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The Effectiveness Of Preoperative Physiotherapy Program On Post-Cardiopulmonary Function Among Coronary Artery Bypass Graft Patients: A Randomized Controlled Trial

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KEYWORDS
Preoperative physiotherapy, CABG, Coronary Artery Bypass Graft, pulmonary function, aerobic endurance.

ABSTRACT

Coronary artery bypass graft surgery (CABG) is one of the procedures to repair cardiovascular disease. At the same time, general anesthesia of the surgery decreases the functional pulmonary capacity by nearly 20% and induces many pulmonary complications in the postoperative period. This study aims to examine the effectiveness of the preoperative physiotherapy interventional program on the postoperative pulmonary function of patients who undergo CABG surgery. A randomized controlled trial with a concealed allocation of twenty-five males and females who underwent CABG surgery at AL-Maqased hospital. Participants were randomly assigned to an intervention group (they received four supervised sessions in the preoperative period) or a control group (not receiving physiotherapy program preoperatively). Patients in both groups received the hospital routine physiotherapy postoperatively. Primary outcome measures were inspiratory and expiratory lung capacity of incentive spirometer, cough functionality, and chest expansion. The experimental group had a significant increase in upper and lower chest expansion ($p=0.037$) ($p= 0.019$) respectively, and cough functionality ($P=0.008$). The suggested pre-cardiopulmonary physiotherapy interventional program in patients awaiting CABG in the hospital has enhanced aerobic capacity and pulmonary function (cough and chest expansion).

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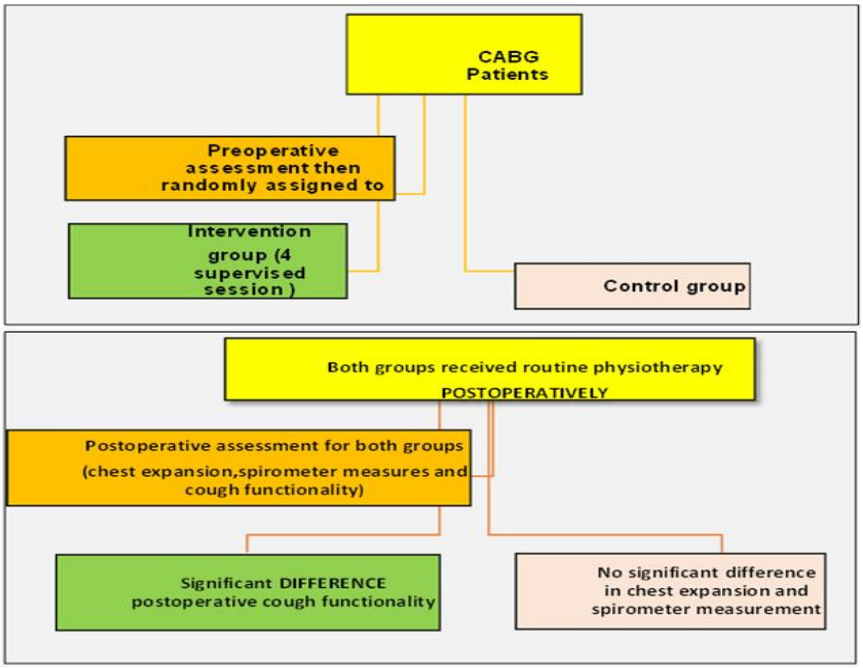
GRAPHICAL ABSTRACT



INTRODUCTION AND LITERATURE REVIEW

Cardiovascular diseases (CVD) are considered one of the most life-threatening causes of death and disability worldwide; 17.9 million people annually die from CVD. Represent in 31% of all deaths; about 7.4 million were due to coronary artery disease (CAD). According to the World Health Organization in 2016 [1], the prevalence of CVD enlarged by age, particularly between 51-60 years, and it is greater among men compared to women, representing 2.7 % of males and 2.5% of females according to the statistics of Palestinian Central Bureau PCBS in 2010 [2].

Coronary artery bypass graft surgery (CABG) is the most common surgery performed for coronary artery diseases [3] . It can be defined as one of the procedures to repair cardiovascular defects and lower the risk of different heart complications, by enhancing blood flow to the heart when the coronary arteries are blocked or narrowed by atherosclerotic plaque [4].

During surgery, general anesthesia is given to the patient, consequently, healthy vessels such as an artery or vein from the arm, chest, or leg are used to produce a bypass around the blocked artery. After that, patients received mechanical ventilation. During cardiac arrest, a cardiopulmonary bypass machine provides perfusion pressure and oxygenation to the patient. Finally, The patients are extubated when they become able to inhale normally, have no bleeding in the drain, and have adequate diuresis [5].

General anesthesia after surgery decreases the functional residual capacity (FRC) by nearly 20% [6]. It induces many pulmonary complications due to the decrease of diaphragmatic movement efficacy, ventilatory function, cilia movement, respiratory muscle strength, lung volume, and perfusion (gas exchanges), making the patient vulnerable to respiratory distress or failure during the postoperative period [7,8].

Inspiratory Pulmonary dysfunctions are well documented after CABG surgery which leads to a significant decrease in tidal volume, vital capacity (VC), total lung capacity, and functional residual capacity (FRC) by 30%–50%, which decreases the level of

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oxygen in the blood, and decreased chest expansion. Furthermore, expiratory muscle dysfunction decreases forced expiratory volume in 1 second (FEV1), Forced Vital Capacity (FVC) and leads to ineffective cough particularly when abdominal muscles are affected [9,10].

The physiotherapy intervention program is recommended to enhance the functional capacity of the respiratory system and to prevent secretions' accumulation after CABG surgery, by clearing the pharynx and bronchial tree which can be received preoperatively and postoperatively [11, 12, 13]. It includes breathing exercises (spirometer training, respiratory muscle training as diaphragmatic breathing, bronchial toileting by splinted cough, lung expansion techniques as deep breathing exercises), and circulatory exercises (range of motion exercise and ambulation to reduce the risk of pulmonary complications in the postoperative period [14, 15].

Alteration of paradigm in mechanical ventilation of lung function is due to general anesthesia and diaphragmatic dysfunction in the intraoperative period leading to reduced pulmonary function (lung volume, reduced respiratory muscle function), and accumulation of secretions which obstruct tiny airways leading to alteration of respiration as described in the figure 1. These physiologic findings confirm the use of techniques that increase lung volumes, enhance cough and function of the diaphragm, and ease secretions' movement. [16, 17].

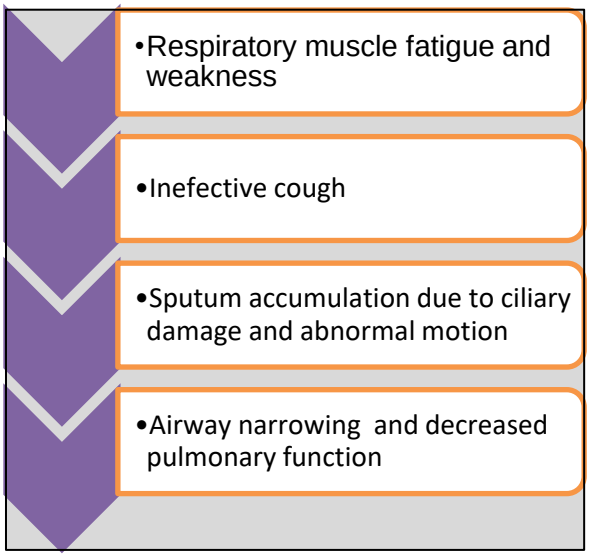

Figure 1. The alteration of normal respiration

Therefore, chest physiotherapy training in the preoperative and postoperative period is essential to prevent the pathological process of the cardiopulmonary system, facilitate airway clearance, and restore normal respiration after a long time of hypo pleural function, especially among patients who are at high risk of developing post pulmonary complications as advanced age, smoking, obesity, and associated diseases.[18]

The concept of preoperative physiotherapy intervention can be supported by Lazarus and Folkman's theory which suggests that people who are challenged by stressful situations such as surgery may change their original perception to learn new information. The surgery itself can be an important stressor resulting in anxiety, and pain, in the postoperative period which will decrease the ability of patients to learn the needed breathing and circulatory exercises postoperatively [19]. In addition, Mishel's 1981 theory suggested that patients confront uncertainty as a significant variable after experiencing illness, hospitalization, and treatment. [20].

In conclusion, uncertainty related to post-surgical treatment has been discussed by different researchers which leads to stress and decreasing cognitive

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perception, Accordingly, the pre-operative physiotherapy training period is a more emotionally and physically stable period to interfere with patients. However, few studies have been conducted to study the effect of preoperative physiotherapy education and training programs among CABG patients, especially in Palestine. Therefore, this study aims to examine the effect of preoperative physiotherapy intervention on post-cardiopulmonary function (lung capacity, cough functionality, chest expansion). Recently, growing evidence suggests that the preoperative interventional program might be effective in post-surgical pulmonary functions among CABG patients. In 2018, Perello et. al conducted a systematic review to identify the effect of preoperative physiotherapy interventions among Coronary Artery Bypass Graft patients. About 14 studies between 2006-2017 were included combining different interventions such as inspiratory muscle training, aerobic exercise, education about breathing exercises, and counseling.

Boden, et al assessed the memorability and patient's opinion of pre-operative physiotherapy education among patients who underwent upper abdominal surgery. The results showed that the participants in the intervention group were six times more likely to remember the breathing exercises, and 11 times more likely to report physiotherapy as the most memorable time in the postoperative period [21].

However, Pouwels et al.conducted a Meta-analysis that focused on postoperative lung function in estimating the effect of physiotherapy before CABG surgery on postoperative spirometer measure and o2 saturation. There is a significantly lower hypoxemia rate in the post-operative period $P < 0.001$, among patients who had received chest physiotherapy in the pre-operative period. While there is no significant difference in spirometer-forced expiratory measure and postoperative complications ($P = 0.65$) among both groups.[22]. However, Moradian et al. conducted a single-blinded randomized clinical trial, among 100 CABG patients, who were randomized to experimental and control groups, the experimental group received deep breathing, cough, and incentive spirometer in the preoperative period. Outcome measures assessed postoperatively were arterial blood gases and atelectasis. The result shows that there was no significant difference between groups in terms of atelectasis and hypoxemia (p Value>0.05).[23]

In conclusion, still there is a debate within evidence related to the effectiveness of preoperative physiotherapy interventional programs on post-pulmonary function (inspiratory and expiratory spirometer measures).

METHODS

Study Design

To achieve the study objectives, a randomized controlled trial design with pre-posttest procedures was used. A convenience sample was recruited from an Al-Maqassed hospital, with a concealed randomized allocation. Twenty-five patients (males and females), ages between 37 to 73 years old, and who underwent CABG from January 2020 -November 2020 were recruited.

Inclusion criteria

- Oriented (able to communicate and understand verbal instructions).
- Able to attend a pre-admission assessment at the medical and surgical wards.
- Willing to attend the study, and to sign an informed consent.

Exclusion criteria

- Patients with neuromuscular, cognitive, and psychological disorders

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- Ages >80 years old
- Emergency surgery patients
- History of CABG surgery
- Respiratory diseases before the operation (pneumonia, Atelectasis, pleural effusion, asthma, unstable angina in the last 2 days)
- Contraindication to perform planned breathing or circulatory exercises
- Severe renal dysfunction patients
- Hemodynamic dysfunction patients
- Uncontrolled hypertension
- Myocardial infarction in the past three months
- Uncontrolled cardiac arrhythmias
- Preoperative chemotherapy during the 4–6 weeks before surgery

Study settings

The study was conducted at Al- Makassed Islamic Charitable Society Hospital, Jerusalem, wards of internal medicine, cardio surgery, cardiac intensive care unit, and Coronary Care Unit during January 2020 - November 2020.

Data collection

- Demographic and clinical characteristics questionnaire

The questionnaire was applied preoperatively for recording demographic clinical data including age, gender, educational level, height, weight, BMI, job status, smoking history, medical history, and other relevant variables.

- The pulmonary function was assessed using the following tools :

- Chest expansion (CE): it displayed good intra and interrater reliability and was linked with lung functions and provided indirect data on lung volume function and inspiratory muscle strength [24].
- Simple incentive spirometer: it measures the amount of inspiratory and expiratory volumes [25].
- Cough functionality: three grades describe the cough functionality as the following:

- Functional cough
- Weak Functional cough
- Nonfunctional cough

The chest expansion measure, expiratory and inspiratory capacity were measured before intervention, and two days after the surgery for both groups, while mid-assessment was done after 4 sessions of supervised intervention for the experimental group.

Pilot Study

Three CABG patients were recruited as a pilot study for collecting preoperative data, introducing exercises, and post-operative assessment, some variables have been added and changed to achieve the intended goals of the study tools, intervention, and assessment.

Randomization

The participants who underwent CABG surgery were randomly assigned to the intervention group or control group. The study used simple randomization by serially numbering the first 25 elective CABG patients' waiting lists; the participants with even numbers will be enrolled in the intervention group and the odd numbers in the control group. The researcher in the preoperative period who is aware of group allocation will not treat patients postoperatively.

Suggested Program

The patients in the control group will not receive a preoperative physiotherapy session. Patients of the intervention group will receive the interventional program four days before surgery which consists of educational and training sessions.

The educational section has provided instructions about post-pulmonary complications (PPCs), the impact of anesthesia on the cilia movement, and the consequences

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of bacteria. Moreover, possible prevention of these complications with early ambulation (as sitting at the edge of the bed), and exercises in the postoperative period until the patient is fully ambulant were discussed. Finally, postoperative lifestyle advice such as smoking cessation, weight loss, and physical training were introduced.

The training program was divided into breathing and circulatory exercises. The breathing exercises consisted of 4 exercises, each exercise consisted of 16 repetitions distributed for 4 sets followed by a minute rest based on the patient's comfort, a full description of the breathing exercises is illustrated in Table 1.

Table 1. Components of breathing Exercises

Breathing Exercises	**Rep/se1**	**Rep/set2**	**Rep/se3**	**Rep/se4**
1. Active diaphragmatic breathing associated with pursed lip	4 times	4 times	4 times	4 times
2. Splinted cough/huff training included instructions to protect incisions after deep breathing.	4 times	4 times	4 times	4 times
3. Expiratory muscle training through a simple incentive spirometer device	4 times	4 times	4 times	4 times
4. Inspiratory muscle training through a simple incentive spirometer device	4 times	4 times	4 times	4 times

By completing the breathing exercises training, each patient was asked to apply these exercises to verify and guarantee that the patient used proper skills to perform the exercises.

The circulatory exercises consisted of four components which are illustrated in Table 2

Table 2. Components of Circulatory Exercises

Circulatory Exercises	
1. Walking for 15 minutes according to the patient's ability	
2. Bilateral Quadriceps isometric exercise with 10 seconds hold	16 Repetitions
3. Bilateral Ankle pump exercises with 10 seconds hold	

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Patients were instructed to practice the breathing and circulatory exercises preoperatively (unsupervised sessions 3 times a day per four days), and postoperatively as possible as she/he can. Memory cues were used to help the patients to remember and repeat the breathing exercises.

One physiotherapist delivered the physiotherapy interventional program. The physiotherapist is a senior therapist, with 7 years of experience to guarantee consistency in providing the intervention.

The intervention and control group received hospital routine physiotherapy postoperatively (once a day for the first five days). Exercises are to be started a day after extubation and continued until the fifth day after surgery, including routine physiotherapy (deep breathing, cough, early mobilization from their beds into a chair, walking around for short distances to walk freely in the corridor).

STATISTICAL ANALYSIS

Data were analyzed using descriptive statistics and inferential statistics using means, medians, and ranges. Statistical analysis was conducted via the Statistical Package for the Social Sciences (SPSS) package, version 24 (SPSS Inc., Chicago, IL). Descriptive statistics were performed to characterize the sample according to gender, BMI …etc. The normality of the distribution of all variables was assessed by the Shapiro-Wilk. T-tests were used to determine differences between the two groups; Mann-Whitney U tests were performed on the ordinal variables such as cough functionality and other ordinal variables. Statistical significance will be set at $P < 0.05$.

ETHICAL CONSIDERATIONS

This study received ethical approval from the research ethical committee at Al-Quds University (Ref no:98/REC/2020).

RESULTS PRESENTATION AND ANALYSIS

Between January and November 2020, a total of 40 patients underwent CABG at Al- Makassed Islamic Charitable Society Hospital. Of all patients screened, 12 patients were excluded, 4 patients due to old age (> 80 years), and the remaining 8 due to their associated medical conditions such as asthma, renal dysfunction, and chronic obstructive diseases. Among the remaining patients, 28 patients were randomized to the intervention group (n=14) and to the control group (n=14), three of them were excluded due to the inability to conduct postoperative assessment due to the Coronavirus lockdown. Moreover, two patients did not continue the post-assessment (death after surgery), in the control group (n=1) and the experimental group (n=1).23 patients were included in the analysis as shown in figure 2.

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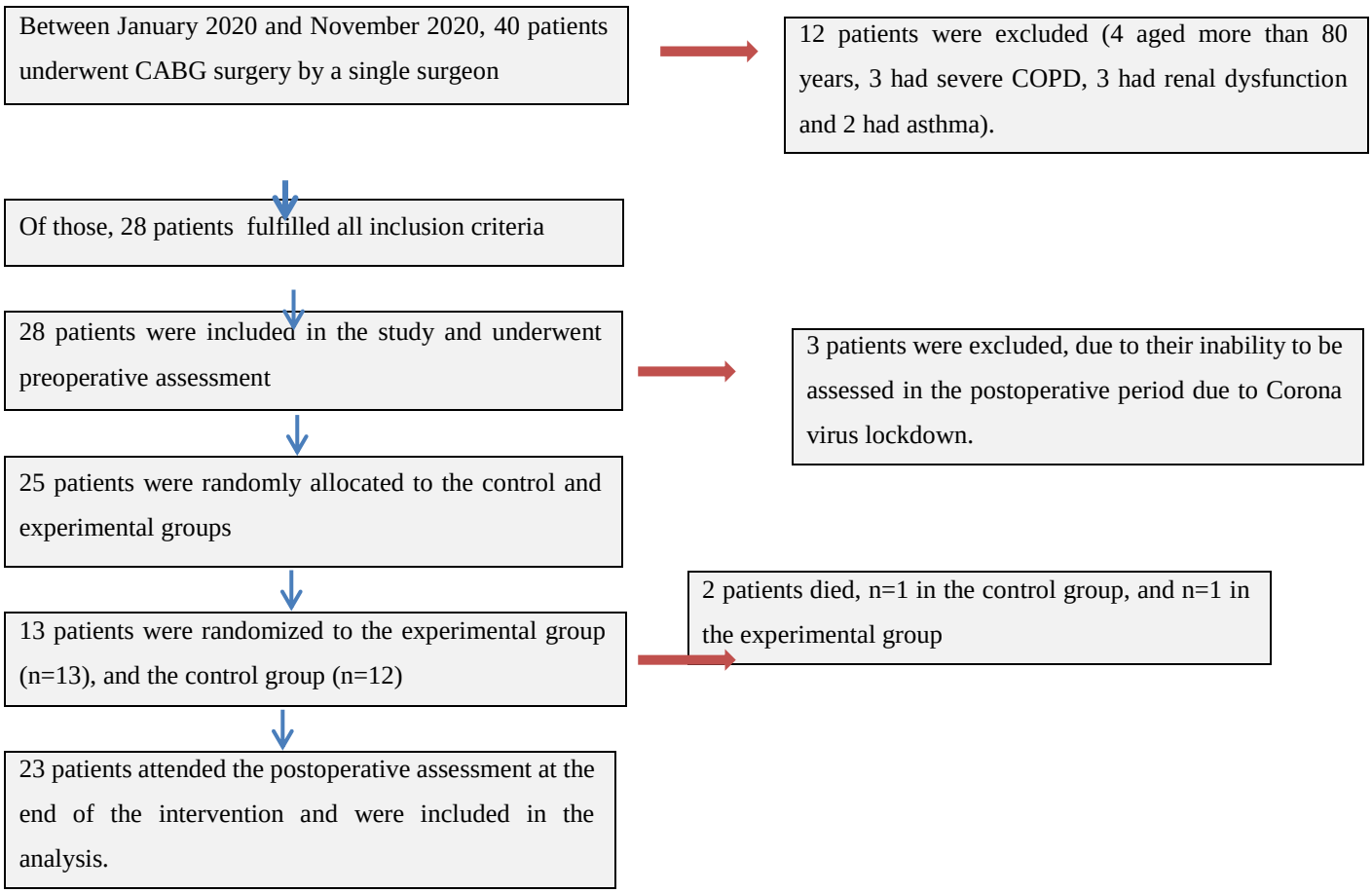

Figure 2. Flow chart of the sample recruitment and pre and post-assessment

Data were collected via a questionnaire, the subjective examination was specifically related to the medical history. The objective data were gathered using tools such as cough functionality, chest expansion, spirometer measurements, and others.

RESULTS

Descriptive Results

Among the respondents who participated in the study, 72% (n = 18) were males, and the remaining 28% (n = 7) were females. The mean age of the participants was 62±9.17 years old; the age ranges between 37 -73 years old. Furthermore, a percentage of (44%) of the sample were smokers, (24%) nonsmokers, and (32%) were previously smokers. A total of (84%) of the participants did not participate in physical activities or sports, and only (16 %) of them were physically active. The majority of the participants were married (92%).

The participants of the study were randomized to control (n=12), and experimental (n=13). The groups, percentages of males and females in the control group were (75% to 25%) respectively, while the percentage of males in the experimental group was (69.2%) and females was (30.8%). Demographic and clinical characteristics of the two groups are illustrated in Table 3

According to the medical condition of the participants, the experimental group had higher percentages of participants who have high blood pressure (61.5%), and diabetes (46.2%), in comparison with the control group

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which were (25%) (50%) (41%) respectively, as shown in Table3

Table 3. Demographic and clinical characteristics of the two groups

Variable	Group	Percentages
Gender (Male-Female)	Control n (12)	75 - 25%
	Experimental n (13)	69.2 -30.8%
Blood pressure	Control	25%
	Experimental	61.5%
Cholesterol	Control	50%
	Experimental	46.2%
Diabetes	Control	41%
	Experimental	46.2%
Smoker	Control	50%
	Experimental	38.5%
Patients who practice physical activity	Control	8%
	Experimental	23.1%

The mean age of the control group was (64.5±7) years, while the mean age of the experimental group was (59.3±10.4), with no significant difference between the two groups (p=0.155) in terms of age. The mean of the BMI among all participants in the study was 30±8.2 with no significant difference between the two groups (p=0.277) at the significance level α=0.05 as shown in Table 4

Table 4. The means of pre-operative data among two groups

Variable	Group	Mean ±SD	P value
Age	Control	64.5±7.0	0.155
	Experimental	59.3±10.4	
BMI	Control	32.3±10.7	0.277
	Experimental	28.0±4.3	

Results of the preoperative ejection fraction values among the majority of participants in the experimental group were between 50-70 EF (61.5%), in addition, the majority of the control group were from 50-70 EF value (58.3%) as shown in figure 3

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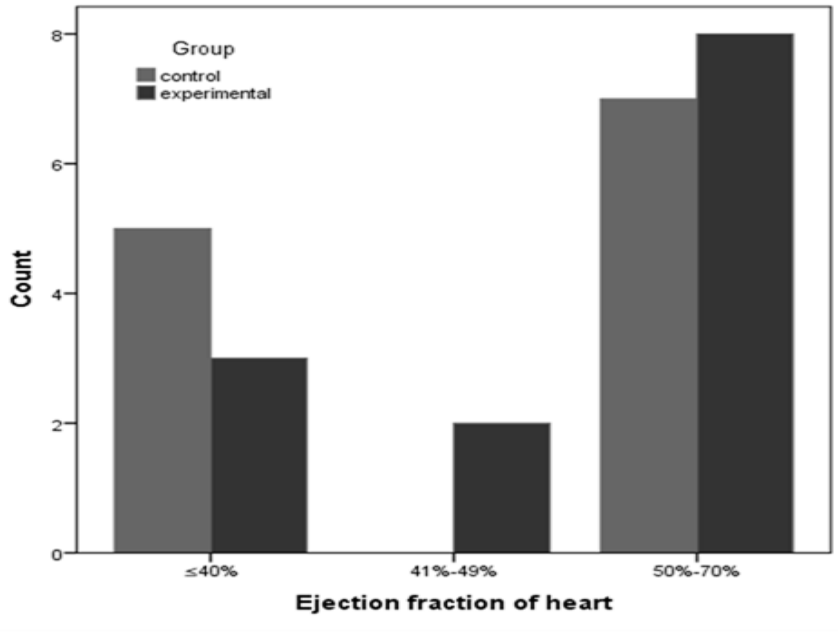

Figure 3. Percentages of ejection fraction values among the two groups

Results of the pre and post-test values between the two groups

- **pulmonary function (chest expansion and spirometer measures)**

The two groups had similar values in the preoperative measures of pulmonary function. The mean of pre-upper chest expansion in the control group was (1.89±0.95) cm, while the mean in the experimental group was (1.67±0.40) as shown in figure 4.5. In addition, the mean of pre-lower chest expansion in the control group was (1.49±1.27) cm, while the mean of the experimental group was (1.42±0.61), as shown in Figure 4.6 with no significant difference between the two groups in pre-upper and lower chest expansion (0.650) (0.503) respectively.

There are statistically significant differences at the level $\alpha = 0.05$ between pre (upper chest expansion) and post (upper chest expansion (0.037) and between pre (lower chest expansion) and post (lower chest expansion (0.019) as shown in Table 4, figures 4 and 5

Table 5. Values of Preoperative and postoperative chest expansion among groups

Variables		**Control Group (n=11)**		**Experimental Group (n=12)**	
	Median	Mean (SD)	Median	Mean (SD)	P value
Pre-upper chest expansion	1.87	1.89±0.95	1.75	1.67±0.40	0.650
Post-upper chest expansion	0.500	0.67±0.54	1.00	1.25±0.72	0.037

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Pre-lower chest expansion	1.00	1.49±1.27	1.25	1.42±0.61	0.503
Post-lower chest expansion	0.50	0.58±0.43	1.00	1.02±0.40	0.019

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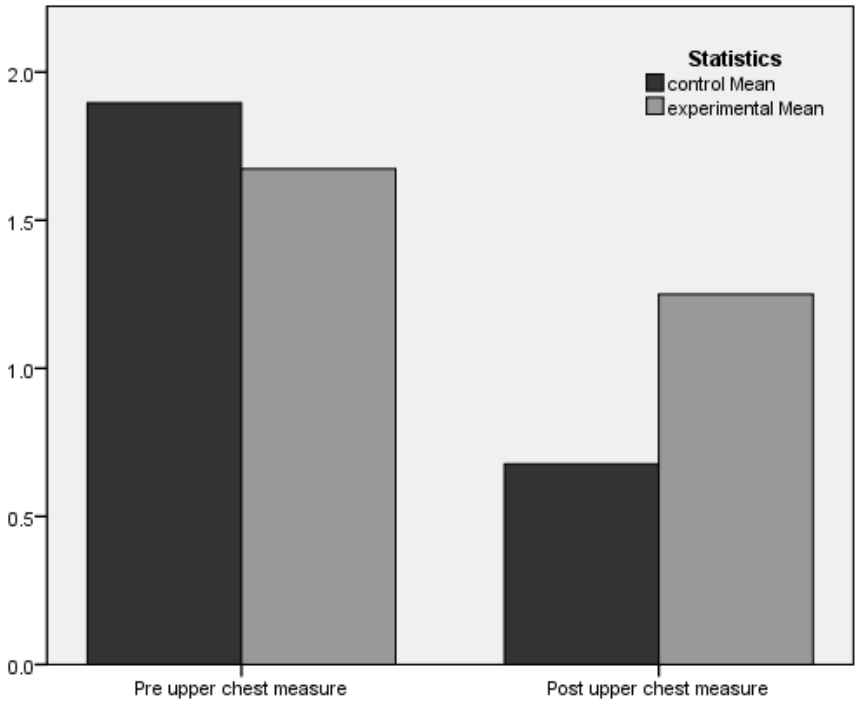

Figure 4. The mean values between pre and post-upper chest expansion among groups

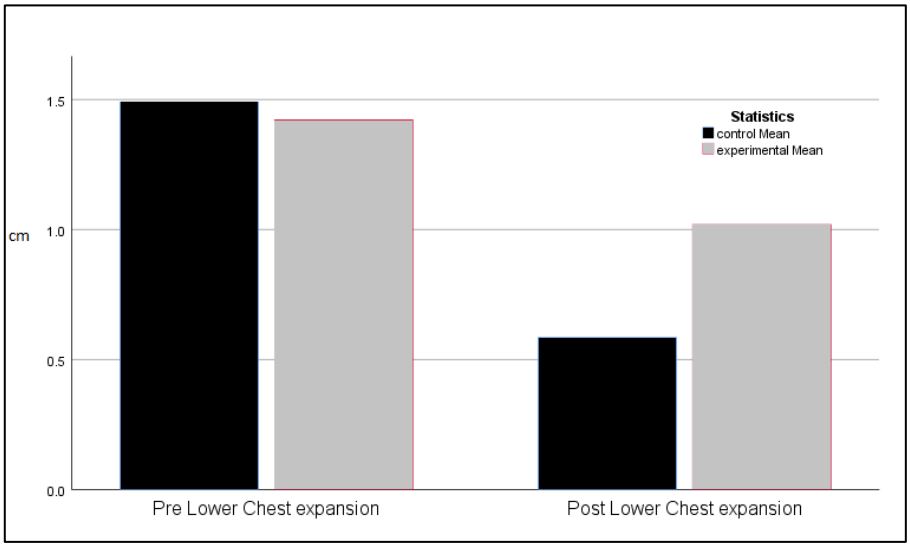

Figure 5. The mean values of pre-lower and post-lower chest expansion in the study

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- **Spirometer Measures**

Table 6 showed that the mean of pre-inspiratory spirometer measures in the control group was (968.75±251.16), while in the experimental group was (994.23±200.04). In addition, the mean of the expiratory spirometer measure in the control group was (1077.08±209.83), while the mean of the experimental group was (1005.76±216.78), with no significant difference between the two groups in pre-inspiratory and pre-expiratory spirometer measures (0.852) (0.137) respectively.

There are no statistically significant differences at the level $\alpha = 0.05$ between pre and post-inspiratory and expiratory measures (0.118) (0.134) respectively.

Table 6. Value of preoperative and post-spirometer measurements

Variables	**Control Group (n=11)**		**Experimental Group**		**(n=12)**
	Median	Mean± (SD)	Median	Mean± (SD)	P value
Pre inspiratory measure	1075.00	968.75±251.16	1050.00	994.23±200.04	0.852
Post inspiratory measure	600.00	636.36±167.46	750.0000	733.33±186.88	0.118
Pre expiratory measure	1200.00	1077.08±209.83	1150.00	1005.76±216.78	0.137
Post expiratory measure	625.00	625.00±200.45	762.50	770.83±258.67	0.134

- **Post Cough Functionality**

The cough functionality was assessed in the post-operative period among two groups which showed that there is a significant difference between the experimental and control groups (0.008) as shown in Figure 5

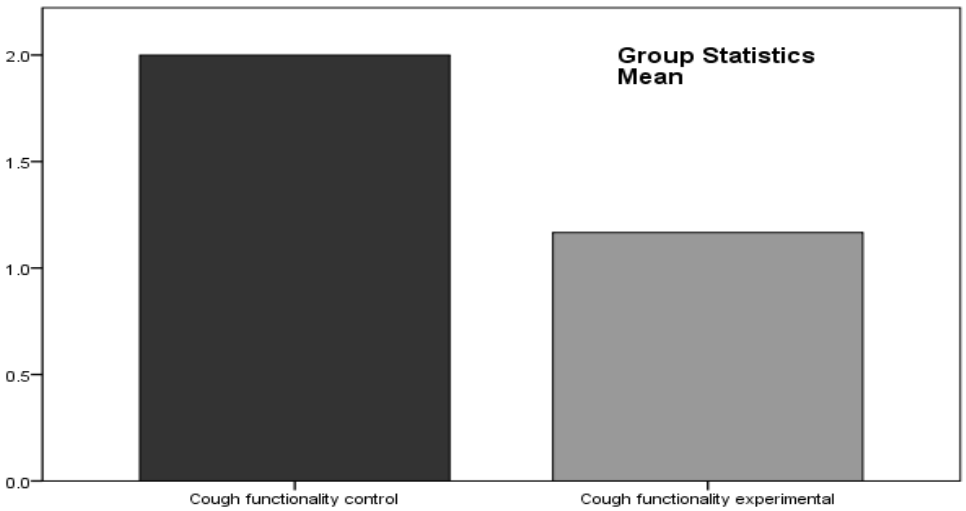

Figure 6. The cough functionality in the post-operative period among groups

Journal of Chemical Health Risks
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JCHR (2023) 13(4), 2266-2282 | ISSN:2251-6727

RESULTS DISCUSSION

Postoperative chest physical therapy is routinely prescribed in most hospitals after CABG, however, the preoperative physiotherapy intervention is not widely used and little information is known about the effects of preoperative breathing and circulatory exercises on postoperative pulmonary function and complications. [26]

In this randomized clinical trial, we aimed to investigate the effect of pre pre-cardopulmonary rehabilitation program on post-operative overall pulmonary function. The results of this study indicated that there was a significant difference in preoperative physiotherapy intervention on post-upper and lower chest expansion among the two groups (p=0.019, 0.037) for upper and lower chest expansion respectively. Despite the decreasing of post pulmonary function values in all participants in the study, when compared with preoperative values which range from 2-5 cm, which might be attributed to the postoperative pain, incision, and hypofunction of the lung after general anesthesia; findings that indicating that the applied pre-operative physiotherapy intervention program had a significant effect on post upper and lower chest expansion after CABG surgery between the participants in the two groups. Our results are consistent with a similar study that was conducted by Westerdahl which showed the effectiveness of the pre-physiotherapy intervention on post-chest expansion [27].

The cough and clearance of secretions were recorded in this study which shows a significant difference (0.008) between the two groups in favor of the experimental group which has better cough functionality.

However, the spirometer lung volumes; and the inspiratory and expiratory measures were not significantly affected by the applied program in the period of post-surgery among the experimental and the control groups. This may relate to general anesthesia which may inflate the alveolar and take time to re-expand all atelectasis tissue postoperatively. Consequently, patients may become unable to breathe deeply or exhale forcedly, This result is similar to Pouwels's study which reported that there is no significant difference in spirometer-forced expiratory and inspiratory measures postoperatively between the two groups [28].

STUDY LIMITATIONS

The following are major issues that have limited the researcher in this study, firstly limited ability to have a large sample size due to a limited number of patients who were admitted to the hospital during the period of Coronavirus, and many patients refuse to undergo cardiac surgery in this risky time. Secondly, limited previous studies are related to this study; most of the research studies the effect of physiotherapy in the postoperative period not in the preoperative period. Thirdly, limited patient admission days to the hospital in the preoperative period (four days), which is the optimal period to educate and train the patient preoperatively.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

- There is a significant effect of the applied pre-operative program on post-upper and lower chest expansion.
- There is no significant effect of the applied program on the post-inspiratory and expiratory spirometer volume.
- There is a significant effect of the preoperative physiotherapy intervention program on post-pulmonary hypoxemia rates after CABG.
- There is no effect of preoperative physiotherapy intervention in post-pulmonary atelectasis,

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pneumonia, length of stay, and time of extubation after CABG.

To conclude, the suggested preoperative physiotherapy program may contribute to improving pulmonary functions and aerobic capacity among CABG patients, in addition to minimizing the risk of complications that may occur during surgery such as hypoxemia.

RECOMMENDATIONS

- Conducting further research about the effect of a pre-operative physiotherapy program on post-pulmonary function with follow-up assessment after a longer period, where patients' conditions would be more stable.
- Develop a long period of preoperative physiotherapy program at the Palestinian hospitals recruiting elective CABG patients in the preoperative period which may be better than limited sessions in the preoperative period of admission.
- CABG patients should be encouraged to have pre- and postoperative physiotherapy cardiopulmonary training, which may contribute to improving the pulmonary functions post-surgery and decrease the patient's risk of hypoxemia postoperatively.
- Highlighting the importance of preoperative physiotherapy intervention program for CABG patients among Palestinian cardiac surgeons in the West Bank and Jerusalem,
- To increase the research related to preoperative physiotherapy intervention with large sample sizes and multivariate models are needed to further examine the effect of preoperative physiotherapy programs on post-pulmonary function and complications.

AUTHORS' CONTRIBUTIONS:

1. Conceptualization: Dr. Tamara
2. Data curation: Dr. Hadeel
3. Formal Analysis: Dr. Hadeel
4. Funding acquisition: Dr. Khaled
5. Investigation: Dr. Hadeel
6. Methodology: Dr. Tamara
7. Project administration: Dr. Tamara
8. Resources: Dr. Tamara
9. Software: Dr. Hadeel
10. Supervision: Dr. Khaled
11. Validation: Dr. Khaled
12. Visualization: Dr. Hadeel
13. Writing – original draft: Dr. Tamara
14. Writing – review & editing: Dr. Khaled

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CONFLICT OF INTEREST

"The authors declare no potential conflicts of interests with respect to the research, authorship, and/or publication of this article."

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AVAILABILITY OF DATA AND MATERIALS

The data is available upon the request from Dr. Khaled Sabarna, K.sabarna@paluniv.edu.ps

CLINICAL TRIAL REGISTRY NUMBER

"This research doesn't contain any clinical trial"

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