to 30 beats per minute of Heart Rate Reserve (HRR), with the target SpO2 set at a maximum of 90% without the use of oxygen therapy. The Modified Borg Scale (MBS) is expected to range between mild and moderate.	Functional capacity (FC) decreased in both groups, but in the intervention group (IG), the decrease was not statistically significant ($P = .11$). Both groups experienced a decrease in respiratory muscle strength and performance on the 1-minute stand-up and sit-down test. However, hospitalization time was reduced in the intervention group, with a trend towards significance ($P = 0.50$).

In certain articles, the sample sizes were constrained, despite incorporating evaluations of quality of life and psychosocial aspects in the interventions. In a different study,[34] participants were categorized according to their risk of developing PPC, while in other studies, the intervention's duration served as a limiting factor.[35] One study focused solely on patients at high risk for PPC postoperatively, while another was selected for implementing general preoperative physiotherapy recommendations in a specific case. Among the trials, one adhered to the principles outlined in the 2001 CONSORT statement.[36] Several studies stood out for their clear delineation of outcomes, emphasizing clinical significance through measures such as reduction of both absolute and relative risk, ensuring that all data entry and analysis were conducted without knowledge of group allocation.[37]

Preoperative Physiotherapy: The review findings indicate that preoperative physiotherapy is employed to mitigate the occurrence of postoperative pulmonary complications (PPC) following coronary artery bypass graft (CABG) surgery. The majority of the research studies examined investigated the impact of

comprehensive interventions (Table 2).[38] These interventions consist of various approaches, such as aerobic exercise, inspiratory muscle training (IMT), instruction on general aspects concerning the surgical procedure, respiratory exercises, and counseling. Although these treatments may differ in their specific areas of focus and underlying mechanisms of action, they all aim to prevent various types of PPC.[39]

Inspiratory Muscle Training (IMT): IMT involves applying resistance during inspiration to strengthen the muscles used in breathing, typically using a device like the Threshold.[40] The resistance level during training is calibrated as a percentage of the patient's maximal inspiratory pressure (MIP), with reported levels ranging from 15% to 40%.[41] IMT has been demonstrated to improve the strength and endurance of the inspiratory muscles, enhancing surgical tolerance and reducing the risk of postoperative complications like pneumonia and atelectasis.[42] Studies have reported positive outcomes, including faster extubation, improved psychosocial well-being, better sleep quality, shorter durations of mechanical ventilation, shorter hospital stays, and decreased mortality risk, particularly in elderly patients. Improved pulmonary function is essential for a smoother recovery, and IMT has been linked to better functional capacity, enabling patients to perform daily tasks more effectively.[43]

Aerobic Exercise (AE): Aerobic exercise as part of preoperative physical therapy offers numerous benefits, including improved quality of life and reduced hospital stays. Research suggests that patients should engage in aerobic exercise four times a week for two to eight weeks, at an intensity level between 40% and 70% of their functional capacity (FC). Some trials combine aerobic exercise with relaxation methods, maintaining exercise intensity between 40% and 60% of the patient's maximum heart rate (MHR) for two weeks. However, many authors advocate for a longer preoperative exercise regimen lasting at least six weeks after surgery. Although aerobic exercise has been shown to enhance physical fitness, more focused studies are needed to examine its influence on postoperative pulmonary complications.[44]

Educational Interventions: Educational interventions as part of preoperative physiotherapy encompass crucial information provided to patients about respiratory techniques, the sternotomy procedure, challenges associated with coughing due to pain and anesthesia, the severity and location of pain, and the importance of early mobilization. This education is typically administered 24 hours before the surgery.[14]

Table 2: Studies related to preoperative chest physiotherapy effects on postoperative outcomes

Author and year of publication	Number of Participants	Study Design	Intervention	Results
Santa Mina et al., 2015 [45]	43	Randomized controlled trial	The Threshold-IMT® program comprises 30-minute sessions starting with an initial load of 30%, which can be progressively adjusted within a range of 15% to 45%, based on the patient's comfort and tolerance levels. These sessions are conducted twice daily, spanning a total of 10 days, with five sessions administered before the surgery and five in the postoperative phase.	Respiratory Muscle Training (RMT) speeds up the restoration of inspiratory muscular power, boosts functional ability, and raises psychological and quality of life well-being in individuals who have had surgery for a coronary artery bypass graft (CABG).
Chen et al., 2019 [27]	30	Randomized controlled trial	The Threshold-IMT® is applied with a load set at 40% of the Maximum Inspiratory Pressure (MIP). This involves performing five sets of 10 deep breaths, each set taking one minute to complete. This intervention is carried out three times a day and is implemented for a duration of two weeks before the surgery.	This program proved to be a safe option for patients, resulting in improvements in Forced Vital Capacity (FVC) and Maximum Voluntary Ventilation. However, it was challenging to clearly demonstrate clinical benefits.

O'Neill & Forman, 2020 [46]	204	Randomized controlled trial	This education covers a range of topics, including dispelling myths and misconceptions related to cardiac health, providing insights into what to expect during the hospitalization and the subsequent phase of recuperation. Additionally, it includes relaxation exercises and motivational strategies aimed at promoting increased physical activity.	This comprehensive program is valuable for secondary prevention and demonstrates superior effectiveness in reducing depression and improving physical functioning when compared to counseling as a standalone approach.
Freedland et al., 2015 [47]	57	Randomized controlled trial	Patients receive guidance on ventilatory exercises, supplemented by informative pamphlets. This education also comprises general advice and detailed instructions about the surgical procedure. This intervention takes place 24 hours prior to the surgery.	This technique dramatically decreased anxiety, particularly in the lead-up to the surgery.
Karanfil & Møller, 2018 [48]	263		Instruction on breathing methods to be followed in the recovery phase is given to patients. This course covers deep breathing techniques, aided coughing, and incentive spirometry.	When compared to patients who did not get preoperative physical therapy, the probability of developing atelectasis was reduced by 52%. This indicates that preoperative physical therapy is an effective means of preventing atelectasis. This corresponds to a 52% reduction in relative risk.
Lagier et al., 2022 [49]	279	Randomized controlled trial	In patients at high risk, the intervention involves daily use of Threshold-IMT® loaded at 30% for a minimum of two weeks, in addition to education on respiratory exercises.	Inspiratory Muscle Training (IMT) boosted the strength and endurance of respiratory muscles, resulting in a decreased incidence of PPC, shorter hospitalization periods, and reduced morbidity.
Moradian et al., 2019 [50]	26	Randomized controlled trial and pilot study	For high-risk patients, the intervention consists of daily use of Threshold-IMT® loaded at 30% for a minimum of two weeks.	The program was found to be feasible, safe, and well-accepted by the patients. Additionally, it efficiently lowered the incidence of atelectasis.

Outcomes and Techniques in Preoperative Physiotherapy: The outcomes observed in one study emphasize a notable reduction in anxiety during the preoperative period. This reduction is significant because higher anxiety levels are often associated with increased pain and prolonged hospital stays.[51] Regarding respiratory technique training, studies present two distinct approaches. These methods can be initiated either 15 days before surgery, involving a total of 15 sessions, or on the day of hospital admission.[52] In both investigations, the respiratory exercises consist of ten sets of deep diaphragmatic breathing with pursed lips (pursed lip breathing) and pulmonary expansion exercises involving three levels of tactile stimulation. Patients are also trained to use the Respiflow® device, which involves slow breathing with passive expiration and completing five series of deep inspirations with 30 to 60 seconds of rest between each series. Additionally, educational sessions cover assisted coughing techniques, proper sitting and turning in bed, early mobilization exercises, and adherence to the treatment plan.[53]

Positive Outcomes and Specific Techniques: Among the observed effects related to postoperative pulmonary complications (PPC), several positive outcomes have been reported.[54] These include improved respiratory efficiency, as indicated by an increase in Forced Vital Capacity (FVC), enhanced walking distance, and a reduction in the occurrence of atelectasis. Counseling predominantly provides patients with general information about the surgical procedures and may include telephonic guidance.[55] However, it does not encompass specific, hands-on training administered by a physiotherapist.[56] This counseling intervention is particularly effective in reducing preoperative anxiety and depression, dispelling negative preconceptions, and encouraging physical activity and mobility.

Comprehensive Interventions: For patients undergoing coronary artery bypass grafting (CABG), preoperative physical therapy includes various interventions such as inspiratory muscle training (IMT), aerobic exercise, education, and counseling.[56] The objectives of IMT are to enhance oxygen

saturation, optimize gas exchange, and reduce the risk of postoperative complications. Psycho-emotional techniques, based on therapy and instruction, help lower anxiety and depression before surgery.[57] However, relatively little research has been conducted on the benefits of aerobic exercise. Since many preoperative physiotherapy programs incorporate multiple interventions, further research is needed to pinpoint the specific benefits of each intervention and provide a comprehensive explanation of their processes. This will assist patients and their families by facilitating the transfer of information to clinical practice and potentially lower the need for additional medical costs.[58]

CONCLUSION

To assess the effectiveness of combination interventions in preoperative physiotherapy more specifically, inspiratory muscle training is recommended to improve respiratory muscle strength and functional capacity in patients undergoing cardiac surgery. Based on this study, it is advised that inspiratory muscle training should be performed preoperatively to reduce the incidence of postoperative pulmonary complications. This strategy not only decreases the incidence of re-intubation, chest tube re-insertion, ICU stay duration, and the need for ICU re-admission but also offers significant benefits in terms of healthcare resource utilization.

AUTHORS' CONTRIBUTION

WS, AE, AJ, SAB, ZH, and HMJ: Concept and design, data acquisition, interpretation, drafting, final approval, and agree to be accountable for all aspects of the work. WS, AE, AJ, SAB, ZH, and HMJ: Data acquisition, interpretation, drafting, final approval and agree to be accountable for all aspects of the work.

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REFERENCES

1. Shahood H, Pakai A, Rudolf K, Bory E, Szilagyi N, Sandor A, et al. The effect of preoperative chest physiotherapy on oxygenation and lung function in cardiac surgery patients: a randomized controlled study. Ann Saudi Med. 2022;42(1):8-16.
2. Montrief T, Koyfman A, Long B. Coronary artery bypass graft surgery complications: A review for emergency clinicians. Am J Emerg Med. 2018;36(12):2289-97.
3. Brookes JD, Williams M, Mathew M, Yan T, Bannon P. Pleural effusion post coronary artery bypass surgery: associations and complications. J Thorac Dis. 2021;13(2):1083.
4. Winzer EB, Woitek F, Linke A. Physical activity in the prevention and treatment of coronary artery disease. JAHA. 2018;7(4):e007725.
5. Dewantoro D, Nenna A, Satriano U, Chello M, Spadaccio C. Advantages and disadvantages of total arterial coronary artery bypass graft as compared to venous coronary artery bypass graft. Vessel Plus. 2018;2:20-29.
6. 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(8):1180-6.
7. 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(4):290-4.
8. Chikwe J, Lee T, Itagaki S, Adams DH, Egorova NN. Long-term outcomes after off-pump versus on-pump coronary artery bypass grafting by experienced surgeons. J Am Coll Cardiol. 2018;72(13):1478-86.
9. Kowalewski M, Pawliszak W, Malvindi PG, Bokszanski MP, Perlinski D, Raffa GM, et al. Off-pump coronary artery bypass grafting improves short-term outcomes in high-risk patients compared with on-pump coronary artery bypass grafting: meta-analysis. J Thorac Cardiovasc Surg. 2016;151(1):60-77.
10. Chaudhary S, Chaudhary NI, Ghewade B, Mahajan G. The Immediate Effects of Breathing Exercises with Acapella and Incentive Spirometer on Preventing Early Pulmonary Complications Following Cabg.-A Comparitive Study. Int J Curr Res Rev. 2020;12(17):51-8.
11. Waite I, Deshpande R, Baghai M, Massey T, Wendler O, Greenwood S. Home-based preoperative rehabilitation (prehab) to improve physical function and reduce hospital length of stay for frail patients undergoing coronary artery bypass graft and valve surgery. J Cardiothorac Surg. 2017;12:1-7.
12. Braunwald E. Treatment of left main coronary artery disease. N Engl J Med. 2016;375(23):2284-5.
13. Yuan S-M, Lin H. Postoperative cognitive dysfunction after coronary artery bypass grafting. Braz J Cardiovasc Surg. 2019;34:76-84.
14. Højskov IE, Moons P, Egerod I, Olsen PS, Thygesen LC, et al. Early physical and psycho-educational rehabilitation in patients with coronary artery bypass grafting: A randomized controlled trial. J Rehabil Med. 2019;51(2):136-43.
15. Javed K, Niazi R, Waheed A, Rasheed N, Khalil S, Awan IZ. Effects of Physical Therapy in Preventing Complications of Postoperative Coronary Artery Bypass Grafting: Physical Therapy in Post-CABG Patients. Healer J Physiother Rehabil Sci. 2023;3(6):578-86.
16. Hadel S. The Effect of Preoperative Chest Physiotherapy on Oxygenation and Lung Functions among Open Heart Surgery Patients. 2023;
17. Afxonidis G, Moysidis DV, Papazoglou AS, Tsagkaris C, Loudovikou A, Tagarakis G, et al. Efficacy of early and enhanced respiratory physiotherapy and mobilization after on-pump cardiac surgery: A prospective randomized controlled trial. Healthcare (Basel). 2021;9(12):1735.
18. Naveed A, Azam H, Murtaza HG, Ahmad RA, Baig MAR. Incidence and risk factors of pulmonary complications after cardiopulmonary bypass. Pak J Med Sci. 2017;33(4):993.

19. Perelló-Díez M, Paz-Lourido B. Prevention of postoperative pulmonary complications through preoperative physiotherapy interventions in patients undergoing coronary artery bypass graft: literature review. J Phys Ther Sci. 2018;30(8):1034-8.
20. van Adrichem EJ, Meulenbroek RL, Plukker JT, Groen H, van Weert E. Comparison of two preoperative inspiratory muscle training programs to prevent pulmonary complications in patients undergoing esophagectomy: a randomized controlled pilot study. Ann Surg Oncol. 2014;21:2353-60.
21. Sweity EM, Alkaissi AA, Othman W, Salahat A. Preoperative incentive spirometry for preventing postoperative pulmonary complications in patients undergoing coronary artery bypass graft surgery: a prospective, randomized controlled trial. J Cardiothorac Surg. 2021;16(1):1-11.
22. Gomes Neto M, Martinez BP, Reis HF, Carvalho VO. Pre-and postoperative inspiratory muscle training in patients undergoing cardiac surgery: systematic review and meta-analysis. Clinical rehabilitation. 2017;31(4):454-64.
23. Yau DKW, Underwood MJ, Joynt GM, Lee A. Effect of preparative rehabilitation on recovery after cardiac surgery: a systematic review. Annals of Physical and Rehabilitation Medicine. 2021;64(2):101391.
24. Shakouri SK, Salekzamani Y, Taghizadieh A, Sabbagh-Jadid H, Soleymani J, Sahebi L, et al. Effect of respiratory rehabilitation before open cardiac surgery on respiratory function: a randomized clinical trial. J Cardiovasc Thorac Res. 2015;7(1):13.
25. Cook A, Smith L, Anderson C, Ewing N, Gammack A, Pecover M, et al. The effect of Preoperative threshold inspiratory muscle training in adults undergoing cardiac surgery on postoperative hospital stay: a systematic review. Physiother Theory Pract. 2023;39(4):690-703.
26. Humphrey R, Malone D. Effectiveness of preoperative physical therapy for elective cardiac surgery. Physical Therapy. 2015;95(2):160-6.
27. 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 Rehab. 2019;33(5):913-22.
28. Bano A, Aftab A, Sahar W, Haider Z, Rashed MI, Shabbir HM. Combined Effects of Continuous Positive Airway Pressure and Cycle Ergometer in Early Rehabilitation of Coronary Artery Bypass Surgery Patients. J Coll Physicians Surg Pak. 2023;33(8):866-71.
29. Moradian ST, Najafloo M, Mahmoudi H, Ghiasi MS. Early mobilization reduces the atelectasis and pleural effusion in patients undergoing coronary artery bypass graft surgery: A randomized clinical trial. J Vasc Nurs. 2017;35(3):141-5.
30. 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(6):E19-E25.
31. Cui Z, Li N, Gao C, Fan Y, Zhuang X, Liu J, et al. Precision implementation of early ambulation in elderly patients undergoing off-pump coronary artery bypass graft surgery: a randomized-controlled clinical trial. BMC Geriatr. 2020;20:1-10.
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 Rehab. 2020;34(10):1256-67.
33. Windmöller P, Bodnar ET, Casagrande J, Dallazen F, Schneider J, Berwanger SA, et al. Physical exercise combined with CPAP in subjects who underwent surgical myocardial revascularization: a randomized clinical trial. Respir Care. 2020;65(2):150-7.
34. Çırak Y, Karahan Z, Yelvar GD, Erden İ, Demirkılıç U. Is physiotherapy effective on the occurrence of postoperative pulmonary complications in patients undergoing coronary artery bypass graft surgery? A randomised controlled trial. Turk J Thorac Cardiovasc Surg. 2015;23(4):622-30.
35. Munir U, Umar Riaz NF, Sahar W, Tariq K. Effects of Preoperative Aerobic Training for Improving Postoperative Functional Mobility in Coronary Artery Bypass Graft Patients. Examines Phy Med Rehab. 2023;4(2):1-4.
36. Khushnood K, Sultan N, Awan MMA, Altaf S, Mehmood R, Qureshi S. Effects of Pre-Operative Physical Therapy on Functional Capacity, Kinesiophobia, and Post-Operative ICU Stay in Coronary Artery Bypass Grafting Candidates. Iran Rehabil J. 2023;21(1):81-8.
37. Nardi P, Pellegrino A, Pisano C, Vacirca SR, Anselmi D, Saulle S, et al. The effect of preoperative respiratory physiotherapy and motor exercise in patients undergoing elective cardiac surgery: short-term results. Kardiochir Torakochirurgia Pol. 2019;16(2):81-7.
38. Salehi Derakhtanjani A, Ansari Jaberi A, Haydari S, Negahban Bonabi T. Comparison the Effect of Active Cyclic Breathing Technique and Routine Chest Physiotherapy on Pain and Respiratory Parameters After Coronary Artery Graft Surgery: A Randomized Clinical Trial. Anesth Pain Med. 2019;9(5):e94654.
39. Goñi-Viguria R, Yoldi-Arzoz E, Casajús-Sola L, Aquerreta-Larraya T, Fernández-Sangil P, Guzmán-Unamuno E, et al. Respiratory physiotherapy in intensive care unit: Bibliographic review. Enferm Intensiva (Engl Ed). 2018;29(4):168-181.
40. Elmarakby A. Effect of threshold inspiratory muscle training on maximal inspiratory pressure and pulmonary gas exchange in patients undergoing coronary artery bypass graft surgery. Crit Rev Phys Rehabil Med. 2016;28(4):249-61.
41. 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.
42. Amaravadi SK, Shah K, Samuel SR, N R. Effect of inspiratory muscle training on respiratory muscle strength, post-operative pulmonary complications and pulmonary function in abdominal surgery-Evidence from systematic reviews. F1000Research. 2022;11:270.
43. Smith JR, Taylor BJ. Inspiratory muscle weakness in cardiovascular diseases: Implications for cardiac rehabilitation. Prog Cardiovasc Dis. 2022;70:49-57.
44. Assouline B, Cools E, Schorer R, Kayser B, Elia N, Licker M. Preoperative Exercise Training to Prevent Postoperative Pulmonary Complications in Adults Undergoing Major Surgery. A Systematic Review and Meta-analysis with Trial Sequential Analysis. Ann Am Thorac Soc. 2021;18(4):678-88.
45. Santa Mina D, Scheede-Bergdahl C, Gillis C, Carli F. Optimization of surgical outcomes with prehabilitation. Appl Physiol Nutr Metab. 2015;40(9):966-9.
46. O'Neill D, Forman DE. The importance of physical function as a clinical outcome: Assessment and enhancement. Clin Cardiol. 2020;43(2):108-17.
47. Freedland KE, Carney RM, Rich MW, Steinmeyer BC, Rubin EH. Cognitive behavior therapy for depression and self-care in heart failure patients: a randomized clinical trial. JAMA Inter Med. 2015;175(11):1773-82.
48. Karanfil ET, Møller AM. Preoperative inspiratory muscle training prevents pulmonary complications after cardiac surgery-a systematic review. Dan Med J. 2018;65(3):A5450.
49. Lagier D, Zeng C, Fernandez-Bustamante A, Vidal Melo MF. Perioperative pulmonary atelectasis: part II. Clinical implications. Anesthesiol. 2022;136(1):206-36.
50. Moradian ST, Heydari AA, Mahmoudi H. What is the Role of Preoperative Breathing Exercises in Reducing Postoperative Atelectasis after CABG? Rev Recent Clin Trials. 2019;14(4):275-9.
51. Ghorbani A, Hajizadeh F, Sheykhi MR, Asl AMP. The effects of deep-breathing exercises on postoperative sleep duration and

quality in patients undergoing coronary artery bypass graft (CABG): a randomized clinical trial. J Caring Sci. 2019;8(4):219.
52. Jarrah MI, Hweidi IM, Al-Dolat SA, Alhawatmeh HN, Al-Obeisat SM, Hweidi LI, et al. The effect of slow deep breathing relaxation exercise on pain levels during and post chest tube removal after coronary artery bypass graft surgery. International J Nurs Sci. 2022;9(2):155-61.
53. Hany SM, Ali ZH, Abdel-Azeem Mostafa H. Effect of deep breathing technique on severity of pain among postoperative coronary artery bypass graft patients. International J Novel Res Healthc Nurs. 2019;6(2):32-46.
54. Amin R, Alaparthi GK, Samuel SR, Bairapareddy KC, Raghavan H, Vaishali K. Effects of three pulmonary ventilation regimes in patients undergoing coronary artery bypass graft surgery: a randomized clinical trial. Sci Rep. 2021;11(1):6730.
55. Arazi T, Aliasgharpour M, Mohammadi S, Mohammadi N, Kazemnejad A. Effect of a breathing exercise on respiratory function and 6-minute walking distance in patients under hemodialysis: a randomized controlled trial. J Nurs Res. 2021;29(2):e146.
56. Sahar W, Ajaz N, Haider Z, Jalal A. Effectiveness of pre-operative respiratory muscle training versus conventional treatment for improving post operative pulmonary health after coronary Artery bypass grafting. Pak J Med Sci. 2020;36(6):1216.
57. McCann M, Stamp N, Ngui A, Litton E. Cardiac prehabilitation. J Cardiothorac Vasc Anesth. 2019;33(8):2255-65.
58. Zaouter C, Damphousse R, Moore A, Stevens L-M, Gauthier A, Carrier FM. Elements not graded in the cardiac enhanced recovery after surgery guidelines might improve postoperative outcome: a comprehensive narrative review. J Cardiothorac Vasc Anesth. 2022;36(3):746-5.

Address for Correspondence:

Dr. Asita Elengoe, Department of Biotechnology, Lincoln University College, Malaysia.
Email: elengoeasita@gmail.com