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Research Article

The Effect of Early Mobilization Techniques on Meliorating Fatigue and Physical Activity Tolerance of Patients Admitted to Cardiac Intensive Care Units

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ABSTRACT

Background: Patients undergoing Coronary Artery Bypass Grafting (CABG) frequently experience fatigue and physical activity tolerance as post-operative complications. The early mobilization technique is one of the beneficial nursing intervention programs that amend patients' outcomes, intercept immobilization, and increase quality of life. This study aimed to assess the effect of the early mobilization (EM) protocol on fatigue and physical activity tolerance in patients who underwent CABG.

Methods: We designed this study as a quasi-experiment with a control group. Participants involved patients who underwent CABG at the Intensive Care Unit (ICU) of Tehran Shahid Modarres Hospital in Iran between April and September 2023. The study included 96 patients, with 48 patients each in the intervention and control groups. Two distinct time points were used to select intervention and control groups (the initial three months and the following three months). Both the control and intervention groups received standard hospital care, but the intervention group also received an EM protocol education. We dedicated three days to intervention education and employment: day 0 (immediately after extubation), day 1 (24 hours later), and day 2 (48 hours later). We collected data were using the Visual Analog Scale-Fatigue (VAS-F) and the Borg scale at two time points (day 0 and day 2). We performed a paired t-test, an independent sample t-test, and an ANCOVA to analyse data.

Results: 56.3% of participants were men and 43.7% were women. The mean age of participants was 52.7±8.8. In both groups, hypertension (29.2%), hyperlipidemia (27.1%), and diabetes (20.8%) were the most prevalent CVD risk factors. The intervention group's mean fatigue decreased significantly on day 2 (4.40±0.94) compared to day 0 (6.65±1.12) while the mean PA tolerance increased significantly on day 2 (11.82±1.90) compared to day 0 (7.31%±1.20) ($P<0.001$). The control group did not experience any statistically significant intragroup changes ($P>0.05$). Significant intergroup changes were observed in the mean fatigue and PA tolerance values on day 2 ($P<0.001$) while there were no statistically significant intergroup changes in them on day 0 ($P>0.05$).

Conclusion: This study highlighted that early mobilization was an effective and safe inhibition program to meliorate fatigue and physical activity tolerance in CAD patients.

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Introduction

Coronary artery disease (CAD), a subset of cardiovascular diseases (CVDs), has been known as the major cause of hospitalization, morbidity, and mortality throughout the world, especially in developing countries. According to the World Health Organization (WHO), CAD is a chronic and growing disease that causes an estimated 7.4 million deaths annually in the world and will reach 23.3 million in 2030 [1-3]. Over 75% of CVD mortality rates occur in the low- and middle-income countries. The prevalence of CVD in Iran is the highest age-standardized rate recently [2, 4]. The primary risk factors of CVDs involve behavioral functions such as smoking and using tobacco, excessive usage of alcohol, unsuitable diet and obesity, physical inactivity, sex, and age. Accordingly, CAD's causes include diabetes mellitus, hypertension, and dyslipidemia [1, 4-6].

One of the leading treatments for patients with CAD is Coronary Artery Bypass Grafting (CABG). CABG has been a standard and prevalent treatment since the 1960s. This cardiac surgery is used to alleviate variation between demand and supply of heart tissue when three main coronary arteries are involved, mainly the upper left coronary artery. CABG ameliorates the quality of life, reduces the relapse of morbidity and mortality of heart diseases and ischemia, and lengthens survival [1-2, 7-9]. CABG postoperative complications are associated with physical and psychosocial problems. The physical complications include pulmonary injuries, respiratory distress syndrome, arrhythmia, ventricular dysfunction, gastrointestinal dysfunction, chest pain, and renal impairment. Because of long-term ICU hospitalization and health management, CABG patients experience negative emotions including depression, anxiety, cognitive disorders, poor appetite, social seclusion and loneliness, sleeping disorders, and fatigue. These psychosocial problems impact physical activity (PA), daily sleep, and well-being. The persistence of these complications in patients undergoing CABG causes delayed lesion improvement, decreases the quality of life, and increases the death risk [2, 8-11]. Fatigue is defined as postoperative fatigue syndrome, a group of undesirable feelings such as sleeplessness, stress, anxiety, depression, and lack of focus that lead to disabling physical activity and mental efforts. Fatigue arises in the recovery time, especially 2–4 weeks after CABG. Previous studies have shown that 20% of CAD patients experience fatigue before rehabilitation treatment, while the majority of patients (80%) report fatigue 4-24 months after CABG. The fatigue syndrome followed by important surgeries such as CABG is the consequence of high tryptophan plasma in plasma condensation. The period of fatigue after CABG is linked with some factors such as a reduced amount of cortisol, patient fatigue level before surgery, decreased level of exercise due to the patient's CVD condition, and notable reduction of muscle and heart function. Also, fatigue after CABG harms the amelioration of psychological health and PA and so increases the hospitalization time, financial burden, and patient's inability to get back to society and work [9, 12-13]. PA is described as an improvement program for physical and mental health following CABG. Researchers have found that physical activity after CABG reduces death rates from cardiovascular diseases, signs of tiredness, and side effects from treatment, while also enhancing physical ability and heart and lung fitness [13-14]. Consequently, effective intervention to mitigate the effects of bed rest following cardiac surgery must be established. Early mobilization (EM) has attracted attention as one of the nursing intervention programs to manage postoperative CABG problems in the intensive care unit (ICU). EM, as a safe rehabilitation intervention, has significant effects that improve patient PA and care outcomes. However, limited studies have been performed to assess the benefits of EM on patients after CABG [3, 14-16]. Accordingly, this study aimed to assess the effect of EM on fatigue recovery and PA tolerance of ICU-hospitalized patients.

Methods

Design

A quasi-experimental study with intervention and control group design was performed. The research hypotheses are as follows:

H1: EM meliorates fatigue in patients who undergo CABG.

H2: EM meliorates PA tolerance in patients who undergo CABG.

Participants and Settings

The study population involved patients who underwent CABG at the Intensive Care Unit (ICU) of Tehran Shahid Modarres Hospital in Iran between April and September 2023. Participants were selected using the convenience sampling method. Then the minimum sample size was estimated as a total of 96, containing 48 patients each in the intervention and control groups. The sample size was determined with a 95% confidence interval, 90% power, 0.70 effect size, and 10% dropout rate in the following formula:

$$n \geq \frac{(Z_{\alpha/2} + Z_{\beta})^2 \sigma^2}{(\mu_1 - \mu_2)^2}$$

Inclusion Criteria

We selected patients who met the following criteria: they were undergoing CABG in both genders, were between the ages of 18 and 75, were willing to participate in the study, were sober, had spent at least 3 days in the

ICU, had hemodynamic stability, were free of unstable chest pain, had systolic blood pressure greater than 200 mmHg, diastolic blood pressure greater than 100 mmHg, had no acute systemic disease, had no electrolyte abnormalities, and had no uncontrolled tachycardia or bradycardia.

Exclusion criteria

We excluded patients who left the research at any step, didn't follow the exercise instructions, had a history of psychological disorders, needed an aortic pump, and failed to answer all questions on the questionnaire.

Measures

The instrument used in this study was a researcher-made questionnaire with three parts involving demographic information, a visual analog scale for fatigue (VAS-F), and a Borg scale for PA tolerance. In addition, we used a valid educational booklet including a structured early mobilization protocol for patients.

Demographic Information Questionnaire

Demographic information included gender, age, marital status, job, employment status, education level, job history, and risk factors for CAD. The researcher completed this part for both groups on the day patients were discharged from the ICU.

Visual Analog Scale-Fatigue (VAS-F)

In this study, VAS-F was used to quantify fatigue in the patients who underwent CABG. VAS-F is a single-item and continuous scale from 0 to 10 cm ruler, where zero refers to "no fatigue" and 10 indicates the greatest severity of fatigue. Compared to other valid fatigue scales, VAS-F measures the fatigue level simultaneously, not retrospectively (VAS-F2) [17-18]. The reliability of VAS-F in this study was 0.89 (alpha Cronbach's=0.89).

Assessment of Physical Activity

We utilized the Borg scale to assess PA tolerance. Gunnar Borg introduced this tool in 1960. Borg is a 6-20 scale in which the severity of PA tolerance is determined from 6 (very light PA) to 20 (maximal PA). The validity and reliability of this scale were determined in the Daneshmandi et al. (2012) study with ICC=0.847. The scoring method for the Borg scale is shown in (Table 1) [19-20]. This study's reliability was confirmed by the alpha Cronbach's coefficient of 0.86.

Early Mobilization Protocol Booklet

This booklet was created based on the gathering of information from previous studies and then translated into Persian. The validation of this booklet was validated by 20 professors who specialize in this field, who reviewed the booklet and made the required corrections.

Data collection

In this project, the process of selecting groups (control and intervention) and gathering data was implemented at different separate times to avoid any effects of the early mobilization intervention between the groups. In this regard, two distinct time points were used to select intervention and control groups. During the initial three months, data was collected for the control group, and in the following three months, data was collected for the intervention group. 48 eligible patients who underwent CABG surgery within the first three months of the study were considered the control group. During the next three months, the intervention group contained 48 eligible patients undergoing CABG surgery. Both groups were surveyed using the face-to-face interview technique in the ICU. Data collection was accomplished by interviewing each patient for an average of 30 to 45 minutes. The patient's information, including demographics, fatigue level, and PA tolerance, was documented using study tools during two time points (day 0 and day 2) in each group (control and intervention). In this study, day 0 (post-operation) is defined as the first 24 hours after the operation room and immediately after extubation in the ICU. As a result, day 2 is defined as 48 hours after entering the ICU. Then, the study implementation programs were conducted for each group. The control group received standard and routine hospital care in the ICU, and then they were assessed for fatigue and PA tolerance using study tools on the first day after surgery (day 0) and 48 hours later (day 2). The intervention group, assisted by the researcher in the ICU, followed the protocol for early mobilization for three days in addition to routine hospital care. The level of fatigue and PA tolerance of the intervention group was measured using study instruments on the first day after surgery (day 0) and 48 hours later (day 2).

Intervention implementation (Early Mobilization)

The early mobilization protocol for the intervention group was initiated during three days of hospitalization in the ICU with patients who were extubated, fully conscious, with stable hemodynamics, and with written permission from the attending physician.

Table 1- The Borg scale scoring

6-9	10	11-12	13	14-15	16	17	18	19	20
Minimum PA	Mild-easy	Light	light with little effort	Moderate	Little difficult	Difficult	Very difficult	Too difficult	maximal

The intervention group received training booklets that prepared them for active participation in the early mobilization program. Following the protocol, the researcher assisted patients in performing early mobilization techniques in the ICU. Patients were instructed to discontinue the activity and inform the researcher if they experienced any abnormal symptoms or chest pain. In the training booklet, the patients were taught to deep breath, cough, do passive-active range of motion (ROM) exercises, and encourage spirometry, as well as learn about the activity program's benefits in line with the early mobilization protocol. The early mobilization exercises are illustrated in Table 4 (Supplementray Table). After surgery, the intervention group carried out the activities listed below (for 3 days):

Post-operation (Day 0):

Day 0 is marked as the time when patients leave the operating room and immediately after being extubated. The bed head was raised to 30° to 45°, and deep breathing and coughing exercises were carried out eight times daily. In two sessions per day, five sets of passive ROM exercises were performed for both the lower and upper extremities. Patients were permitted to sit on the inclined bed and stay in a sitting position for 15 minutes twice daily.

Post-operative (Day 1):

On the second day after surgery, the bed head was elevated 30-45 degrees, and deep breathing and coughing exercises were performed eight times a day, consisting of five deep breathing exercises and one coughing exercise in three or four cycles. Five repetitions of passive or active ROM exercises (lower and upper extremities) were done three times a day. The patient was allowed to sit on the bed for 20 minutes three times per day and walk 150 steps in their room.

Post-operative (Day 2):

On the third day after surgery, the head of the bed was elevated to 30-45 degrees, and deep breathing and coughing exercises were performed eight times a day, five deep breathing exercises and one cough. Three times a day, the patient was permitted to sit in a chair for 20 minutes, and five sets of ROM exercises (lower and upper extremities) were done three times daily.

Data analysis

Normality was checked using the Shapiro-Wilk test. Descriptive statistics were defined with mean ± standard deviation (mean ± SD) and frequency (percent). An independent sample t-test was used to compare the mean values of outcome variables (fatigue and PA tolerance) before intervention between the two groups (intervention vs. control). To obtain within-group changes in outcome variables in each group, a paired t-test was applied. Analysis of covariance (ANCOVA) was used to compare outcome scores after the intervention at day 2 (48h later) to control the post-operative (day 0) effect as a covariate. The statistical significance level was 5%. SPSS statistical software version 22 was used to analyze the data.

Results

In total, 56.3% of patients were male and 43.7% of them were female. The mean ages of participants in the intervention and control groups were 52.2±9.6 and 53.4±8.3, respectively. 77.1% of the intervention group and 83.3% of the control group were married. Most of the patients in both groups were at the bachelor's educational level (intervention= 50% vs. control=56.3%). Also, 54.2% and 58.3% of the intervention and control groups were employed. Hypertension and hyperlipidemia had the highest percentage in both groups. The rates of risk factors in the intervention group were, respectively, hypertension (25%), hyperlipidemia (22.9%), diabetes (20.8%), alcohol and cigarette usage (18.8%), and family history (12.5%). The risk factor ratios in the control group were, respectively, as follows: hypertension (33.3%), hyperlipidemia (31.3%), diabetes (20.8%), alcohol and cigarette usage (10.4%), and family history (4.2%). There were no significant differences between patients in both groups in terms of demographic characteristics ($P>0.05$).

(Table 2) shows the within-group changes in fatigue and PA tolerance. The mean fatigue in the control group on day 0 (post-operative) (6.27±1.20) did not change significantly compared to day 2 (48h later) (6.21±1.10) ($P>0.05$), while the mean fatigue in the intervention group 48h later (4.40±0.94) significantly decreased compared to day 0 (6.65±1.12) ($P<0.001$). Also, in the control group, the mean PA tolerance of day 0 (7.52±1.30) did not change significantly compared to 48h later (7.70±1.25) ($P>0.05$), while there was a significant increase in the intervention group on day 2 (11.82±1.90) compared to day 0 (7.31±1.20) ($P<0.001$).

(Table 3) shows the between-group changes in fatigue and PA tolerance. No statistically significant difference was observed in the mean value of fatigue between the groups on day 0 ($P=0.12$). However, there was a statistically significant difference between the two groups in the mean fatigue score on day 2 (48 hours later) ($P<0.001$). Also, there was no statistically significant difference in the mean value of PA tolerance on day 0 (post-operative) ($P=0.41$), while the mean value of PA tolerance in the intervention group (11.82±1.90) was significantly higher than that in the control group (7.70±1.25) on day 2 (48h later) ($P<0.001$) (Table 2).

Table 2- Within-group comparison of outcome variables

Variables	Intervention (n=48)	Control (n=48)
	Mean±SD	Mean±SD
Fatigue		
Day 0 (post-operative)	6.65±1.12	6.27±1.20
Day 2 (48h later)	4.40±0.94	6.21±1.10
Mean difference	2.25	0.06
P value	0.00***	0.62
PA tolerance		
Day 0 (post-operative)	7.31±1.20	7.52±1.30
Day 2 (48h later)	11.82±1.90	7.70±1.25
Mean difference	-4.5	-0.21
P value	0.00***	0.051

Note: P values obtained from paired t-test; PA tolerance= physical activity tolerance; Mean difference= Day 0- Day 2; ***P<0.001

Table 3- between-group comparison of outcome variables

Variables	Day 0 (post-operative)	Day 2 (48h later)	Partial Eta	P value [a]
	Mean±SD	Mean±SD		(F)
Fatigue				
Intervention (n=48)	6.65±1.12	4.40±0.94	0.66	0.00***
Control (n=48)	6.27±1.20	6.21±1.10		(181.7)
P value [b]	0.12	-		
PA tolerance				
Intervention (n=48)	7.31±1.20	11.82±1.90	0.74	0.00***
Control (n=48)	7.52±1.30	7.70±1.25		(27.06)
P value [b]	0.41	-		

Note: P values obtained from ANCOVA (a) and independent sample t-test (b); PA tolerance= physical activity tolerance; ***P<0.001.

Discussion

The purpose of this quasi-experimental study was to investigate how EM affects fatigue and PA tolerance in patients who were ICU-hospitable due to CABG. In this context, two hypotheses were created to evaluate the outcome variables independently. According to our findings, the intervention group experienced statistically significant intragroup changes in fatigue and PA tolerance, while the control group did not experience any statistically significant intragroup changes. Compared to day 0, the mean value of fatigue on day 2 in the intervention group decreased. In contrast, the mean value of PA tolerance on day 2 increased compared to day 0. In addition, there were no statistically significant intergroup changes in fatigue and PA tolerance on day 0 (post-operative). In contrast, significant intergroup changes were observed in the mean fatigue and PA tolerance values on day 2 (48 hours later). On day 2, the intervention group's mean fatigue score was lower than the control group's, but the mean PA tolerance score of the intervention group was higher than that of the control group. A review of other studies revealed that each study varied in the amount of fatigue and PA tolerance changes. This issue can be explained by the fact that not all studies utilized a single intervention method, and the populations studied were not the same.

Following the results of the first study hypothesis, which demonstrates that EM meliorates fatigue in patients undergoing CABG, some surveys have sometimes achieved comparable or dissimilar results. In the experimental study of De Almeida et al. (2017) on 108 patients who had major abdominal oncology surgery, two groups of EM and standard care were compared. The EM protocol was centered on training core stability and orthostatic, gait, aerobic, and resistance, and standard rehabilitation care was focused on core control and orthostatic. The EM group was less likely to report fatigue duration on postoperative day 5 than the standard care group, and those who did report it were less intense [14]. Fagevik Olsén et al. (2021) investigated the brief-term effects of EM on oxygenation in patients after open surgery for pancreatic cancer in the ICU. The findings indicated that EM had an impact on patients in the same-day EM group compared to the next-day EM group and led to enhanced oxygenation, while there were no significant intergroup changes for the time sitting in a chair, time sitting over the edge of the bed, and time standing. Despite the positive oxygenation, they observed no significant changes in patients' complications, including fatigue levels [21]. The similarity between these studies and the present study is in the type of intervention, with the difference that our study was conducted with a control group, and the duration of the

EM protocol implementation for the intervention group was 3 days. According to our results, the amounts of changes in fatigue were greater than in their studies.

In another study conducted by Rezaei-Adaryani et al. (2009), a different intervention method was compared to routine care (control group) in 70 patients after cardiac catheterization. They confirmed that changing positions and the early ambulation method led to a significant decrease in fatigue levels compared to the control group at 3, 6, and 8 hours, and the next morning [22]. Herisson et al. (2016) compared two sitting procedures at the acute phase of ischemic stroke. They showed that there were no differences between the early- and progressive-sitting groups, and both groups tolerated the procedure well. The two groups did not differ in the prevalence of fatigue at 3 months: 43.1% in the early sitting group and 48.5% in the progressive sitting group [23]. The implementation method and duration of the intervention were the areas where our study differed from those two studies. It was determined that changing positions and the early ambulation method significantly affected fatigue, and the two methods of early and progressive sitting have no difference in reduction of fatigue.

The second study hypothesis confirmed that EM meliorates PA tolerance in patients undergoing CABG. In this regard, other studies were conducted with similar or different findings. Da Costa Torres et al. (2017) tested functional capacity in two groups: the breathing exercise and the other consisting of both breathing exercises and aerobic exercises at both short and long term in patients undergoing CABG. They discovered that using both breathing exercises and aerobic exercises greatly enhanced patients' ability to function, resulting in longer walking distances during the 6MWT, shorter stays in the ICU, and fewer lung problems [24]. In Kinas et al.'s (2024) study, deep breathing and coughing exercise training and routine care in patients with open-heart surgery were compared. They reported that patients who received deep breathing and coughing exercise training before open heart surgery experienced an improvement in their respiratory functions and PA tolerance in the postoperative period [11]. While the intervention used in their study was different than ours, it was still a part of the method we used. The results were in line with ours and proved that this intervention, such as breathing and coughing exercises, had an impact on physical activity tolerance.

In another trial study performed by Li et al. (2024), two groups of EM programs and the usual care in patients undergoing pancreatic surgery in the ICU were assessed. The results showed that EM had no significant impact on postoperative complications, but it can boost postoperative mobilization and improve the recovery of gastrointestinal and physical function. Compared to the control group, the EM group showed significant improvement in outcomes such as time to first ambulation, daily walking distance, and average walking distance. The EM group walked more than normal on postoperative days 1-7 after their first postoperative ambulation earlier [25]. De Almeida et al. (2017) found that, besides feeling less tired, the EM program helped improve the group's ability to function, and they also saw a big drop in issues like not being able to cross the room. The 6-minute walk test of patients in the EM group had significantly increased on postoperative day 5. However, there were no significant changes in the length of hospital stay [14]. The two previous studies used a similar intervention implementation method as ours, and our results aligned with theirs. Due to the positive changes observed in PA tolerance following the EM program, it can be concluded that the program had a positive impact on all forms of physical activity, including walking distance.

Conclusion

Implications for practice

This study revealed that reducing postoperative complications could be achieved through early mobilization in the ICU. Our results showed that early mobilization performed in the intervention group was effective in increasing the PA tolerance and decreasing the fatigue level of patients who underwent CABG, and no significant changes were observed in those of patients in the control group since they could not benefit from the positive effects of the program. Using this protocol in the ICU will guarantee that patients are moved safely and that early mobilization is implemented as a standard of care. The importance of the early mobilization protocol should be communicated to healthcare professionals and nurses. The early mobilization protocol's effectiveness in several outcomes, particularly fatigue and PA tolerance, needs to be determined through studies in a large sample of patients who undergo cardiac surgery and in different patient groups.

Study Strengths and Limitations

This study investigated the effectiveness of the EM protocol on both common factors of fatigue and PA tolerance after open heart surgery in the ICU. According to our research, there have been few studies done for these purposes on CABG patients in the ICU. Our study has a limitation due to the use of a quasi-experimental design, but the EM protocol appears to be effective, but it needs to be confirmed in a randomized controlled trial. Due to the cardiac intensive care unit and the acute condition of this group of patients, sample collection was difficult. The EM program for the intervention group was faced with limitations due to the condition of cardiac patients.

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Ethical Considerations

The ethics committee at Shahid Beheshti University of Medical Sciences approved the written consent provided by the hospital study site (IR.SBMU.PHARMACY.REC.1403.109). All patients were given written and verbal consent to participate.

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