Research Article

Two methods of aerobic and combined training on biomechanics of Vessels in patients after bilateral femoral artery coronary grafting

Gholamreza Rostami [1], Haider Sadeghi* [2], Yahya Sokhanguei [3]

1. Department of Biological Sciences and Sports Biomechanics, Central Tehran Branch; Islamic Azad university; Tehran, Iran.

2. Department of Biological Sciences and Sports Biomechanics, Kharazmi University, Tehran, Iran.

3. Department of physiotherapy, university of social Welfare and Rehabilitation science, Tehran, Iran.

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Abstract

Background: Cardiovascular disease is one of the most common causes of death in the world and its prevalence increases with age. For the purpose of cardiac rehabilitation after heart disease, performing exercise training causes functional and structural adaptations in patient's cardiovascular system and consequently reduces mortality from related diseases. Therefore, the aim of this study was to investigate the effect of two methods of aerobic and combined exercise training biomechanics of blood in middle-aged patients after bilateral femoral artery coronary bypass grafting surgery.

Materials and Methods: In this semi-experimental study with a pre-post test design, 68 middle-aged men (mean age 56.19± 1.26 years) were studied after bilateral femoral artery coronary bypass grafting surgery. Subjects were randomly and availably divided into 3 groups: aerobic (n =20) and combined (aerobic + resistance) (n =20) exercise training, and control groups (n =28). Subjects in the intervention groups performed 8 weeks of training/3 sessions per week. Each training session in aerobic and combined groups was considered for 40 minutes with the intensity of 70-85% heart rate reserved, and 60 minutes with the intensity of 40-80% one repetition maximum for each patient, respectively. In order to analyze the data, Leven, MANOVA and Bonferroni statistical tests were used at the significance level of $P \leq 0.05$.

Results: The results of one-way MANOVA test showed that the levels of functional capacity, ejection fraction and maximal oxygen consumption were increased significantly after aerobic and combined exercise training compared to control group ($p < 0.05$). However, Bonferroni post hoc test showed no significant differences between functional capacity, ejection fraction and maximal oxygen consumption post-test levels in aerobic and combined exercise training groups ($p > 0.05$).

Conclusion: the findings of this study show that both aerobic and combined exercise training can improve the heart functional variables in middle-aged patients after bilateral femoral artery coronary bypass grafting surgery, and this improvement levels appears to be independent of the types of training.

***Corresponding author:** Haider Sadeghi
Address: Department of Biological Sciences and Sports Biomechanics, Kharazmi University, Tehran, Iran.
Email: sadeghih@khu.ac.ir **Tell**: 00982188329220

H S: 0000-0001-6563-9882

1. Introduction

Today, cardiovascular disease (CVD) is the main cause of death worldwide (1, 2). According to the World Health Organization, CVD was the main cause of death in the world (22%) and Iran (35%) in 2002 (3) and it is likely to be the cause of 33% of all deaths worldwide in 2030. (4). On the other hand, coronary artery bypass surgery (CABG) or the rehabilitation of blocked arteries in CVD patients causes some adverse effects such as irregularity and variability in heart rate and disturbance in the tone of the vagus nerve, which indicates a malfunction in the ventricles. It is the left side of the heart (5). The inability of these diseases, clinical treatments, and high treatment costs at different ages (6) has caused much research to be carried out to develop effective strategies to prevent and improve the disease. Therefore, it seems necessary to address the clinical problems caused by aging, especially in patients with CVD, and preventing secondary events after CABG and the progression of the Atherosclerosis process in them is of great importance (7). One of the most important causes of CVD is arteriosclerosis (8), so atherosclerosis of the aorta, coronary, carotid, and peripheral arteries, including the brachial and femoral arteries, is at the top of CVD diseases in people over 40 years old or Middle-aged, with an age range of 40-65 years (9). Considering that atherosclerosis or the accumulation of lipid deposits begins in childhood and increases in older ages and with narrowing of the arteries (10, 11) and subsequently, disruption of blood supply to the heart, brain, and other peripheral organs lead to heart attack, stroke and Lower limb ischemia occurs (12, 13). This can justify the increase in peripheral vascular occlusive diseases and age (14). In other words, the pathogenic changes of atherosclerosis progress with increasing age (15) and finally lead to clinical problems and death (16). Therefore, it seems that increasing age and gender (more men than women) are uncontrollable risk factors in the development of CVD (17).

In addition, aging is associated with an increasing decrease in the levels of maximum oxygen consumption (VO2max) (18), functional capacity (FC) (19), and a decrease in ejection fraction (EF) (20) in the heart. VO2max is an indicator of maximum cardiorespiratory performance, aerobic fitness, and how the heart system works, which decreases with age, and its decrease is a known risk factor in CVD mortality. Therefore, the reduction of VO2max along with increasing age is effective in increasing the risk of mortality in middle-aged and elderly people (18). Another main cause of heart failure is a decrease in EF, an indicator of the function of the left ventricular of the heart (20). When the muscle strength of the heart decreases so much that the decrease in EF reaches less than 40%, we will witness heart failure in a person (21). FC is also the maximum ability of a person to perform a sport or physical activity beyond the level at rest. A decrease in FC has been observed after the onset of coronary artery disease followed by CABG (7).

Also, increasing age (2, 22, 23) combined with an unhealthy lifestyle (24) such as reducing the amount of sports activity (23) and inactivity is associated with an increasing increase in CVD risk factors (22). Inactivity is a modifiable risk factor in CVD (25), while sports activity is known as the most effective intervention in improving age-related performance (20) and because of its preventive and protective effects against CVD (26) and prevention of deaths caused by it (27) Many experts recommend regular physical activity, which among the adaptations caused by sports activity can increase the shear stress caused by blood flow.

it pointed out on the arterial walls and finally the improvement of endothelial function during sports activities. Also, endurance exercises have potential anti-ischemic effects and increase coronary blood flow by strengthening capillary density (26). In general, a sport or physical activity beyond the amount of rest will improve FC or the peak ability of a person in patients with CVD (7). In addition, volume overload on the heart caused by endurance and aerobic exercise leads to an increase in the volume of cavities and eccentric hypertrophy of the left ventricle of the heart (28), so it is logical that this type of exercise can increase VO2max levels. The increase in VO2max after sports training is related to the increase in the function of the left ventricle of the heart and subsequently to the increase in the maximum output of the heart (central adaptation) (29). Other adaptations caused by endurance sports activity, such as a decrease in vascular resistance, an increase in blood volume, an increase in EF, and an increase in the oxidative capacity of skeletal muscles can also increase VO2max levels (30). Khorramdel et al. (2015) investigated the effect of 8 weeks (three sessions per week) of Pilates exercises and balanced movements on VO2max levels in middle-aged women and showed that a period of exercise improved VO2max in middle-aged subjects (31). Bahramian et al. (2018) studied 10-week-old rats suffering from myocardial infarction and showed that 6 weeks (5 sessions per week) of intermittent aerobic activity in 3 different intensities could increase EF levels and they stated that exercise training, regardless of Due to its intensity, it can improve the structure and function of the left ventricle of the heart, however, increasing the intensity causes better effects (32). In this regard, the findings indicate that moderate-intensity sports activity can reduce CVD in elderly people, however, it seems that middle-aged men should exercise more intensely in order to achieve its protective benefits. pay (27, 33). Therefore, although the endurance and aerobic exercises by improving cardiovascular fitness bring many health benefits to the elderly (18), its quantitative and qualitative indicators in the development of VO2max in the middle-aged population are still unknown. However, it seems that the development of CVD can be prevented by changing lifestyles and controlling modifiable risk factors (12).

Moderate intensity continues training (7) are considered cardiac rehabilitation programs. Therefore, by using cardiac rehabilitation programs after CABG, functional capacity (FC) and quality of life can be improved in middle-aged patients (7), and compared to only drug therapy, it can further reduce the death rate caused by CVD. 34). By creating structural adaptations in the left ventricle, rehabilitation exercises help the contractility of the heart and adjust the vagal tone, which is associated with an increase in EF (35). However, the findings indicate that the cardiac rehabilitation program in the form of submaximal aerobic exercises (36) and moderate intensity (34) is an effective treatment and rehabilitation program after CABG (36).) and is considered one of the most common types of cardiac rehabilitation programs (34), but since in ischemic heart patients (7) and after CABG, there is a decrease in muscle mass and strength, followed by a decrease in VO2peak and subsequent reduction of FC and quality of life (37), it is believed that by increasing muscle strength we will achieve performance optimization in this segment (7). Therefore, in order to increase muscle strength and aerobic capacity, resistance exercises can be used in addition to aerobic exercises (7). Therefore, strength training is recommended as part of the rehabilitation program in cardiac patients (38) and it is assumed that combined rehabilitation protocols (resistance-aerobic) can bring a greater improvement in FC values after CABG in adults.

Existing studies have indicated the effect of different methods of cardiac rehabilitation programs (combined (7) and aerobic (7, 36)) on FC (7) of cardiovascular patients, however, few studies have investigated the effect of combined exercises and Aerobic exercise has been performed in middle-aged men after CABG surgery, and the best type of rehabilitation program that can achieve more favorable effects on the biomechanical behavior of blood and vascular structure of these patients has not yet been determined. Therefore, assuming that exercise training is effective, the purpose of this study was to investigate the effect of two methods of aerobic and combined exercise on factors affecting heart function, including FC, EF, and VO2max in middle-aged male patients after bilateral femoral artery CABG surgery.

2. Materials and Methods

In this semi-experimental study, with a pre-and post-test research design, a causal-comparative model, and an applied type, from within the statistical population of 2648 middle-aged cardiac patients 40 to 65 years old (W.H.O) underwent coronary artery bypass grafting (968) had been performed in Tehran Heart Center Hospital, and among 382 male coronary artery transplants, 68 middle-aged people who were two to three weeks after their operation was introduced to the rehabilitation center of Tehran Heart Center Hospital, the subjects of the present study They gave. Subjects were randomly selected and placed in three groups: 1) aerobic exercise training (20 people), combined exercise training (20 people), and control group (28 people). The type and severity of the disease were diagnosed by the doctor present in the clinic.

By filling in the questionnaire of personal information and physiological health, complete explanations were given to the subjects regarding the purpose of the research, the method of conducting it, and the confidentiality of the information, and a consent letter was obtained to declare the consent of the subjects to participate in the research. The article is based on letter number 101/1000-2 dated 4/31/2018 from the University/Research Institute of Movement Sciences and has ethics approval.

After the patients were referred to the cardiologist and the doctor's approval to participate in the research, the subjects were introduced to the imaging center to perform the pre-examination tests one day before the start of the training programs. Before starting the test, the patients were explained about the purpose of the research and then the consent forms for the research were completed by the patients. Then the patients began aerobic and combined exercise programs under the supervision of a nurse familiar with monitoring and a researcher at the rehabilitation center of Tehran Heart Center Hospital. The subjects of the aerobic exercise group performed eight weeks of submaximal aerobic exercise protocol/three sessions per week and each session lasted 40 minutes with treadmills, arm ergometers, and exercise bikes. In each session, after warming up, the patients first run on a treadmill for 10 to 20 minutes with an intensity of 70% of the reserve heart rate reserve, which was calculated according to Karvonen's formula, and with a maximum speed of five kilometers per hour at the beginning of the session and In the continuation of the training sessions, they increased to 85% of the reserve heart rate and increased to a maximum speed of nine and a half kilometers per hour. Then, they continued to exercise with an arm ergometer and a stationary bike for 8 to 10 minutes, respectively, with an intensity of 50 watts, which increased to 80 watts during the sessions.

The subjects of the combined exercise group (70% aerobic and 30% resistance) first exercised for 40 minutes according to the aerobic exercise protocol and then did resistance exercise twice a week for 20 minutes with four hip adductor machines. They did seat chest presses, leg extensor, and abdominal. The intensity of these exercises was initially 40 to 50% of one maximum repetition (RM1) and then to 60 to 70% of RM1 with 8 to 12 repetitions in 2 to 3 sets. It should be mentioned that during the training period, the relevant officials constantly checked the heart rate and the training pressure in order to prevent excessive pressure and not harm the patient in case of possible training pressure on the patient. In order to investigate the effect of sports training on the desired parameters, after eight weeks of aerobic and combined training, a post-test was taken from the subjects. Also, to evaluate the values of the emptying fraction, the echocardiograph model VIVD3 made by General Electric of America was used, and to determine the levels of functional capacity and maximum oxygen consumption, an exercise test was used on the Kansas USA model treadmill. Functional capacity is expressed based on MetS, and each MetS is equivalent to 3.5 liters of oxygen per kilogram of body weight per minute.

The subjects of the control group were selected from the patients who did not visit the rehabilitation center. In addition to nutritional recommendations, all three groups of patients were advised to walk (three days a week). It should be noted that a number of coronary artery graft patients either refused to continue this research due to personal reasons, or due to death, repeated MI and hospitalization, or absenteeism for more than two sessions, the researcher excluded them from continuing the research.

Statistical analysis

To describe the data in descriptive statistics, mean and standard deviation were used. In addition, based on the size of the samples in the research groups, firstly, the normality of the distribution of the studied variables was checked using the Kolmogorov-Smirnov (K-S) test, and after confirming the normal distribution of the data, to determine the homogeneity of the error variances of the dependent variables. In all groups, Levin's test was used, and to investigate the effectiveness of aerobic and combined exercise methods on selected variables of heart function, the one-way MANOVA test was used, and to determine the location of differences and comparison between groups in the groups, Bonferoni post hoc test was used at the level P≤۰/۰۵significance was used. Also, SPSS version 24 statistical software was used to analyze the raw data.

3. Results

Table 1 shows the basic characteristics of the subjects such as age, height, weight, resting, and maximum heart rate in all three groups separately.

Table 1: Descriptive statistics indicators are related to subjects' background variables (mean ± standard deviation) in the research groups.

Background variables	Groups		
	Aerobic training	Combined training	Control
Age (Year)	671/55±6	031/76±7,54	109/11±5,58
Weight (Kg)	807/44±6,79	578/44±7,76	417/50±8,75
height (Cm)	822/32±5,174	052/40±4,171	389/72±5,171
resting heart rate (thud . minutes)	398/20±13,80	517/32±11,83	285/56±10,78
Maximum heart rate (thud . minutes)	431/60±14,131	962/88±12,122	733/33±16,128

To investigate the effectiveness of aerobic and combined exercise methods on selected blood variables, the one-way MANOVA test was used and the results of this test were reported in Table 4-9. According to the results of the one-way MANOVA, the group effect was not significant for the pre-test values in any of the variables under study, so there was no significant difference between the pre-test values of the groups in the selected blood biomechanical variables. Also, the results of the MANOVA test related to the post-test values showed that in the variables of blood flow velocity in the systolic phase, the intensity of blood flow in the systolic phase of the group effect was not significant, in the sense that there is no significant difference between the post-test values of the groups in these variables, but for The post-test values of blood flow velocity in the diastolic phase and blood flow intensity in the diastolic phase of the group, the effect was significant in the sense that there is a significant difference between at least one pair of groups.

In the following, Bonferroni's post hoc test was used to investigate the post hoc comparisons in blood flow speed and intensity variables in the diastolic phase, the results of which are reported in Table 2.

Table 2 : Summary of one-way MANOVA test results related to the selected values of vascular biomechanics

The dependent variable	Time	Aerobic exercise group			Combined training group			control group		
		Number	Average	standard deviation	Number	Average	standard deviation	Number	Average	standard deviation
Diastolic resting lumen diameter Dd	Pre-test	25	579,0	110,0	25	514,0	092,0	18	555,0	156,0
	post-test	25	589,0	103,0	25	603,0	119,0	18	540,0	153,0
Resting systolic lumen diameter Ds	Pre-test	25	695,0	137,0	25	672,0	105,0	18	665,0	106,0
	post-test	25	712,0	117,0	25	759,0	157,0	18	672,0	163,0
Intimal thickness ratio lmt	Pre-test	25	132,0	272,0	25	124,0	032,0	18	146,0	069,0
	post-test	25	116,0	024,0	25	112,0	020,0	18	147,0	052,0
Media in diameter lumens Lmt.dm	Pre-test	25	127,0	032,0	25	117,0	025.	18	127,0	046,0
	post-test	25	136,0	036,0	25	121,0	029,0	18	13,0	040,0

Table 4-12 : Summary of post-test results for paired comparisons of blood flow speed and intensity in systolic and diastolic phases.

Variable	Time	Group		Mean Difference	Amount P
Intimal thickness ratio LMT	Pre-test	Aerobic training	Combined training	0.008	1.000
			Control	-0.014	0.924
		Combined training	Control	-022،0	307،0
	post-test	Aerobic training	Combined training	004،0	000،1
			Control	-031،0	009،0
		Combined training	Control	-035،0	003،0
Blood flow intensity in the diastolic phase PDMM	Pre-test	Aerobic training	Combined training	002،0	000،1
			Control	-039،0	919،0
		Combined training	Control	002،0	000،1
	post-test	Aerobic training	Combined training	008،0	000،1
			Control	074،0	033،0
		Combined training	Control	-066،0	071،0

According to the results of Table 10-4, the post-test related to blood flow speed in the diastolic phase showed that there was no significant difference between the groups under study in the pre-test. In the post-test, there is only a significant difference between the aerobic exercise group and the control group, but there is no significant difference between the other groups.

Also, the results of the post hoc Bonferroni test related to blood flow intensity in the systolic phase also showed that there was no significant difference between any of the pairs of groups in the pre-test, and in the post-test, there was only a significant difference between the aerobic exercise group and the control group.

4. Discussion

Sports training has strong and significant effects on the morphology of blood vessels. Structural changes appear following functional changes in the vessels and lead to improved blood flow. Exercise causes angiogenesis (and Arteriogenesis) in the formation of vessels with high transmissibility, in fact, angiogenesis is the result of the balance between positive (negative) angiogenic and angiostatic regulators of blood vessels. Another important aspect of the effect of exercise on capillaries is the initiation and continuation of arteriogenesis. Considering that arteriogenesis leads to the formation of vessels with high transfer capability, which is able to compensate for the loss of function of blocked vessels, the establishment of arteriogenesis causes vascular adaptation. Angiogenesis and arteriogenesis are very sensitive to local mechanical conditions. An increase in shear stress levels caused by exercise leads to a decrease in vascular resistance and an increase in tissue perfusion. An increase in wall shear stress causes an increase in the production of nitric oxide, which results in a decrease in the degree of contractility of vascular smooth muscle and strong vasodilation. Vascular adaptations resulting from regular and continuous aerobic exercise activities include lower arterial stiffness in people with higher aerobic capacity, protection against systemic oxidative and inflammatory stress, increased endothelium-dependent vasodilation capacity, as well as increased coronary blood circulation due to increased Nitric oxide production. Animal studies and clinical observations have provided evidence that shows that there is a significant correlation between regular physical exercise and an increase in the diameter of the lumen in the coronary artery.

Exercise can also exert beneficial effects against atherosclerosis by increasing the flow of endostatin, which prevents the expansion of atherosclerotic plaque by blocking angiogenesis in the plaque tissue. Endurance activities also improve angiogenesis by reducing endostatin plasma levels. The results of the present study in the variables of blood vessels also showed that, except for the ratio of intima thickness, there was no significant difference between the groups in the post-test values. Although there was no significant difference between the groups in the diameter of the resting lumen in the systolic and diastolic phases, the lumen diameter increased in both the diastolic and systolic phases from the pre-test to the post-test in both groups of aerobic exercise and combined exercise. The results of the follow-up test related to the ratio of intima thickness showed that there are significant differences between the aerobic and combined exercise groups with the control group, and it is significantly less for the aerobic and combined exercise group than the control group. These results were in line with the studies of Maiorana et al. (2011), Tiejsen et al. (2011), Tiejsen et al. (2012), and Okamoto et al. (2007). In this way, it can be stated that aerobic exercise improves the structure of the internal damaged surfaces of the vessels and leads to an increase in the blood flow rate resulting from the shear stress force of the inner layer of the vessel. On the other hand, increasing the intensity of strength training causes a sharp increase in blood pressure compared to aerobic training. The exact cause of these changes has not been determined, but strength training is known as a strong stimulator of the parasympathetic nervous system and causes an increase in vascular contraction. Long-term aerobic exercise regimens improve cardiovascular function, reduce total environmental resistance, and increase the conduction of the circulatory system.

This fact can be observed in healthy subjects without any basic risk factors, in elderly people as well as those with cardiovascular risk factors. Following exercise training in cardiovascular patients, the peak aerobic capacity is increased, and the increase in maximum cardiac output is consistent with the stability of the average aortic pressure, as a result of which peripheral resistance is also reduced in patients with hypertension, type 2 diabetes, metabolic syndrome, Stable cardiovascular disease, myocardial infarction, and heart failure all benefited from the exercise program compared to those who did not participate in any exercise program. In fact, people with cardiovascular risk factors will benefit more. In healthy individuals, a more intense and prolonged exercise protocol is required to produce measurable changes in cardiovascular parameters, whereas older, healthier subjects may benefit from less intense exercise regimens. In addition, it has been proven that only the veins that have experienced high shear forces during sports training have improved their performance. Also, research has shown that exercise training in coronary artery bypass graft candidates significantly increased the endothelium-dependent vasodilation capacity and, when compared with matched sedentary volunteers, increased the average peak blood flow velocity of the left internal artery. . It has been reported that the risk of a heart attack in relatively sedentary people is 0 to 6 times higher during exercise than at rest compared to people who do regular exercise. However, the risk of sudden cardiac death or myocardial infarction increases transiently during high-intensity exercise.

Conclusion

In general, the results obtained from the present study showed that performing eight weeks of aerobic and combined exercise programs at the same rate can increase the intima-media thickness ratio and blood flow intensity in middle-aged men after bilateral femoral artery coronary artery bypass grafting. Therefore, to improve the health status after coronary artery bypass surgery and prevent the progression of atherosclerosis in middle-aged men, it is recommended to include aerobic and combined exercise programs in their treatment process.

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Compliance with ethical standards

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Author contributions

Conceptualization: GH.R., H.S., Y.S.; Methodology: GH.R., H.S., Y.S.; Software: GH.R., H.S., Y.S.; Validation: GH.R., H.S., Y.S.; Formal analysis: GH.R., H.S., Y.S.; Investigation: GH.R., H.S., Y.S.; Resources: GH.R., H.S., Y.S.; Data curation: GH.R., H.S., Y.S.; Writing - original draft: GH.R., H.S., Y.S.; Writing - review & editing: GH.R., H.S., Y.S.; Visualization: GH.R., H.S., Y.S.; Supervision: GH.R., H.S., Y.S.; Project administration: GH.R., H.S., Y.S.; Funding acquisition: GH.R., H.S., Y.S.

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