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Research Article

The effect of two methods of aerobic and combined training on biomechanics of blood in middle-aged patients after bilateral femoral artery coronary grafting

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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-posttest 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≤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.

Keywords:
Aerobic and Combined Exercise Training, biomechanics of blood, blood pressure, blood flow

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1. Introduction

Nowadays, cardiovascular disease (CVD) is considered 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 will probably be the cause of 33% of all deaths in 2030(4). deaths all over the world. 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 vague nerve, which indicates a malfunction in the ventricles. It is on the left side of the heart (5). An inability after the occurrence of these diseases, clinical treatments, and high treatment costs at different (6) ages have caused much research to be carried out in order to develop effective solutions to prevent and improve it. 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) in such a way that 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 or middle-aged, with the age range is 40-65 years (9). Considering that atherosclerosis or the accumulation of lipid deposits begins in childhood and increases in older ages, and with the narrowing of blood vessels (10, 11) and subsequently, disruption of blood supply to the heart, brain, and other peripheral organs, it leads to heart attack, stroke, and ischemia. becomes the lower limb (12, 13).

This can justify the increase in peripheral vascular occlusive diseases along with aging (14). In other words, changes in atherosclerosis progress with increasing age (15) and ultimately lead to clinical problems and death (16). Therefore, increasing age and gender (more men than women) seem to be uncontrollable risk factors in the development of CVD (17). In addition, aging is associated with an increasing decrease in the levels of maximal oxygen consumption (VO2max) (18), functional capacity (FC) (19), and a decrease in ejection fraction (EF) (20) in the heart. VO2max is the index of maximum cardiorespiratory performance, aerobic fitness, and how the heart system works, which decreases with age and its decrease is a risk factor in CVD mortality is known. 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 left ventricular function (20). When the muscle strength of the heart decreases so much that the decrease in EF reaches less than 40%, we will see 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) is associated 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 preventing the 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 the blood flow on the wall Arterial and finally 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, logically, 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 resulting from 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). Khorram Del 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 sports activity 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 the intensity 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 to achieve its protective benefits. (27, 33). Therefore, although endurance and aerobic exercises by improving cardiovascular fitness bring many health benefits to the elderly (18), the 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 the lifestyle and controlling modifiable risk factors (12). Moderate intensity continues training (7) are considered as 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, the mortality rate due to CVD can be further reduced. 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 in ischemic heart patients (7) and after CABG, there is a decrease in muscle mass and strength, followed by a decrease VO2peak and subsequent decrease in FC and quality of life (37), it is believed that by increasing muscle strength we will achieve performance optimization in this segment (7). Therefore, to increase muscle strength and subsequently 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 pointed out the effects of different methods of cardiac rehabilitation programs (combined (7) and aerobic (7, 36)) on the FC (7) of cardiovascular patients. However, few studies have investigated the effects of combined and aerobic exercises in Middle-aged men who have undergone 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-test and post-test research design, the influence measurement model (scientific-comparative) and applied type, from within the statistical population of 2648 middle-aged heart patients 40 to 65 years old (W.H.O.) who underwent coronary artery bypass grafting (968) in Tehran Heart Center Hospital, and among 382 male coronary artery bypass grafts Kroner, 68 middle-aged people who were referred to the rehabilitation center of Tehran Heart Center Hospital two to three weeks after their operation, constituted the subjects of the present study. Subjects were randomly selected into three groups:1) Aerobic exercise training (20 people), Combined exercise training (20 people), and control group (28 people) were included. 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, 68 subjects were introduced to the imaging center for pre-examination one day before the start of the training programs. Before starting the test, the patients were explained the purpose of the research and then the consent forms for the research were completed by the patients.

Then the patients started 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 Heart Rate Reserve, which was calculated according to Karonen'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 training group (70% aerobic and 30% resistance) first exercised for 40 minutes according to the protocol of aerobic exercise and then did resistance exercise twice a week for 20 minutes with four thigh adductor machines. They did Seated chest press, 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 noted that during the training period, the relevant officials constantly checked the heart rate and the training pressure to prevent excessive pressure and not harm the patient in case of possible training pressure on the patient. 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 ejection fraction, the VIVD3 echocardiograph machine made by General Electric of America was used, and to determine the levels of functional capacity and maximum oxygen consumption, the 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 arteries graft patients either refused to continue this research due to personal reasons, or due to death, repeated MI and hospitalization, or absence of more than two sessions, the researcher excluded them from continuing the research.

Statistical Analyses

In order 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, using Levene test and in order to investigate the effectiveness of aerobic and combined exercise methods on selected variables of heart function, using the one-way MANOVA test, and in order to determine the location of differences and comparison between groups in the groups, using Bonferoni Post hoc Test at the level $P \leq 0.05$ significance 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' land variables (Average± standard deviation) in the research groups.

Background variables	Groups		
	Aerobic training	**Combined training**	**Control**
Age (Year)	٥٥±٦/٦٧١	٥٤/٧٦±٧/٠٣١	٥٨/١١±٥/١٠٩
Weight (Kg)	٧٩/٤٤±٦/٨٠٧	٧٦/٤٤±٧/٥٧٨	٧٥/٥٠±٨/٤١٧
height (Cm)	١٧٤/٣٢±٥/٨٢٢	١٧١/٤٠±٤/٠٥٢	١٧١/٧٢±٥/٣٨٩
resting heart rate (thud / minutes)	٨٠/٢٠±١٣/٣٩٨	٨٣/٣٢±١١/٥١٧	٧٨/٥٦±١٠/٢٨٥
Maximum heart rate)thud / minutes)	١٣١/٦٠±١٤/٤٣١	١٢٢/٨٨±١٢/٩٦٢	١٢٨/٣٣±١٦/٧٣٣

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 ANOVA, the effect of the group 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 blood flow velocity variables in the systolic phase, the blood flow intensity in the systolic phase did not have a significant group effect, meaning 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 velocity and intensity variables in the diastolic phase, the results of which are reported in Table 4-10.

Table 4-9: Summary of one-way MANOVA test results related to selected blood biomechanical values

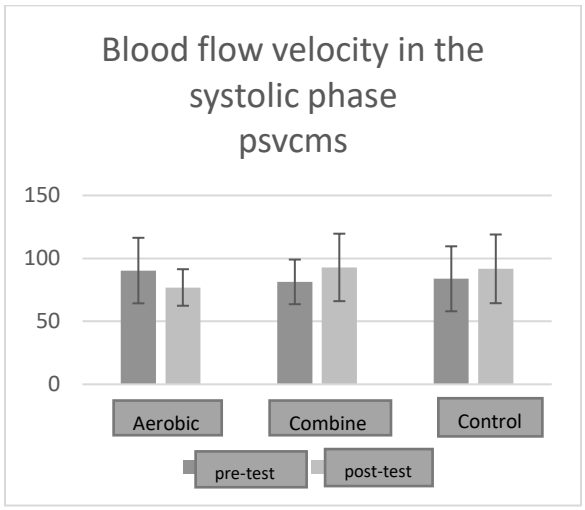
		Source of changes	sum of squares (SS)	degrees of freedom	mean square (MS)	Amount P	Value P	Effect size
Blood flow velocity in the systolic phase psvcms	Pre-test	Group	۲۰۷/۸۵۸	۲	۱۰۳/۹۲۹	۰/۱۹۶	۰/۸۲۲	۰/۰۰۶
		Error	۳٤٤٦٤/۲۹۲	٦٥	٥۳۰/۲۲۰			
	post-test	Group	۲٥۰٦/۳٦٥	۲	۱۲٥۳/۱۸۲	۲/٥۱٥	۰/۰۸۹	۰/۰۷۲
		Error						
Blood flow velocity in the diastolic phase Edvcms	Pre-test	Group	۱۱۹/۷۹٤	۲	٥۹/۸۹۷	۲/٤۱۷	۰/۰۹۷	۰/۰٦۹
		Error	۱٦۱۰/۷۳۸	٦٥	۲٤/۷۸۱			
	post-test	Group	۷۹٤/٦٥۸	۲	۳۹۷/۳۲۹	۱۳/٤٦۹	۰/۰۰۰	۰/۲۹۳
		Error	۱۹۱۷/٤۰۲	٦٥	۲۹/٤۹۸			
Blood flow intensity in the systolic phase psmm	Pre-test	Group	٦/۸۳۰	۲	۳/٤۱٥	۱/۱۲٥	۰/۳۳۱	۰/۰۳۳
		Error	۱۹۷/۲٥۸	٦٥	۳/۰۳٥			
	post-test	Group	۱۲/۳۱۳	۲	٦/۱٥٦	۱/٥۰٦	۰/۲۲۹	۰/۰٤٤
		Error	۲٦٥/۷٤٥	٦٥	٤/۰۸۸			
Blood flow intensity in the diastolic phase	Pre-test	Group	۰/۰۲۰	۲	۰/۰۱۰	۰/٦٤۰	۰/٥۳۱	۰/۰۱۹
		Error	۰/۹۹۲	۰/٦٥	۰/۰۱٥			
	post-test	Group	۰/۰٦٥	۲	۰/۰۳۳	۳/۹۰۱	۰/۰۲٥	۰/۱۰۷
		Error	۰/٥٤٥	٦٥	۰/۰۰۸			

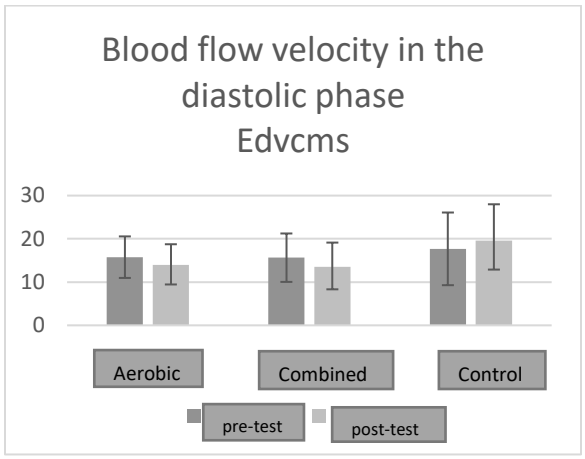
Table 4-10: Summary of post-test results for paired comparisons of blood flow speed and intensity in systolic and diastolic phases.

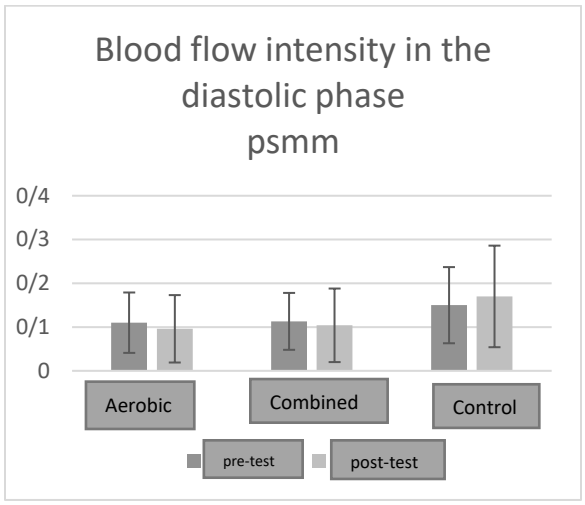
Variable	Time	Group		Mean Difference	Amount P
Blood flow velocity in the systolic phase Edvcms	Pre-test	Aerobic training	Combined training	۱/۳۷٤	۰/۹۹۸
			Control	-۲/۰۰۹	۰/۵۸۹
		Combined training	Control	-۳/۳۸۳	۰/۹٤
	post-test	Aerobic training	Combined training	۰/۷۳٤	۱/۰۰۰
			Control	-۷/۳٤۹	۰/۰۰۰
		Combined training	Control	۰/۷۳٤	۱/۰۰۰
Blood flow intensity in the diastolic phase PDMM	Pre-test	Aerobic training	Combined training	۰/۰۰۲	۱/۰۰۰
			Control	-۰/۰۳۹	۰/۹۱۹
		Combined training	Control	۰/۰۰۲	۱/۰۰۰
	post-test	Aerobic training	Combined training	۰/۰۰۸	۱/۰۰۰
			Control	۰/۰۷٤	۰/۰۳۳
		Combined training	Control	-۰/۰٦٦	۰/۰۷۱

According to the results of Table 4-10, 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 pair of groups in the pre-test, and in the post-test, there was only a significant difference between the aerobic training group and the control group.


Blood flow velocity in the systolic phase
psvcms
150
100
50
0
Aerobic
Combine
Control
pre-test
post-test


Blood flow velocity in the diastolic phase
Edvcms
30
20
10
0
Aerobic
Combined
Control
pre-test
post-test


Blood flow intensity in the diastolic phase
psmm
0/4
0/3
0/2
0/1
0
Aerobic
Combined
Control
pre-test
post-test

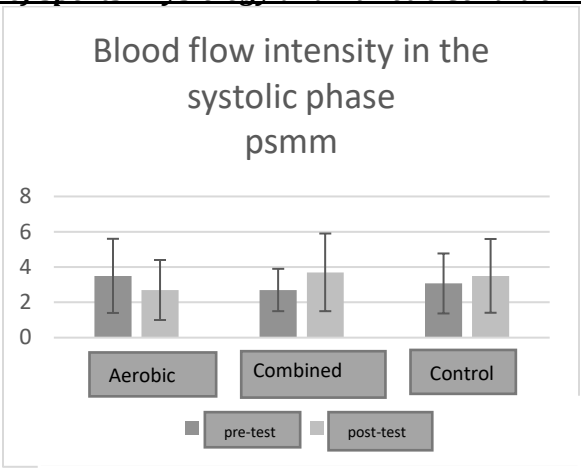


Chart 1: Chart of changes in blood flow speed and intensity in systolic and diastolic phases from pre-test to post-test in the studied groups

4. Discussion

This research aimed to investigate the effect of two types of aerobic and combined exercise (aerobic and resistance) on selected blood biomechanical variables (speed and intensity of blood flow in the systolic and diastolic phases) in middle-aged male patients after CABG surgery. The effect of cardiac rehabilitation exercises on selected blood biomechanical variables in cardiovascular patients were studied. The results of the research showed that in the systolic phase, there was no difference between the speed and intensity of blood flow in the groups under study. Blood flow velocity increased in the combined exercise group from pre-test to post-test, but decreased in the aerobic exercise group. In the diastolic phase, there was a significant difference in blood flow speed and intensity between the groups under study, and the aerobic training group had the greatest effect on the speed and intensity of blood flow compared to the combined training group and the control group, although there were differences between the two groups of combined training and aerobic training.

There was no sign. The results of this part of the research were in line with the research results of Xing et al. (2020) who reported improvements in blood biomechanics due to combined and aerobic exercises. Cardiac patients can increase their capacity and physical strength by performing regular sports activities and thus improve their health and quality of life (39). The results of the findings confirm that due to the occurrence of arterial atherosclerosis, the structure of the vessel wall and the nature of its components are changed and become hard and thick. The results of the research with the results of the studies of Green et al. (2017) agreed with the blood flow rate (40). Besides, with the development of atherosclerosis of the artery, the blood flow changes from a uniform state to a turbulent flow. The mechanical forces acting on the vessel wall, including the shear stress of the blood flow on the vessel lumen and the peripheral stress caused by blood pressure, will change the pattern and increase the severity of the disease with the progress of atherosclerosis injuries (41).

Studies have shown that the effects of sports rehabilitation on atherosclerotic patients include morphological changes that lead to improved blood flow (42). The results of the present study also showed that aerobic exercises can affect the turbulent flow of blood. 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. The research results were consistent with the research results of Maiorana et al. (2001), by studying eight weeks of a combination of aerobic and resistance training on type 2 diabetic patients, concluded that these exercises increased the intensity of their brachial artery blood flow (43), The results of the present study also showed that the aerobic training group had a greater effect on blood biomechanical indices, although the differences were not significant compared to the combined training group. It seems that it is necessary to check the durability of the effects of exercises over a longer period, which is one of the limitations of the present study, so it is suggested that in future studies, subjects should be subjected to longer periods after implementing the exercise protocols. be monitored by researchers so that the effects of cardiac rehabilitation programs can be examined more precisely.

۵. Conclusion

In general, the results obtained from the present study showed that performing eight weeks of aerobic and combined exercise programs can increase the intensity and speed of blood flow 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

Conflict of interest The authors declare no conflict of interest in publishing this article.

Ethical approval the research was conducted with regard to the ethical principles.

Informed consent Informed consent was obtained from all participants

Author contributions

Conceptualization: GH.R., H.S., Y.S.; Methodology: GH.R., H.S., Y.S.; Software: GH.R.; 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.; 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: H.S.; Project administration: GH.R.; Funding acquisition: GH.R., H.S., Y.S.

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