The Effect of Aerobic and Parallel Exercise Methods on Selected Hematological Variables and Heart Function in Patients Aged 40 to 65 Years Following Coronary Angioplasty

Masumeh Baghban Baghdadabad [a], Heydar Sadeghi [b,c*], Hassan Matinhomaee [d], Yahya Sokhangoii [e]

a Department of Biomechanics and Sport Pathology, School of Physical Education and Sport Sciences, Central Tehran Branch, Tehran, Iran; **b** Department of Sport Biomechanics and Injuries, Faculty of Physical Education and Sport Sciences, Kharazmi University, Tehran, Iran; **c** Department of Sport Biomechanics and Injuries, Kinesiology Research Center, Kharazmi University, Tehran, Iran; **d** Department of Exercise Physiology, Central Tehran Branch, Islamic Azad University, Tehran, Iran; **e** Department of Physiotherapy, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran

Corresponding Author: Heydar Sadeghi, Department of Sport Biomechanics and Injuries, Faculty of Physical Education and Sport Sciences, Kharazmi University, Tehran, Iran. ***E-mail***: sadeghih@yahoo.com.com

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Abstract

Introduction: Considering the important role of cardiac rehabilitation exercises for patients after coronary angioplasty, this study aimed to determine the effect of an eight-week parallel exercise period on hematological variables (red and white blood cells, hemoglobin, and hematocrit) and cardiac function (functional capacity, ejection fraction, and maximum oxygen consumption) in patients aged 40 to 65 years following the coronary angioplasty. **Materials and Methods:** In this semi-experimental study with pre-and post-test design, 90 men and women with coronary heart disease who underwent angioplasty, were randomly divided into two experimental groups (aerobic and parallel exercise) and a control group. Using the instructions of ACSM, 40 minutes of aerobic exercise in eight weeks for rehabilitate of heart patients (three times a week) in the aerobic exercise group, and 40 minutes of aerobic exercise (three times a week) and 20 minutes of resistance exercise program (twice a week) in parallel exercise group. The control group had no exercise other than the recommendation of three days of walking during the week. Kruskal-Wallis and Mann-Whitney U tests were implemented to compare pairs of groups in variables with abnormal distribution. In normal variables, the Levin test was used to check the homogeneity of variance of the data. Due to heterogeneity of variance, the Welch test and Tamhane's T2 Post-Hoc test were used for intra- and inter group comparisons at a significance level of 0.05. **Results**: Using parallel exercise, selected hematologic variables (hemoglobin and red blood cells) were significantly increased. Also, selected variables of cardiac function including (maximum oxygen consumption and ejection fraction and functional capacity) through aerobic and parallel exercises in middle-aged patients following coronary angioplasty, showed an increasing trend. The variable of maximum oxygen consumption in the parallel exercise group was significantly higher than the aerobic exercise group. **Conclusion:** According to findings, the beneficial effects of both regular aerobic and parallel exercises in appropriate intensity and duration with the priority of parallel exercise are recommended to improve hematological variables and cardiac function in patients 40 to 65 years after coronary angioplasty.

Keywords: Aerobic Exercise; Coronary Angioplasty; Heart Function; Hematology; Middle-Aged; Parallel Exercise

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Introduction

According to the definition of the World Health Organization, the ages of 40 and 65 is called middle age associated with physical and mental changes in individuals. At this age, metabolic changes occur in the body (1, 2). As in youth, metabolism is not well done in the body, and more fat is stored in the cells, leading to some weight gain. With age, the risk of cardiovascular disease, hypertension, and diabetes is much more common, and cardiovascular disease is the leading cause of death and disease in the community that also increases the financial burden on the health care system (3). However, considering the role of physical activity in the prevention and treatment of many diseases, researchers believe that regular exercise (not too hard) for this group of people is a healthy and desirable activity (4). For middle-aged people, moderate-intensity exercise is usually suitable. According to the World Health

Organization, 150 minutes of moderate-intensity physical activity per week or 75 minutes of high-intensity exercise is desirable for people in this age group (5).Regular exercise and physical activity are effective factors in preventing the occurrence of cardiovascular problems. Also, increasing the volume of physical activity from low to medium and from medium to high, as well as adding weight training to aerobic physical activity, have beneficial effects on some cardiovascular risk factors and reduce the risk of coronary heart disease (6, 7). This disease is a type of coronary artery insufficiency that eventually leads to a decrease and disruption of myocardial blood flow, followed by permanent cessation of myocardial blood flow, causing muscle dysfunction and necrosis (8).Atherosclerosis causes the narrowing and blockage of coronary arteries by the local accumulation of lipids and fibrosis inside the coronary arteries. This blockage reduces myocardial blood flow. Ischemic heart disease is caused by an imbalance between blood flow and myocardial demand determined by the progression of atherosclerosis and the degree of coronary artery occlusion (9).

Appropriate physical activity and exercise (training) affect the body following two ways. First, it strengthens heart muscles, which with a stronger, more regular beat and more capacity, leads to survival and life. Second, it can also strengthen other muscles in the body, dilate blood vessels, and increase blood flow and heart rate to prevent the stenosis due to the deposition of fatty substances inside the veins(5). Maximum ability to perform physical activity or exercise, to a greater extent than rest, is known as functional capacity. This capacity is calculated by measuring the peak oxygen consumption (VO_{2max}) (10). Previous studies in the field of cardiovascular disease have proven the effectiveness and safety of mild to moderate-intensity aerobic exercise (8, 11). Muscle strength is essential for optimal performance. It has been shown that in ischemic heart patients, muscle strength decreases, which leads to a diminish in functional or exercise capacity(12). The study of Ghroubi*et al.* (11) showed that after a 8-weeks strength and aerobic exercise, functional capacity, peak oxygen consumption, and muscle strength at cardiac patients with coronary artery bypass grafting were significantly higher than aerobic exercise, but changes in body composition were reported to be the same in both groups (11).The findings of Sousa*et al.*(13)indicated that after 9 months of combined exercise, the percentage of body fat in the elderly was decreased and strength and endurance of their muscle were increased, which was higher than aerobic exercise. Besides, a study by Marzolini*et al.* (14)confirmed that combined exercise is more effective than aerobic exercise in increasing peak oxygen intake, muscle strength, and improving body composition in people with coronary artery disease. In patients with myocardial infarction, after cardiac rehabilitation, an increase in the number of red blood cells was observed, which leaded to improved capillary circulation and a reduced risk of thrombogenesis(15). Also, after myocardial infarction, acute bleeding, bacterial infection, and even after intense exercise, white blood cells are increased, without any specific pathological cause (16). Exercise, especially aerobic exercise, can have beneficial effects on physical activity, including improved function in heart and lung, more regular breathing, increase in blood volume, plasma, red blood cells, maintaining hemoglobin, hematocrit, and red blood cells in a natural range (17).

The innovation of angioplasty significantly has reduced the side effects and mortality resulting from coronary artery disease (18). Shorter hospital stay, early return to work (19, 20), and better adaption to life have been the results associated with angioplasty in patients (21).Despite this method, vascular stenosis frequently occurs 25% to 40% of patients within 6 to 12 months (18). Therefore, researchers are always looking for newer ways to slow or stop the progression of the disease (22)that using regular exercise can be used to achieve this purpose.

Although combined exercise (aerobic and resistance) seems to have a more important role than aerobic exercise in improving the patient's condition after coronary artery angioplasty, few studies have been carried out to confirm this hypothesis. On the other hand, although studies have shown the safety of both exercise programs and their positive effect on the functional status and quality of life of heart patients, there are still many differences regarding the use of an optimal exercise program that can maximize the benefits for patients (11, 13, 14, 23). As a result, because of the different effects of each exercise on the structural, functional, and physiological responses on the heart, arteries, and blood, cardiac rehabilitation programs can be utilized after myocardial infarction, transplantation, or angioplasty, which has several clinical advantages and also a significant reduction in mortality caused by cardiovascular disease(24). Assuming the effectiveness of exercise, this study determined the effect of two methods of eight-week aerobic and parallel exercises on hematological variables (red and white blood cells, hemoglobin, hematocrit) and heart function (functional capacity, ejection fraction, and peak oxygen consumption) in patients 40 to 65 years following the coronary angioplasty.

Materials and Methods

This research was quasi-experimental with a pre-test and post-test design. The study group included patients (middle-aged men and women) aged 40 to 65 years in the rehabilitation ward of Tehran Heart Hospital who underwent coronary angioplasty and were not prohibited from exercising. This study was conducted under the supervision of a specialist physician and rehabilitation staff in the hospital. The research protocol was approved by the ethics code: IR-PAK-1000-101-1.

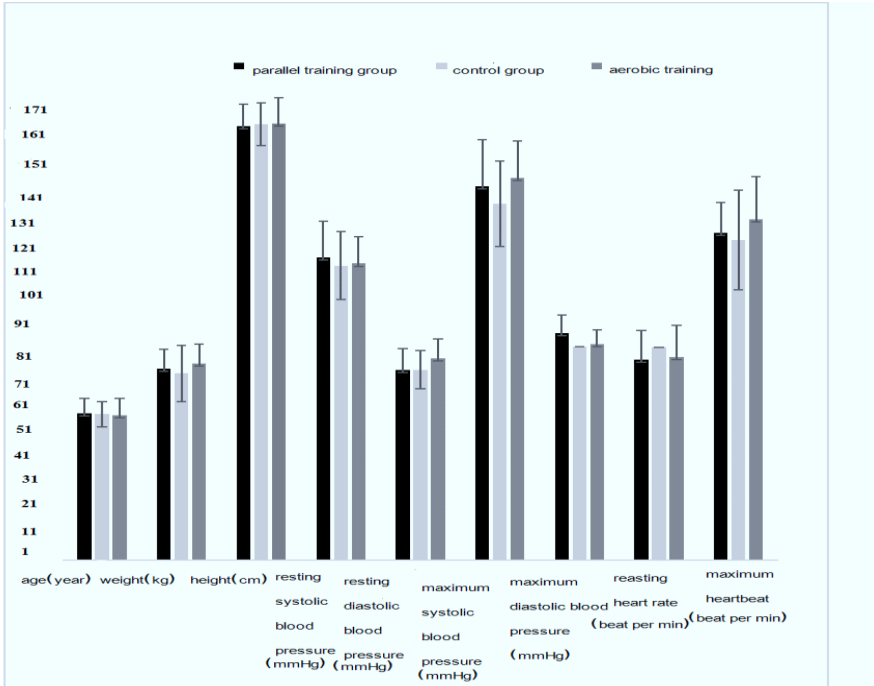

Figure 1. Mean and standard deviation of initial information of PCI patients in experimental (aerobic and parallel) and control groups

Participants

G-Power software was used to determine the sample size. Consideringa statistical power of 0.8 and an effect size of 0.5 at the alpha level of 0.05, 75 people participated in the study. Predicting the possibility of withdrawal of some participants in the exercise program, 90 people who met the inclusion criteria were non-randomly selected. Then, they were randomly divided into three groups: aerobic exercise (15 females and 15 males), parallel exercise (15 females and 15 males), and control (15 females and 15 males).

The inclusion criteria were low-risk cardiac patients aged 40 to 65 years (middle age) who had coronary angioplasty,having one to three heart failures according to the New York Heart Association (NYHA) classification, physician consent for participation in the exercise program, ejection fraction of 50% or more, having a functional capacity equal to or greater than 7 meters (25), no orthopedic problems, and no smoking or alcohol.Exclusion criteriawere no more than two absences in training, relevant physician diagnosis that the patient did met unfavorable physical or mental conditions, and patient's appeal for cessation of program. To handle the research, the following steps were carried out.

Set-up system

To perform the test, the sonography device was placed in a suitable place and calibrated.Then, the conditions of the test environment such as light, temperature, silence, etc. were controlled. Each participant laid down and relaxed for 10 minutes and next the measurement was carried out. To increase the accuracy of the test, each test was repeated three times and then the average was recorded.

Preparation of participants

First, the specialist at the clinic determined the type and severity of the disease. By filling the questionnaire out, personal information and physiological health of the participants were provided to the researcher. The purpose and method of the research and the confidentiality of the information were explained to the participants. After these steps, consent to participate in the study was obtained from the participants. All tests were performed in Tehran Heart Center Hospital.

Test

Coronary angioplasty patients, after approval by a cardiologist to participate in the study, were sent to a blood laboratory and imaging center (echo and exercise test) for the pre-test. Patients were then referred to the Rehabilitation Center of Tehran Heart Hospital to begin an exercise program that included an aerobic and parallel course (aerobic-resistance) under the supervision of a nurse (expertin monitoring).

One day before the start of the exercise program, a sample of the participants' blood (25 ml) was delivered to the laboratory to determine the amount of red and white blood cells, hemoglobin,

Table1. The results of descriptive statistics of selected hematological variables and cardiac function after aerobic and parallel exercise programin the control and parallel groups

Variable	Stage	Exercise group						Control		
		Aerobic			Parallel					
		Mean (SD)	Mean difference	Coefficient of variation (CV)	Mean (SD)	Mean Difference	Coefficient of variation (CV)	Mean (SD)	Mean Difference	Coefficient of variation (CV)
Hematocrit (%)	pre	37.97 (5.38)	1.9	14.17	39.14 (3.9)	1.16	9.96	36.02 (4.7)	2.34	11.30
	post	39.87 (5.50)		13.79	40.3 (3.17)		7.86	38.36 (4.33)		11.29
Red blood cell (mil/cumm)	pre	4.67 (0.54)	0.41	11.56	4.54 (0.72)	0.57	15.85	4.48 (0.46)	0.19	10.27
	post	5.08 (0.55)		10.85	5.11 (0.61)		11.93	4.67 (0.46)		9.85
White blood cell (mil/cumm)	pre	1952.3 (7176)	−224	27.20	6646 (2725.7)	487	41.01	7356 (2279.5)	60	30.99
	post	6952 (1741.6)		25.05	7133 (619.9)		8.69	(1361.3) 7416		18.35
Concentration of hemoglobin (gr/dL)	pre	12.76 (1.49)	0.54	11.68	12.71 (1.65)	1.04	12.98	12.26(1.7)	0.55	13.87
	post	13.3 (1.27)		9.55	13.75 (1.41)		10.25	12.81 (1.63)		12.72
Function capacity (METs)	pre	8.31 (2.32)	2.73	27.92	8.04 (1.52)	3.35	18.90	7.88 (1.73)	−0.89	21.95
	post	11.04 (2.8)		24.56	11.39 (1.61)		14.13	6.99 (2.65)		37.91
Ejection fraction (%)	pre	51.33 (3.7)	3.84	7.21	50.33 (3.92)	4.17	7.79	50.67 (3.14)	−3.34	6.20
	post	55.17 (2.45)		4.44	54.5 (2.01)		3.69	47.33 (4.87)		10.29
Maximum oxygen consumption (ml/kg/min)	pre	29.77 (7.38)	8.94	24.79	28.16 (5.30)	11.69	18.82	27.89 (5.69)	−2.88	20.40
	post	38.71 (9.66)		24.95	39.85 (5.64)		14.15	25.01 (7.85)		31.39

and hematocrit. Then, participants' blood pressure and body mass index (BMI) were measured. Functional capacity and ejection fraction as factors for patients' admission in the study (as a low-risk group) were measured by echocardiography and exercise test.Theexercise programof experimental groups was carried separately out for eight weeks (three times a week) and with a certain intensity and time according to each training program. During these eight weeks, the number of beats and brachial blood pressure was recordedbefore and after each exercise. The variables were re-measured after the end of the eight-week exercise program to give short-term effects of the duration of exercise programon these variables (post-test) in all 90 participants. Factors measuring the effectiveness of exercise on patients were hemoglobin level, white and red blood cells, and hematocrit to the normal range reported in the blood test, as well as increaseof cardiac function factors after exercise compared with before.

Exercise test

Patients were advised not to eat heavy foods three hours before the scheduled time for the test.Also, they took their heart medications. The exercise protocol was a modified Bruce exercise test. After the patient entered the test room, twelve ECG evaluation derivatives were installed on their chest. Then, the patient was called on the treadmill and by running the program through the computer connected to the treadmill, the test steps began according to the protocol. The patient was told to report any chest pain and shortness of breath during the test. At the end of each stage of the test, the patient's blood pressure and its ECGwere recorded to determine if there was a problem such as ST-segment depression, T-wave inversion, as well as arrhythmia, chest pain, limb pain, general fatigue, etc. If those occurred, the test was ceased and the reason for discontinuation of the test was also mentioned in the report.

Exercise protocol

According to the ACSM standard guidelines, patients in the aerobic exercise group didsub-maximal aerobic exercisethree times a week (40 minutes) with treadmills, arm ergometer, and bike ergometer for eight weeks. After warming up, they worked on the treadmill for 10 to 20 minutes with an intensity of 60% of the heart rate reserve based on the Karvonenformula, which was at a maximum speed of five kilometers per hourat the beginning of the course.Following training sessions, the intensity was increased to 80% heart rate reserve with a maximum speed of nine and a half kilometers per hour. Then, they continued theirexercisewith an arm ergometer (8 minutes) and a stationary bicycle (10 minutes) with an intensityof 50 watts. As the experiment continued, the

Table 2.Results of the non-parametric Kruskal-Wallis test. Intergroup comparison of the effect of exercise on selected hematological variables and cardiac function

variable	Chi-Square	df.	Sig.*
white blood cell count(mil/cumm)	0.60	2	0.73
Ejection fraction (%)	45.54	2	0.00*
functional capacity(METs)	48.87	2	0.00*
maximum oxygen consumption(ml/kg/min)	51.39	2	0.00*

** Significant difference at the level of P≤0.05.*

Table 3. The results of Welch test, intergroup comparison of the effect of exercise on selected hematological variables

Variable	F	df1.	df2.	Sig.*
Red blood cell (mil/cumm)	7.42	2	52.03	0.00*
Hematocrit (%)	0.76	2	53.78	0.46
Hemoglobin (gr/dL)	3.93	2	52.60	0.02*

** Significant difference at the level of P≤0.05.*

intensity of the exercises was increased to 80 watts. In the parallel exercise group (aerobic and resistance), patients had a combination of two types of exercise during the week, 70% aerobic exercise, and 30%resistance exercise program. Patients performed the aerobic exercise according to the sub-maximum protocol and then completed resistance exercise program twice a week for 20 minutes with four devices of thigh adductors, sitting chest press, leg extensions, and abdomen, respectively. The intensity of these exercises was initially 40 to 50% of one-repetition maximum and then 60 to 70% of one-repetition maximum with 8 to 12 repetitions in 2 to 3 sets (25).

During the exercises, the relevant technicians monitored the patients' heart rate to stop or reduce the activity if the exercise program pressure was high for the patient and there was a possibility of injury. Based on the Borg scale, the congruence of the intensity of the exercises was measured after each exercise (aerobic and parallel). If the intensity of the exercise was high, its amount was kept constant in the next session. The control group was the patients who not referred to the rehabilitation center to perform rehabilitation exercises. Necessary nutritional tips and advice to walk three days a week were announced to all three groups of patients.

Statistical Methods

Research findings are indicated as mean and standard deviation. To check the normality, Kolmogorov-Smirnov was used. Kruskal-Wallis nonparametric test was performed to examine variables that did not have a normal distribution. Also, the post-hoc comparison test for groups with abnormally distributed variables was performed using the Mann–Whitney test. In normal variables, the Levin test was utilized to evaluate the homogeneity of data variance. As a result of heterogeneity of variance, the Welch test and Tamhane's T2 Post-Hoc test were used for intra-group and inter-group comparisons at a significance level of 0.05.

Results

Figure 1 shows the basic characteristics of the subjects such as age, height, weight, resting heart rate, and maximum heart rate. The mean of age, height, and weight of the participants were in the range of 55 to 56 years, 165 to 166 cm, and 71 to 75 kg, respectively. No significant difference was observed in blood pressure and heart rate indices between the groups (P>0.05).

In Table 1, the results of descriptive statistics of selected hematological variables, cardiac function, and the difference between the means of post-test values compared to pre-test in the control and parallel groups are shown after aerobic and parallel exercise program. The results of the Kolmogorov Smirnov test showed normal distribution of data in variables such as red blood cell count, hematocrit, and hemoglobin. The data distribution on ejection fraction, functional capacity, maximum oxygen consumption, and white blood cell count were abnormal.

Regarding selected hematologic variables, despite the decrease in white blood cells for the aerobic exercise group and the increase for the parallel exercise group, the results of the Kruskal-Wallis nonparametric test showed that there was no significant difference between the effects of exercise on white blood cell count between groups (Table 2). According to the results of the Levin variance test, the variables of erythrocytes, hemoglobin, and hematocrit were heterogeneous. So, using the results of the Welch test, a significant increase was observed in the variables of red blood cell count (P=0.00) and hemoglobin (P=0.02) after eight weeks of exercise program between three groups, but no significant effect was reported in the hematocrit variable (Table 3). According to the information reported in Tamhane's T2table (Table 4) which shows the intergroup comparison, although the erythrocyte and hemoglobin were significantly improved in the aerobic exercise group compared to the control group, eight weeks of aerobic exercise on the globular

Table4.Tamhane's T2 Post-Hoc test. Intergroup comparison of the effect of exercise program (training) on selected hematological variables

Variable	Group(i)	Group(j)	Mean difference(i-j)	Standard error	Sig.*
Red blood cell (mil/cumm)	Aerobic training	control	0.22	0.12	0.22
	Parallel training	control	0.38	0.10	0.00*
	Parallel training	Aerobic training	0.16	0.14	0.59
hemoglobin (gr/dL)	Aerobic training	control	0.0003	0.18	1
	Parallel training	control	0.48	0.17	0.02*
	Parallel training	Aerobic training	0.48	0.22	0.1

** Significant difference at the level of P≤0.05*

Table5.Mann-Whitney test, intergroup comparison of the effect of exercise on selected heart function variables

Variable	Groups	Mann-Whitney test	z	Sig.*
Ejection fraction (%)	Aerobic training– control	84.50	-5.68	0.00*
	Parallel training– control	72	-5.88	0.00*
	Aerobic training – Parallel training	435	-0.25	0.80
Functional capacity (METs)	Aerobic training– control	96	-5.47	0.00*
	Parallel training– control	26.50	-6.45	0.00*
	Aerobic training – Parallel training	365	-1.33	0.18
Maximum oxygen consumption (ml/kg/min)	Aerobic training– control	84.5	-5.58	0.00*
	Parallel training– control	25.50	-6.44	0.00*
	Aerobic training – Parallel training	313.50	-2.14	0.03*

variables of red blood cells, hemoglobin, and hematocrit had no significant effect. However, red blood cells (*P*=0.00) and hemoglobin (*P*=0.02) were significantly increase in the parallel exercise group compared to the control group. Also, in the aerobic and parallel exercise group, no significant change was observed between the variables of red and white blood cells, hematocrit, and hemoglobin.

Regarding the selected variables of heart function, by looking at the results of the Kruskal-Wallis test, one can understand a significant increase in the ejection fraction, functional capacity, and maximum oxygen consumption after eight weeks of training between three groups (Table 1). By observing Mann-Whitney table for comparison between groups, the effect of eight weeks of aerobic and parallel training on increasing the ejection fraction (*P*=0.00), functional capacity (*P*=0.00), and maximum oxygen consumption (*P*=0.00) can be understood between two groups of aerobics and control, as well as two groups of parallel and control. Also, a significant increase (*P*=0.03) in maximum oxygen consumption was observed between two groups of aerobic and parallel training. Finally, eight weeks of training did not make a significant difference in the functional capacity and ejection fraction (Table 5).

Discussion

This study aimed to investigate the effect of two methods of aerobic and parallel eight-week exercise programon hematological variables (red and white blood cells, hemoglobin, and hematocrit) and heart function (functional capacity, ejection fraction, and maximum oxygen consumption) in patients aged 40 to 65 years following coronary angioplasty. The study on selected hematological variables of blood showed that there was no significant difference between the two aerobic and parallel groups. The results indicated an improvement of these variables in both aerobic and aerobic-resistance training groups compared to the control group. However; this increase was Significant in the parallel training group. Findings obtained about hematocrit variables were not consistent with the studies of Razaghi *et al.* (26), Najarian *et al.* (27), Brown *et al.* (28), and Church *et al.* (29).Blood viscosity can decrease with a decrease in blood hematocrit, but this decrease can be due to a decrease in the transfusion efficiency of red blood cells and ultimately a decrease in blood flow affected by exercise. Red blood cells were associated with an increase in both aerobic and parallel exercise groups compared to the control group, although this increase was more pronounced in the parallel exercise group. But the exercise did not make a significant difference in the number of red blood cells between two groups of aerobic and parallel exercise. The results of the present study were consistent with the findings of Razaghi *et al.* (26)and Pabysiak *et al.*(30). Also, a study conducted by Yektayar *et al.* (31) showed that one session of resistance exercise program increased the red blood cell count. Also, after a cardiac rehabilitation exercises in heart patients, the number of red blood cells was increased, thereby improving capillary blood circulation ability and reduce the risk of thrombogenesis.

Intra- and intergroup comparisons showed that there was no significant difference in white blood cell count after exercise in the two groups of aerobic and parallel exercise and also between them.This result was consistent with the study of Razaghi *et al.* (26)but did not confirm the findings of Pabisiak *et al.* (30) who reported a decrease in the number of leukocytes. Examining the changes caused by moderate-intensity exercise in healthy young people demonstrated that hematological variables such as the number of white blood cells was increased(32). Also, the number of white blood cells in the blood circulation was increased after a lot of intense exercises, without any pathological reason (33). It has been claimed that this increase may occur after myocardial infarction or acute bleeding (34). According to the results of the study, the concentration of hemoglobin in the blood was improved due to exercise in the groups. Intra- and intergroup comparisons showed that improvement was increased in both aerobic and parallel exercise groups compared to the control group, but no significant difference was observed in hemoglobin concentration between aerobic and parallel exercise groups. This increase in the parallel group was Significant. These results are compatible with the findings of Razaghi *et al.* (26)but are not consistent with the finding of Pabysiak *et al.* (30) which showed the hemoglobin content was reduced. On the other hand, Ahmadizad *et al.* (35)who studied the acute and short-term effects of resistance training on rheological determinants of blood in healthy men, observed that resistance training increased hemoglobin in the blood. Since hemoglobin is responsible for transporting oxygen and carbon dioxide in the blood, a significant increase in normal hemoglobin can be evaluated as a positive effect.

By studying literature review on the effects of physical activity on hematological factors, it can be understood that only resistance training programs have been used. Hence, there is a lack of information about hematological changes after parallel training (endurance-resistance). In most studies, only the effects of one session of resistance activity have been evaluated, and there is no discussion about the effects of parallel exercises (31, 36). The results of most previous studies on the changes of white blood cells under various physical activities confirm that in intense and long-term activity, white blood cells increase is more probable. However, the lack of significant increase in white blood cells in similar studies may be the cause of factors such as insufficient stimulation of immune factors, hypothalamic-pituitary-adrenal axis and inadequate training in terms of duration and intensity to cause these changes which indicate the safety of such exercises

Concerning the effect of exercise on selected functional variables of the heart, it was seen that both aerobic and parallel groups did not significantly increase maximum oxygen consumption, functional capacity, and ejection fraction, but except for maximum oxygen consumption. However, eight weeks of aerobic and parallel training had a significant effect on selected variables of cardiac function including functional capacity, maximum oxygen consumption, and ejection fraction. The results showed a significant increase in ejection fraction in the aerobic and parallel exercise groups compared to before the rehabilitation program. This study had the same results as the findings of some researchers (26, 30, 37-41), and did not consistent with others (42, 43) who reported the values of the ejection fraction unchanged. Shabani *et al.*(24)reported an increase in ejection fraction after rehabilitation exercise in patients with coronary disease, which is similar to the results of the present study. Decreasing the left ventricular ejection fraction caused by poor heart pump function and left ventricular dilatation. Therefore, improving heart function and reducing left ventricular volume, which increases the ejection fraction, are important therapeutic goals (44, 45). Combined exercise can improve systolic function by strengthening heart muscles, thereby increasing the ejection fraction. The results of our research displayed that functional capacity was improved as a result of aerobic and parallel training, which showed a significant increase in functional capacity in the training group compared to before the rehabilitation program. These results were consistent with the data of some researchers (26, 46-50). Functional capacity in patients can be improved by using a cardiac rehabilitation program, probably due to environmental adaptations as a result of exercise (48).

Finally, parallel exercise resulted in an increase in red blood cells and hemoglobin compared with control group. The type of exercise used did not make a significant difference in white blood cells, which can be attributed to the role of intensity and duration of exercise and the lack of control over subjects' diet. Also, aerobic and parallel training were involved in increasing the functional capacity of patients after coronary angioplasty. Having regular exercise in people with cardiovascular disease by making adjustments in the cardiovascular system as well as the neuro-hormonal system help improve functional capacity, reduce complications of the surgery, improve quality of life, reduce mortality, and improve ejection fraction and maximum oxygen consumption. Performing a rehabilitation program can help both heart contraction (characterized by an increase in ejection fraction) and return the vaginal tone to normal by making structural changes in the left ventricular and improving the size of the left ventricle during diastole and systole. Also, improves aerobic capacity and oxidative capacity of skeletal muscle by improving peripheral blood flow and structural and functional muscle adaptations.

In this study, we were faced with limitations including daily activities, busyness, amount and time of daily rest, genetics, psychological issues, diets and medications, and other diseases such as diabetes, hyperlipidemia, and hypertension. It is suggested that researchers compare the impact of continuous exercise, flexibility exercises in the form of yoga exercises, as well as peripheral and central arteries following the application of similar exercise program in hematological variables and heart function.

Conclusion

Eventually, it can be concluded that aerobic exercise due to endurance nature and response to adaptation to increased ejection fraction, functional capacity and maximum oxygen consumption, in contrast, parallel exercise due to increased red blood cells, hemoglobin, ejection fraction, functional capacity and maximum oxygen consumption. The findings showed that both aerobic and parallel training increased the maximum oxygen consumption in patients after coronary angioplasty, but the effect of parallel training compared to aerobic training was greater. Therefore, regular exercise with appropriate intensity and duration is recommended for the repair, reconstruction, and improvement of hematology and cardiovascular function of patients 40 to 65 years old following coronary angioplasty.

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