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The Relationship between the Intensity of Activity and Cardiovascular Risk Factors in Young Girls

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Abstract

***Background & Aims*:** Today, regular physical activity and sports are widely supported by the medical and sports community. Since the intensity of activity is an important factor in the secretion of cardiovascular risk factors, the present study examined the relationship between the intensity of activity and cardiovascular risk factors in young girls.

Materials & Methods: A total of 45 female students with average values of age (20.7 ± 1.3 years), weight (58.4 ± 1.3 kg), height (164.1 ± 0.9 cm), and body mass index (23.1 ± 0.5 kg/m^2) participated voluntarily in the project. Participants were divided into three groups of high-intensity (70-90% of one-repetition maximum or 1RM) and low-intensity (40-60% of 1RM) resistance training, with a control group without exercise. The two experimental groups were subjected to resistance training for 6 weeks. To measure the desired indices, blood samples were taken before and 24 h after the end of the research protocol.

Results: Results of one-way analysis of variance indicated a significant difference in hs-CRP and non-significant differences in lactate, glucose, fibrinogen, growth hormone to insulin-like growth factor ratio, and levels of LDL, HDL, and TC between the three groups. According to a post hoc test, the hs-CRP level in the high-intensity resistance training group showed a significant decrease compared to that of the control group.

Conclusion: The results of this study demonstrated no significant differences between high- and low-intensity resistance training in terms of affecting the levels of cardiovascular risk factors in young girls.

***Key words*:** Intensity of activity, cardiovascular risk factors, young girls

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Introduction

Given the declining age of cardiovascular disease and the spread of heart attack among the youth, determining the effect of type, intensity, and duration of regular and controlled exercise, in particular strength training, on these indices in the youth can play a substantial role in preventing the progression of this condition and increasing public health and longevity.

Also, examining risk factors for cardiovascular disease can raise our knowledge about the reduction of cardiovascular disease at older ages. Sudden death in exercise is due to the coronary artery occlusion as a result of clot formation. Additionally, increased aggregation and deformation of red blood cells may lead to atherosclerosis, and capillary pressure has been observed in the pathological state of increased red blood cell aggregation. Factors involved in the aggregation or sedimentation rate of red blood cells are divided into plasma factors (e.g. fibrinogen and albumin), cellular factors, and physical factors, with slow rates in normal conditions (1). Inflammatory indices and their possible effects on different bodily tissues are of special importance. According to previous research, inflammation plays a pivotal role in the onset and progression of arterial clots. In addition, resistance training is associated with many biochemical changes that can have a significant determining impact on the immune system. Researchers believe that low-intensity exercise has a positive effect on the immune system, while high-intensity exercise evokes a negative reaction. In other words, these exercises with different intensities will have different effects on performance indices (2). Some reports indicate that the pressure-induced by resistance activity leads to undesirable changes in the fatigue indicators and secretion of metabolic and inflammatory factors (3). Lactic acid is a product of the conversion of sugars in human cells, which is present in the pH of the body as its ionic form, i.e. lactate, acting as a key factor in the modulation mechanism of the immune response to exercise. As such, researchers reported that changes in PT and PTT are caused by such factors as blood lactate concentrations, platelets, and catecholamine changes (4). Fujita et al. examined young men and found that low-intensity resistance activity (20% of 1Rm) led to increased blood lactate concentrations (5). Moreover, fibrinogen is a soluble protein in the blood and is known as the best inflammatory indicator in the presumptive evaluation of coronary artery problems, for which exercise intensity and duration are known to be two important factors influencing its reduction (6). Exercise activities increase the secretion of catecholamines and sympathetic nerve activity, reduce insulin secretion, and increase the secretion of stress hormones (growth hormone, cortisol, epinephrine, and glucagon), thereby providing the ground for the mobilization of fats and the release of fatty acids (6). Growth hormone is known as a metabolic hormone that stimulates lipolysis and lowers carbohydrate metabolism to maintain blood glucose levels. According to the literature, increasing or decreasing the ratio of growth hormone to insulin-like growth hormone (IGF-1) can account for a factor in boosting or weakening the cardiovascular function (2). Besides, favorable changes in the concentration of blood lipoproteins as a result of exercise activities are the most important factors considered in the relationship between exercise activities and reduction of cardiovascular disease risk. In this regard, regular exercise and physical activity reduce the risk of cardiovascular disease by creating optimal changes in the concentrations of various lipid and lipoprotein components (7). Recent studies have shown that hs-CRP is a stronger indicator than LDL in the prediction of cardiovascular events, and that this indicator has an inhibitory effect on the glucose transporter $(GLUT)_4$ protein gene and induces insulin resistance (8). According to the above, a resistance training course can effectively prevent thrombosis and sudden onset of heart disease in the youth by reducing fibrinogen levels, hs-CRP, and blood lipoproteins, and by increasing the growth hormone to IGF-1 ratio. Reports of resistance training intensity contain conflicting results in some cases that necessitate further studies in this field. Furthermore, relatively prolonged periods of training used in the majority of previous researches will incur more time and cost to people, and also people may be unable to tolerate long-term, high-intensity programs both psychologically and physically. Also, the problem of a sedentary lifestyle and related diseases is a more fundamental and severe problem for the society, necessitating the implementation of various researches to provide appropriate solutions for the prevention of this problem and also for optimal intensity and duration of exercise, particularly in girls (9). Also, the intensity of exercise plays a role in fibrinogen changes and metabolic factors and affects the type of their responses. Therefore, the aim of this study was to compare the metabolic response to different intensities of resistance training to determine whether or not resistance training at different intensities can affect these indicators, or factors other than the intensity of exercise affect the secretion and response of metabolic indicators.

Method

In this quasi-experimental research with a pretest and posttest design, the statistical population consisted of female undergraduate students in the discipline of physical education at Shahid Chamran University of Ahvaz. After completion of medical questionnaires and being prepared to participate in the research, written consent was signed by the subjects. All stages of the research were approved (EE/97.24.3.69926/scu.ac.ir) by the ethics committee of Shahid Chamran University of Ahvaz. Inclusion criteria were no dietary regimen for weight loss or gain, no use of medication and supplements, no tobacco use, no history of disease and infection affecting immune factors, and familiarity with weight training. Physiological, anthropometric, body composition, maximum oxygen consumption (via Bruce's test), and 1RM were measured. Among 54 volunteers to participate, 45 individuals with average values of age (20.7 ± 1.3 years), weight (58.5 ± 2.4 kg), height (164.1 ± 0.9), and body mass index (23.1 ± 0.5 kg/m^2) were selected as the statistical sample (10). Subjects were randomly divided into three groups of high-intensity resistance training (n=15), low-intensity resistance training (n=15), and a control (n=15) by a research assistant. During the 6 weeks of the research phase, two members of the high-intensity resistance group (due to personal problems), one member of the low-intensity resistance group (for unknown reasons), and three members of the control group (two for personal problems and one due to illness) withdrew from the study (Fig. 1). To calculate 1RM, each subject selected a weight based on her muscular ability, and then the movement was repeated to the exhaustion point. Then, 1RM was calculated by shifting the weight and the number of performed repetitions using the following formula:

1RM = shifted weight/(0.278 × (number of repetitions to fatigue) − 1.028)

A researcher-made training protocol with high- and low-intensities was designed based on 1MR equation, and performed by both groups for 6 weeks (three sessions a week). During the protocol implementation, the control group was engaged in their daily activities. In three sessions before the start of the main protocol, the subjects performed light movements with halters and dumbbells to familiarize them with resistance exercises under the supervision of researchers. Each session consisted of general and specific warm-up (jogging, stretching, and using light weights) for 10 min. The main body of the training included forearm, back arm, chest press, armpit, bending the torso, squat, leg press, lounge with two high (70% of 1RM in the first week up to 90% increase of 1RM in the last week with 5-15 repetitions) and low (40% of 1RM in the first week up to 60% increase of 1RM in the last week with 20-30 repetitions) intensities, with cooling (stretching) exercises in the last 10 min. Each move was repeated for five sets. There was a 30-second rest between each set and a 2-minute rest between each move (11). To control the intensity of the exercise, 1RM of the subjects was calculated every 2 weeks. Before the start of the training protocol, 24 h after the completion of the research protocol, and after at least 12 h of fasting, blood samples (10 cc) were taken from the brachial vein of subjects in a sitting position. Blood samples were immediately centrifuged at 3000 rpm and the isolated serum was stored at −70 C. Measured parameters were blood fibrinogen levels (mg/dl) with a Gmbh kit (Germany), hs-CRP (ng/ml) using a Biomerica kit (Germany), IGF-1 (ng/ml) using an Eliza kit (R&D system, MN USA, Minneapolis), growth hormone (Iu/mLµ) using an ELISA kit (Monobind Inc., Lake Forest, CA, USA) and levels of TC, HDL-C, and LDL-C (mg/dl) enzymatically. Also, glucose (mg/dl) and lactate (mg/dl) were respectively measured using the calorimetric enzymatic method by the Pars Azmoon kit (Iran), and the Biovision Calorimetric method with a commercial kit (CA Co.).

The variation coefficient of all the kits was less than 10%. Finally, the means and standard deviations of data were calculated by descriptive statistics. Normal distribution of the research variables was determined using the Shapiro-Wilk test. Given normal distributions, all data were statistically analyzed using one-way analysis of variance (ANOVA). Bonferroni post-hoc test was used in case of statistical significance. Intra-group differences were determined by the dependent t-test. Pearson correlation coefficient was also used to investigate the relationships between the indicators. All statistical tests were performed by SPSS software (version 16) at a significance level of $p < 0.05$.

Result

The individual information of the subjects in separate groups is presented in Table 1. As shown in Table 2, the amounts of fibrinogen, hs-CRP, LDL, and TC in both training groups decreased compared to the control group after 6 weeks of the training protocol. Also, the amounts of HDL and GH to IGF-1 ratio increased significantly in both training groups compared to the control group ($p < 0.05$). In addition, no significant differences were observed between the three training groups in terms of fibrinogen, hs-CRP, LDL, TC, lactate, glucose, and GH to IGF-1 ratios ($p > 0.05$). According to Table 3, only the hs-CRP index decreased significantly among the three groups, with a significant difference only between the intensive training group and the control ($p < 0.05$).

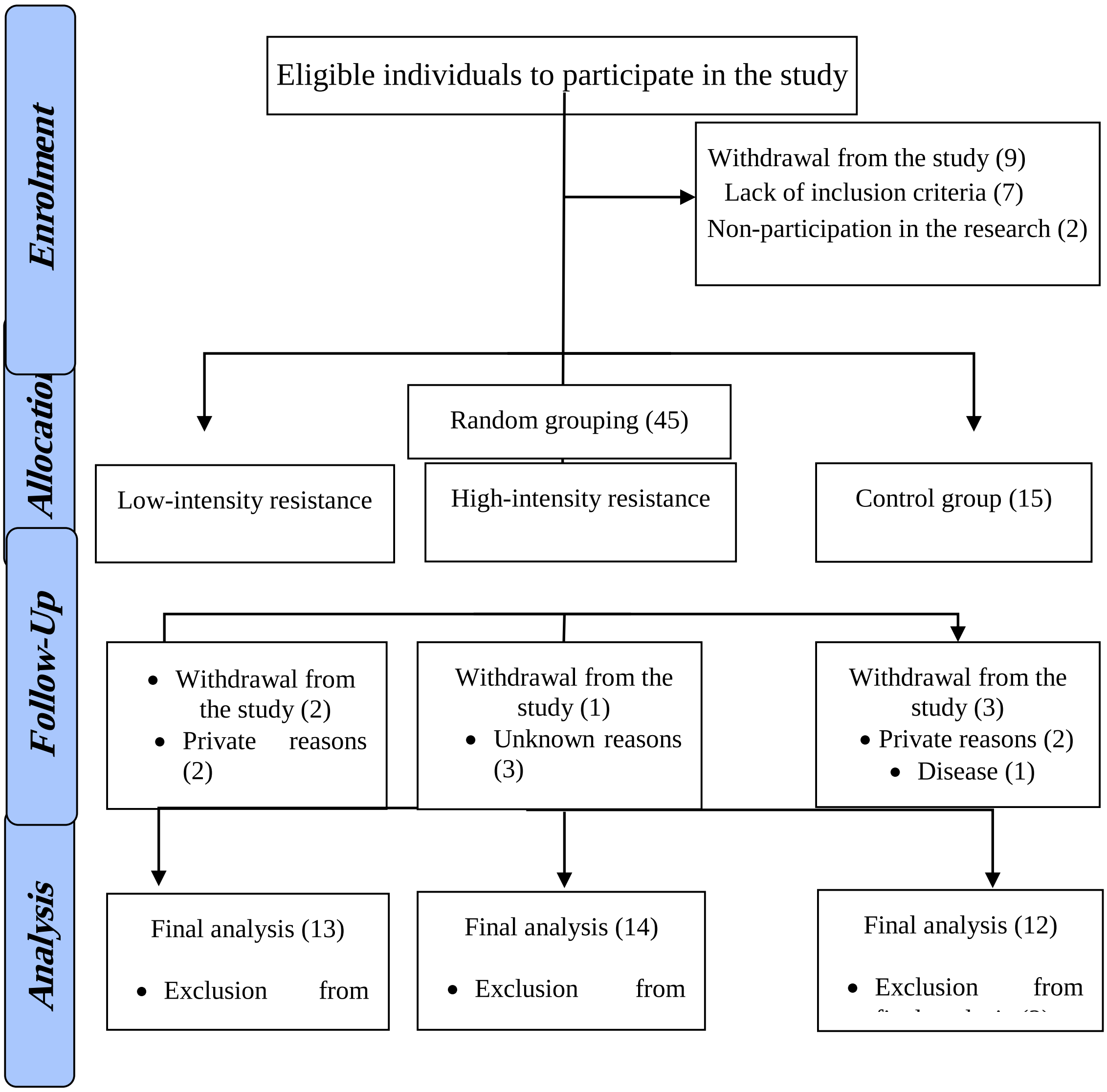

Figure 1. Flowchart of CONSORT (Consolidated Standards of Reporting Trials)

Table 1. Comparisons of baseline values for some anthropometric and physiological indices in the subjects Results of one-way ANOVA at a significance level of $p \geq 0.05$.

Index	Control	Low-intensity resistance	High-intensity resistance	p-value Between group
	Mean ± SD	Mean ± SD	Mean ± SD	
Age (year)	21±0.5	21.1±1.1	20.3±0.8	0.927
Height (cm)	161.7±1.1	162.3±1.2	163±1.1	0.813
Weight (kg)	57.3±1.7	58.4±2.7	59.5±3.2	0.459
BMI (kg/m2)	22.1±0.8	23±0.5	23.1±1.5	0.664
Max. oxygen use (ml/kg/min)	1.77±40.29	4.94±39.15	5.46±41.23	0.522
Body fat (%)	33.3±2.8	29.4±0.9	28.5±2	0.138

Table 2. Intragroup and intergroup comparisons of FIB, GH/IGF-1, TC, HDL, LDL, lactate, and glucose variables (mean ± standard deviation) in pre- and post-test phases

	Control		P Intragroup	High-intensity resistance training		P Intragroup	Low-intensity resistance training		P Intragroup	P Between group
	Baseline	Post-activity		Baseline	Post-activity		Baseline	Post-activity		
Fibrinogen	86±254/54	34±246.68	0.34	78±269.9	39±250.14	0.01*	77±267.11	43±249.9	0.002*	0.4
Glucose	8.7±89.6	4.2±87.52	0.23	71±84.2	5.9±86.2	0.1	0.1±82.3	9.4±83.2	0.5	0.67
hs-CRP	0.37±0.80	0.35±0.78	0.26	2.02±2.27	0.41±0.71	0.009*	0.88±1.03	0.45±0.43	0.017*	0.006*
TC	35±162.11	86±161.11	0.11	22±164.1	46±160.10	0.05*	66±184.11	03±182.13	0.02*	0.08
LDL	65±93.5	51±93.5	0.54	10±85.7	9±81.5	0.03*	9±89.8	8±87.8	0.00*	0.07
Lactate	4.7±28.3	4.2±26.2	0.76	5.7±25.5	7.2±31.7	0.26	6.07±30.56	7.9±32.3	0.15	0.59
HDL	43±40.7	00±40.6	0.18	54±37.6	5±40.4	0.01*	38±39.4	2±43.3	0.02*	0.11
GH/IGF-1	0.00±0.089	0.00±0.093	0.79	0.00±0.0108	0.0±0.0120	0.000*	0.00±0.088	0.00±0.0104	0.000*	0.06

- Data are reported as mean ± standard deviation
- Intragroup p results are based on dependent t-test
- Intergroup p results are based on one-way ANOVA
- The significance level is at $p < 0.05$

Table 3: Comparisons of hs-CRP levels between the three groups (Bonferroni post-hoc test)

Variables	Groups		Sig.
hs-CRP	High-intensity resistance	Low-intensity resistance	1
		Control	*0.00
	Low-intensity resistance	Control	0.06

*The significance level is at $p < 0.05$.

Discussion

According to cardiologists and sports physiologists, heart attacks occur more frequently in people over the age of 35 years, as well as in men and sedentary individuals. Exercise is recommended to maintain health and reduce the risk of various diseases (12), but prolonged exposure to sports activities stimulates reactive oxygen species (ROS) and antioxidant defense systems. However, some existing evidence confirms the production of free radicals and the development of cellular damage and inflammation after strenuous exercise. It is believed that regular physical exercise improves the body's antioxidant status and reduces injury (13). Shepper (1991) found that the risk of heart complication decreased significantly with increasing intensity of physical activity, and identified high levels of physical activity as a protective factor in the prevention of heart disease (14). However, Weiss (1998) reported that the risk of coagulation in healthy individuals occurred only after strenuous exercise (15). Iran is among the countries with rapid ecological changes and a high prevalence of metabolic syndrome has been proven among adults and young people (16). In this regard, some studies have suggested that low-intensity training can lead to favorable changes in cardiovascular risk factors, while some others consider strenuous exercise to be helpful in the reduction of risk indicators. The results of the present study showed that hs-CRP values decreased significantly after both high- and low-intensity resistance training. Intensive activity as an influential factor may result in acute myocardial infarction and sudden death in susceptible people (17). Therefore, the intensity of exercise is one of the factors affecting the reduction of cardiovascular risk factors. Research has shown that levels of fibrinogen are lower in active people than in inactive people and, on the other hand, high-intensity exercise causes more fluid shifts into interstitial spaces, higher blood concentration, lower plasma volume, and ultimately increased levels of circulatory fibrinogen (18). Average oxygen consumption increases with high-intensity activity, followed by increased ROS and oxidative stress in the body, resulting in damages of these oxidative reactions to proteins, DNA, enzymes, and lipids. Besides, other changes in molecular structures and membrane processes lead to cell damage, eventually leading to the development and exacerbation of cardiovascular disease, diabetes, cancer, and premature aging. On the other hand, increased fibrinogen levels after exercise in young and healthy athletes and non-athletes have been reported in most studies (19). Ahmadizad (2006) found that strength training at 80% of 1RM led to significant increases in fibrinogen levels in healthy men (20). Findings of different researchers and their different interpretations, differences in subjects (type, gender, and age of individuals), exercise program, time of activity and exercise, training status, intensity and duration of exercise, post-activity blood sampling time, healthiness or sickness of people, and measurement methods are all of the reasons for the discrepancy between the results. On the other hand, fibrinogen is positively associated with age and is inversely correlated with physical activity and training levels. Fibrinogen concentrations generally increase with age (21). Studies indicate that a reduction in hs-CRP is interpreted as an adaptation resulting from exercise and boosting the cardiovascular system. This process directly improves endothelial function and increases antioxidant factors by increasing nitric acid produced by the endothelial, resulting in reduced production of inflammatory cytokines from the endothelial wall muscles and finally reducing the production of hs-CRP inflammatory index from the liver. Hubner and Ochooki (2009) observed that hs-CRP and other cardiovascular risk factors reduce significantly in elite wrestlers as a result of strenuous exercise (22). Odenvan et al. (2005) investigated the effect of exercise intensity on cardiovascular disease, and found desirable changes in TC, LDL, HDL, and fibrinogen levels in training groups, but only high-intensity training caused significant changes in TC, LDL, and LDH (23). Lagali examined changes in blood lactate after one week of resistance training with three different intensities (30, 60, 90), and noted that blood lactate levels increased significantly in all three training intensities (24). In other words, resistance contractions cause arterial obstruction and consequently muscles use the anaerobic system due to decreased usable oxygen thereby increasing intramuscular lactate levels (25). However, exercise and physical activity, alongside other factors, affect immune responses. Some studies demonstrate differences between active and inactive people in terms of antioxidant responses, so that levels of lymphocyte cells are much higher in female athletes than those of non-athletes, and trained people utilize more estrogen and catalase levels to deal with inflammatory factors and free radicals (26). Therefore, duration and severity of activity and levels of people’s physical fitness are three important and basic factors in the secretion of this index. The antioxidant enzyme gene expression does not affect significantly and poses less risk in trained individuals due to the exercise-mediated adaptation in spite of increased free radicals resulting from high-intensity exercise (27). Therefore, a selected exercise program with appropriate intensity increases one's efficiency by affecting various systems of the body. Additionally, exercise has far fewer side effects than other therapeutic interventions. A well-reckoned exercise program in terms of the intensity and volume of exercise helps the person to return to an active lifestyle and to control and treat disease symptoms with minimal risk and cost thereby reducing many of the costs imposed on the society. Findings from previous research suggest that age, gender, and the intensity of activity are three important factors in the development of heart disorders. Researchers have reported that electron transfer chains in women produce lower levels of free radicals than those of men, and that estrogen is a factor differentiating men from men. Estrogen has been reported to inhibit more NADPH-oxidase activity in women and prevent further production of free radicals (10). Research has shown that muscle contraction plays an insulin-like role by directing large amounts of glucose into the cell to be used for energy production. It also increases membrane permeability to glucose due to increased glucose transporters (GLUT4) in the plasma membrane. As a result of exercise, GLUT4 levels increase in trained muscles, which improves insulin action on glucose metabolism (11). Lee et al. (2007) concluded that growth hormone and IGF-1 levels could be used to maintain a normal heart condition, and that the risk of cardiovascular disease increased with reduced GH/IGF-1 ratios (2). In the present study, the GH/IGF-1 ratios were not significant between the three groups after the 6-week resistance activity; therefore, this training in the long run may have a beneficial effect on the cardiovascular system functioning and prevent cardiovascular disease. Examining the effects of exercise and physical activity on fat metabolism and prevention of cardiovascular disease and inflammatory factors in young subjects can be considered as one of the strengths of this study. However, our study suffers from limitations, including 1) lack of control, 2) selection of the sample size, and 3) no control over the mental and psychological conditions and complete nutrition and stress of subjects during the research, in particular during blood sampling. Making positive and effective changes in the range of time and the intensity of high- and low-intensity training can be an effective factor in reducing the potential risk of cardiovascular disease. It is recommended to examine this protocol on overweight young people with diabetes or metabolic syndrome to further clarify the effect of exercise on variables related to cardiovascular disease.

Conclusion

In our research, high-intensity resistance training resulted in better consequences, particularly in the case of hs-CRP index as an important sensitive inflammatory index and the main indicator of cardiovascular disease. Given the determining effects of exercise type and intensity on metabolic factors, the present training as an applied factor can reduce and possibly delay cardiovascular disorders due to the reduction of cardiovascular risk factors. Therefore, at least six weeks of regular resistance activity, with an intensity gradually increasing from 70 to 90 percent of one's maximum capacity, is recommended for young women.

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