The Effect of Planned Deep Breathing along with Cardiac Exercise Rehabilitation on 6-Minute Walk and Hemodynamic Parameters in CABG Patients

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Abstract

Cardiac rehabilitation is a major part of the care given after CABG surgery. This study aimed to examine the effect of planned deep breathing along with cardiac exercise rehabilitation on the 6-minute walk and hemodynamic parameters in CABG patients. In this randomized controlled clinical trial, 60 cardiovascular patients who underwent CABG surgery in Rajaie Hospital in Tehran, Iran were eligible to participate in this research. Patients in the experimental group received the guidelines of planned deep breathing exercises by attending three 60-90-minute sessions of a cardiac exercise rehabilitation program per week (eight weeks total). The collected data were analyzed through SPSS software. Results showed a significant reduction in the average systolic blood pressure and heart rate of patients in both experimental and control groups after the intervention ($P<0.05$); however, the average rate of changes in the control group was significantly greater than experimental group ($P<0.05$). There was also a significant increase in the average rate of arterial oxygen saturation, respiratory rate, and walk distance in 6 minutes by both patients in the experimental and control group after the intervention ($P<0.05$), and the experimental group experienced a significantly greater average rate of change compared to a control group ($P<0.05$). However, the average rate of changes in diastolic blood pressure in experimental and control groups indicated no significant difference ($P>0.05$). The obtained results indicated that planned deep breathing exercises along with cardiac exercise rehabilitation had a significant effect on the 6-minute test and hemodynamic parameters in patients undergoing CABG surgery.

Keywords: *Deep Breathing exercises, Cardiac Exercise Rehabilitation, 6-Minute Test, Hemodynamic Parameters, CABG Patients*

Introduction

Chronic diseases make up the half of global disease rate and anticipation indicates that seven deaths out of every 10 deaths will occur due to chronic diseases, including cardiovascular (CV) ones as the number one killers [1].

CV diseases are the major causes of death and hospitalization in developing countries [2]. Overall, mortality rates, due to CV diseases, account for 25% worldwide and 32% in developing countries [3]. According to WHO estimates, more than 17 million people around the globe die of cardiovascular diseases each year [4]. The critical part of CV disease treatment includes drug therapy and diet orders but non-pharmacological treatments such as PCI[1] or CABG[2] must be taken to treat complications caused by disease in some patients. CABG surgery is chosen for many patients to treat or prolong their lives. Annually, more than 8 million CABG surgeries are performed around the world, and about 40,000 open heart surgeries are done in Iran [5].

Cardiopulmonary bypass (CPB) is the standard surgical technique. In CPB, the vascular system is linked to a specialised mechanical device called an oxygenator pump, which temporarily replaces both the heart pump and the lung's gas exchange system. Large expanses of synthetic materials are exposed to blood during CPB, which causes a variety of chemotactic and vasoactive chemicals to be produced and released. The activation of neutrophils leads to significant damage to the pulmonary endothelium, epithelium, and interstitial tissues when they are trapped in the pulmonary circulation. Reduced lung compliance, increased pulmonary capillary endothelial permeability, and compromised gas exchange might all result from this injury [6]. Consequently, one of the most frequent complications of coronary artery bypass grafting (CABG) is impaired gas exchange due to acute lung damage [7]. Even with ongoing advancements in postoperative critical care and cardiopulmonary bypass (CPB) techniques, lung dysfunction following CABG continues to be a significant cause of morbidity [8], and it is linked to low or high arterial carbon dioxide tension that can last for several days, necessitating prolonged mechanical ventilation [9].

The leading cause of hospitalization-related morbidity, death, and expenses is postoperative pulmonary problems, which occur most frequently and significantly [10].. Pulmonary complication after coronary artery bypass surgery has been reported between 30% and 60% in a study [11].

Additionally, a variety of complications can arise from CABG surgery; some patients may experience early postoperative complications, while others may experience late complications. The most common complications following

[1] Percutaneous Coronary Intervention

[2] Coronary Artery Bypass Grafting

CABG are pleural effusions and atelectasis, but other musculoskeletal issues also arise from immobility and the adoption of a kyphotic posture due to pain from infusion and overload on the respiratory muscles. Patients also fail to follow postoperative phase 1 rehabilitation orders and phase 2 rehabilitation after discharge, which results in decreased breathing efficacy and decreased mobility of the shoulder, neck, and trunk muscles, causing respiratory issues and hemodynamic disorders [12]. Therefore, CABG patients suffer from short functioning. In this case, the maximal oxygen volume is impaired leading to failure in some activities such as the 6-minute walking test (6MWT). 6MWT is one of the most useful and sensitive measures for the assessment health of cardiovascular patients, which includes 6 minutes of walking on the corridor and under controlled symptoms. The results of this test indicate the accurate cardiovascular status of the patient. This is an elective test since it reflects the functional ability of the patient and is more tolerable and simpler than other walking tests [13].

One or more methods are used after surgery to improve oxygenation and pulmonary function in gas exchanges but there is not any consensus on a specific measure [14]. Deep breathing exercises and cardiac rehabilitation can be used as measures, which do not contribute to any complications for patients [15].

Exercises that promote deep breathing help the patient open their closed alveoli and breathe more deeply. This enhances ventilation-to-perfusion ratio, gas exchanges, and oxygenation by preventing lung dysfunction and athelectasis [16]. Deep breathing techniques considerably raise arterial oxygen saturation and arterial oxygen tension, according to research by Urell and colleagues (2011) [17].

Besides pharmacological treatments and other interventions performed for cardiovascular patients, cardiac rehabilitation also can be used to control risk factors, improve lifestyle, and reduce patients' mortality rate [18]. This is the most simple, and understandable non-pharmacological treatment for patients [19]. Cardiac rehabilitation consists of some interventions used to improve physical, mental, and social status, to reduce the process of atherosclerosis, to mitigate mortality rate and reinfection. Cardiac rehabilitation aims to restore the natural function of patients improving their mental-social status. The rehabilitation program includes exercises given to improve, control, and manage risk factors such as blood sugar, blood pressure, and blood lipids [20].

As a major part of postoperative care given to CABG patients, cardiac rehabilitation is a comprehensive process used to improve cardiovascular health by performing personal and group programs to prevent disease development, maximize physical and psychological-social abilities, improve the quality of life and mood of patients, and to reduce morbidity and mortality rates [21].

Results obtained by Mampuya (2012) and Chou et al. (2014) indicated that cardiac rehabilitation could reduce the death rate and disease recurrence by 40% [22, 23]. Beckie and colleagues (2013) found that cardiac rehabilitation could significantly increase the respiratory capacity of patients. It also improved the physical function of patients [24].

Mozafari and colleagues (2015) carried out a study and found a significant rise in the walk distance through 6MWR in post-angioplasty cardiac patients who received cardiac rehabilitation. Therefore, post-angioplasty cardiac rehabilitation is a useful measure in improving the physical ability of patients [25].

Because coronary artery bypass graft surgery is required for a large number of cardiovascular patients and is associated with significant treatment costs, the medical team should be attentive to the requirements of the patients and work to minimise problems and enhance the quality of life following surgery. (26].

Many studies have proven the positive effect of cardiac rehabilitation on the reduction of mortality rate, and improvement of quality of life and mental-social status of patients helping them live in normal conditions [27]. However, there are few studies on the effect of cardiac exercise rehabilitation along with planned deep breathing exercises on the 6-minute walking test among CABG patients. According to the abovementioned point and practical use of 6MWT for cardiovascular patients, this study was conducted to examine the effect of planned deep breathing exercise along with cardiac exercise rehabilitation on 6MWT and hemodynamic parameters in CABG patients.

Materials and Methods

This study involved a randomised controlled clinical trial involving 60 patients undergoing CABG surgery who were hospitalised at the Rajaie Cardiovascular, Medical, and Research Centre in Tehran, Iran. The patients were included in the study based on the following inclusion criteria: age range of 30-65, blood pressure less than 160 mmHg, no severe pulmonary diseases prior to surgery, no musculoskeletal problems (paralysis, severe foot osteoarthritis), and willingness to participate in the study. The subjects were selected using the permuted-block randomization method, and they were divided into two experimental (n = 30) and control groups (n = 30). The subjects underwent a 6-minute walking test. Their hemodynamic status, including their heart rates, systolic and diastolic blood pressure, arterial oxygen saturation percent, and respiratory rate, was measured. The results were recorded in the form along with their sex, age, education level, marital status, history of high blood pressure (hypertension), history of diabetes, history of high blood lipids, and history of smoking.

Patients of the experimental group received the guideline of planned deep breathing exercises under the supervision of the researcher while the control group received regular breathing care. In planned deep breathing exercises, patients were in sitting or semi-setting positions and took deep and slow breathes through their noses while their hands were put on their chests and pushed to lower the pain and breathe easier; after inhaling, patients held their breath for a count of 3 and exhale while lips and stomach muscles were compressed. This exercise was repeated for 10 circuits every 2 hours when the patient awakened. Patients in the experimental group not only received planned deep breathing exercises but also received three 60-90-minute sessions of cardiac exercise rehabilitation program per week (eight weeks total). At the end of rehabilitation sessions, patients were retested throughout 6MWT and their hemodynamic status was assessed. Using SPSS17 software, the gathered data were subjected to statistical tests such as the independent t-test, Mann-Whitney U test, Wilcoxon, and Fisher test; the descriptive statistics were displayed as mean and standard deviation values; and the data analysis was done at the significance level of $P<0.05$.

Findings

The study comprised 60 patients in total (30 in each of the experimental and control groups). Table 1 lists the patients' demographic data. Statistical analyses revealed no discernible differences between the experimental and control groups in terms of age, sex frequency distribution, education level, high blood pressure, diabetes, high blood lipids, smoking, cardiovascular risk factors, clogged right and left circumflex vessels, and left descending arteries.

Table 1. Demographic variable (disease history and clinical symptoms of experimental and control groups)

Variable				**Group**	
Sex	Male			76.7	83.3
	Female			23.3	16.7
Education level	Lower diploma			33.3	26.7
	Diploma			33.3	33.3
	Diploma and higher			33.3	46.7
Age				59.60	60.87
Disease history	hypertension	No		40	33.3
		Yes		60	66.7
	Diabetes	No		36.7	20
		Yes		63.3	24
	High blood lipids	No		46.7	26.7
		Yes		53.3	63.3
Smoking		No		50	40
		Yes		50	60
Cardiovascular risk factor		No		16.7	3.3
		Yes		83.3	96.7
Type of arteries		Right circumflex	Clogging	60	70
		Left circumflex		96.7	93.3
		Left descending artery		96.7	93.3

According to findings, planned deep breathing exercises along with cardiac exercise rehabilitation had a significant effect on 6MWT and hemodynamic parameters in patients undergoing CABG surgery. Table 2 reports Comparison of studied patients in two experimental and control groups during and after the intervention ,Besides, data indicated a significant difference between the effects of planned deep breathing exercises along with cardiac exercise rehabilitation on 5MWT and hemodynamic parameters regarding variables including systolic blood pressure ($p=0.56$), diastolic blood pressure ($p=0.02$), arterial oxygen saturation ($p<0.001$), heart rate ($p=0.04$), respiratory rate ($p<0.05$), and the walk distance with 6 minutes ($p<0.001$). Moreover, results showed a significant difference between average changes in patients in both experimental and control groups regarding some variables, such as systolic blood pressure ($p<0.001$), diastolic blood pressure ($p=0.25$), arterial oxygen saturation ($p<0.001$), heart rate (p=0.04), respiratory rate (p<0.01), and the walk distance with 6 minutes (p<0.001).

Table 2. Comparison of studied patients in two experimental and control groups during and after the intervention

Variable	Stage / Group	Before intervention	After intervention	Result of the Wilcoxon Test	Average changes
		Mean±SD	Mean±SD		Mean±SD
Systolic blood pressure	Experimental	133.33±18.12	126.00±4.98	z=1.97 P=0.05	-7.33±17.99
	Control	156.33±17.37	126.83±7.60	z=4.60 P<0.001	-29.50±19.93
	Result of an independent t-test or Mann–Whitney U test	t=5.02 p<0.001	Z=0.58 P=0.56	-	t=4.52 p<0.001
Diastolic blood pressure	Experimental	77.33±11.35	73.83±5.97	z=1.35 p=0.18	-3.50±13.59
	Control	76.67±10.78	69.50±8.24	z=2.82 p=0.005	-7.17±12.23
	Result of an independent t-test or Mann–Whitney U test	z=0.10 p=0.92	z=2.35 p=0.02	-	z=1.15 p=0.25
Arterial oxygen saturation	Experimental	93.33±0.96	98.40±0.56	z=4.83 p<0.001	5.07±1.05
	Control	93.53±0.82	97.30±0.60	z=4.91 p<0.001	3.77±0.63
	Result of an independent t-test or Mann–Whitney U test	z=0.88 p=0.38	z=5.42 p<0.001	-	z=4.77 p<0.001
Heart rate	Experimental	82.07±14.21	73.27±7.27	z=2.22 p=0.03	-8.80±19.23
	Control	89.97±9.97	69.93±7.36	z=4.14 p<0.001	-20.03±14.33
	Result of an independent t-test or Mann–Whitney U test	z=2.39 p=0.02	z=2.11 p=0.04	-	z=2.46 p=0.001
Respiratory rate	Experimental	17.20±3.06	25.53±1.68	z=4.64 p<0.001	8.33±3.45
	Control	15.90±3.08	22.33±1.71	z=4.71 p<0.001	6.43±3.06
	Result of an independent t-test or Mann–Whitney U test	z=2.27 p=0.02	z=5.39 p<0.001	-	z=2.66 p=0.01
The walk distance is within 6 minutes		134.33±36.57	444.00±52.63	t=13.24 p<0.001	309.67±52.96
		129.67±28.71	393.83±47.56	t=11.52	264.17±53.42

				p<0.001	
		t=0.55 p=0.59	t=3.87 p<0.001	-	z=3.30 p=0.001

Discussion

Results showed that average systolic blood pressure was significantly reduced in both the control and experimental groups after the intervention, while the average rate of changes in the control group was significantly greater than in the experimental group. The average diastolic blood pressure indicated no significant difference in the experimental group after intervention but this rate significantly declined in the control group after the intervention, and the average rate of changes indicated no significant difference between control and experimental groups.

Research on how cardiac rehabilitation affected hemodynamic parameters in patients after coronary artery bypass surgery was carried out by Siavoshi and colleagues in 2012. Significant variations were seen in parameters such as arterial haemoglobin saturation, heart rate, and systolic blood pressure between the initial and final rehabilitation sessions. The initials and times of the therapy showed notable variations in these factors. This is consistent with the findings of the current investigation, since diastolic blood pressure mean values from the first and last rehabilitation sessions did not show a significant change [29].

A study by Raygan and colleagues (2012) looked at how cardiac rehabilitation affected the clinical and paraclinical outcomes of ischemic heart disease patients. They discovered that, while the clinical average (roughly 200 mm Hg) did not significantly decline, the mean systolic and diastolic blood pressure values were lower in the rehabilitation group when compared to the control group. This difference was statistically significant [30]. Kargarfard and colleagues (2011) studied the effects of the cardiac rehabilitation program on blood pressure decline in men with a myocardial infraction and reported significantly reduced systolic and diastolic blood pressure in the rehabilitation group compared with the control group [31], which is not matched with findings of the extant paper.

The lower reduction in systolic and diastolic blood pressure in the intervention group of the present study may stem from improved arterial oxygen saturation and better blood supply to the cardiac muscle. Also, in the control group, the decline in arterial blood gases and blood supply to the heart rather intervention group may weaken the power of the heart muscle which leads to reduced blood pressure in patients during exercise.

The study's findings demonstrated that, following the intervention, the mean arterial oxygen saturation value increased considerably in both the experimental and control groups, with the experimental group seeing a much higher average rate of change than the control group. In order for further changes in the experimental group to be related to the supplied intervention, it is possible that the control group's enhanced arterial oxygen saturation was caused by their condition following surgery.

In a study by Yazdan Nik et al. (2013), the impact of planned deep breathing exercises on arterial blood gases following coronary artery bypass grafting was investigated. The results showed that, on the third postoperative day, patients in the intervention group had significantly higher arterial blood oxygen, arterial blood carbon dioxide, and oxygen saturation than patients in the control group [28]. On the second day following cardiac surgery, Urell and colleagues (2011) found a significant increase in the mean arterial oxygen pressure and oxygen saturation of experimental patients compared to control ones. The study examined the impact of deep breathing exercises on the rate of oxygenation improvement in patients. Stated differently, the percent rate of arterial blood oxygen saturation and arterial oxygen pressure were dramatically enhanced by deep breathing workouts [17].

The impact of deep breathing exercises and incentive spirometry on arterial blood gas parameters following CABG surgery was investigated by Feizi and colleagues (2016). The results revealed that, on the third postoperative day, the means of arterial blood gas parameters (PaO_2, $PaCO_2$, and SaO_2) in patients in the experimental groups were significantly higher than those in the control group; however, there was no significant difference between the two intervention groups with respect to these variables [33]. The impact of scheduled breathing exercises on oxygenation in patients following coronary artery bypass surgery was investigated by Moradyan and colleagues (2012). The experimental group's mean SaO_2 and PaO_2 scores were noticeably higher on the third postoperative day. Stated differently, following coronary artery bypass surgery, patients who underwent scheduled deep breathing exercises had higher oxygenation levels than those who had routine care. As a consequence, these patients' oxygenation improved quickly, and they returned to their preoperative level [33], which was consistent with the current study's findings.

Westerdahl and colleagues (2005) found that deep breathing exercises had no significant effect on arterial blood gas levels (arterial blood oxygen saturation, the partial pressure of carbon dioxide ($PaCO_2$), and partial pressure of oxygen (PaO_2)) in patients undergoing CABG surgery [14]. This finding was not in line with our results. Lack of change in arterial blood gas

levels after intervention can be related to normal gas pressures at fit stage of intervention in both studied groups.
The average heart rate of patients in the experimental group decreased considerably after the intervention, according to the study's results, while patients in the control group experienced alterations at an average rate that was much higher than that of the experimental group. Following the intervention, the experimental group's average respiratory rate dramatically increased, and its average rate of change was significantly higher than that of the control group.
Raygan and colleagues (2012) found that the mean value of heart rate was reduced significantly in the experimental group after the intervention [30]. Kargarfard and colleagues (2011) concluded that the average heart rate of a patient who received the intervention decreased significantly after rehabilitation but there was no significant difference in the control group [31], which is matched with the findings of the extant paper. Since patients in the experimental group were aware of the intervention type and study objective, the observed changes in the heart and respiratory rates may have stemmed from possible concern or anxiety about intervention results.
Regarding the results of the effect of planned deep respiratory exercises along with cardiac rehabilitation on hemodynamic parameters, the physiological use of deep breathing exercises encourages the patient to breathe deeply and opens collapsed alveoli. This prevents lung dysfunction and Atelectasis leading to improvement of ventilation-to-perfusion ratio and gas exchanges and oxygenation [16]. As a major part of postoperative care given to CABG patients, cardiac rehabilitation is a comprehensive process used to improve cardiovascular health by performing personal and group programs to prevent disease development, maximize physical and psychological-social abilities, improve the quality of life and mood of patients, and to reduce morbidity and mortality rates [21]. Results obtained by Mampuya (2012) and Chou et al. (2014) indicated that cardiac rehabilitation could reduce the death rate and disease recurrence by 40% [22, 23]. Beckie and colleagues (2013) found that cardiac rehabilitation could significantly increase the respiratory capacity of patients [24].
The average walk distance of patients in the experimental and control groups increased considerably within 6 minutes of receiving the intervention, according to the results; however, the average rate of change in the experimental group was much higher than that of the control group.
In a 2015 research, Mozafari et al. examined how cardiac rehabilitation affected post-angioplasty cardiac patients' outcomes on the 6-minute walk test (6MWR). They discovered a statistically significant increase in walk distance through 6MWR in both the experimental and control groups following the intervention. Compared to the control group, the experimental group's average walk distance change rate was much higher [25].
Mozafari and colleagues (2015) carried out a study on the effect of cardiac rehabilitation on the results of a 6-minute walk test in post-angioplasty cardiac patients and found a significant rise in the walk distance through 6MWR in patients of experimental and control groups after intervention. The average rate of changes in walk distance in the experimental group was significantly greater than the control group [25]. Bellet and colleagues (2012) conducted a systematic study on the effect of rehabilitation on improved 6MWT and found a significant increase in walk distance after cardiac postoperative rehabilitation [34,].
Abbasi and colleagues (2007) studied the efficacy of a home walking exercise program on the functional performance of patients with heart failure and found a significant increase in the mean walking distance on the 6MWT in patients of the experimental group after intervention but there was not any significant change in the control group [35].
Although the abovementioned studies have examined the effect of the cardiac rehabilitation program and home walking exercise on the walk distance among patients and extant study assessed the effect of planned deep breathing exercises along with cardiac rehabilitation, the obtained results are matched in proving the effectiveness of this intervention on physical function of patients.
In the present study and research conducted by Mozafari and colleagues (2015), the walk distance in six minutes by control patients was significantly increased after the intervention. The reason might be related to the improved cardiac function after a while followed by surgery and controlling risk factors by patients. However, results showed a significant difference between the two groups regarding the walk distance, which indicates the vital role of planned deep breathing exercises along with cardiac exercise rehabilitation in enhancing the exercise capacity of patients besides the time factor that improves patients' performance and ability.
Exercise can help patients with heart failure feel better and happy. It also can mitigate symptoms and improve heart functioning. Besides, antecedents indicate that activity keeps patients enjoying exercises [36,37,38,39]. Beckie and colleagues (2013) found that cardiac rehabilitation could significantly increase the physical function of patients [24].

Conclusions

Results indicated that planned deep breathing exercises along with cardiac exercise rehabilitation had a significant effect on 6MWT and hemodynamic parameters of patients undergoing coronary artery bypass grafting (CABG) surgery.
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None.

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None.
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None.

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