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A comparative study on the effect of resistance training period with and without vascular occlusion hand on changes in fibrinogen, lipids, and lipoproteins in young girls

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Abstract

***Background & Aims*:** Disorders of lipid profile and inflammatory markers are the most important factors that cause cardiovascular disease. Therefore, the aim of this study was to compare the effect of a six-week resistance training with and without vascular occlusion on changes in fibrinogen, lipids, and lipoprotein levels in young girls.

Materials & Methods: A total of 36 female students of physical education with an average age of 20.51 ±1.39 years and BMI of 23.32 ± 2.79 kg/m^2 were divided into three groups: resistance training without occlusion (exercise at 75% of one-repetition maximum or 1 RM), resistance training with vascular occlusion (exercise at 30% of 1 RM with a fastening tourniquet around the proximal arm), and a control group. Both training exercise groups performed a six-week training program consisting of three sessions per week. Then, creatine kinase (CK) levels, lipid profiles, and blood fibrinogen were measured by photometric, enzymatic, and ELISA methods, respectively.

Results: After six weeks of resistance training, CK levels were significantly different in both training groups ($p < 0.05$). Fibrinogen (FIB), triglyceride (TG), high-density lipoprotein (HDL-C), low-density lipoprotein (LDL-C), and cholesterol (COL) decreased significantly in both treatment groups compared to control group, but these changes were not statistically significant between the three groups ($p > 0.05$).

Conclusion: In our research, resistance training could probably improve cardiovascular health and metabolic states to change the fat as a kind of prevention against such diseases, hence, promotion of women's health should be taken into account.

***Keywords*:** Resistance Training; Local Vascular Occlusion; Fibrinogen; CPK; Lipid (TG & TC); Lipoproteins (HDL-C & LDL-C)

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Introduction

Coronary heart disease is the leading cause of death in industrialized and developing countries (24). Physical activity and exercise play an important role in the automatic control of the cardiovascular system, increased parasympathetic control, and decreased cardiac sympathetic control. Resistance exercises cause parasympathetic activity and thus decrease heart rate during exercise (1). Therefore, due to the importance of cardiovascular disease among chronic diseases, it is of paramount importance to predict and treat these diseases, which in turn depends on the recognition of factors affecting the development of this condition. Research findings suggest that some factors, such as elevated concentrations of inflammatory markers including fibrinogen (FIB) and creatine kinase (CK), and other factors like increased proinflammatory cytokines and lipid profile may also be associated with increased risk factors for coronary heart disease (3, 4). Several inflammatory markers can effectively predict cardiovascular disease. FIB is a soluble glycoprotein in plasma that acts upon tissue damage, infection, and inflammation, through a process called inflammation homeostasis. The release of cytokines (e.g. IL-6 and IL-1) as general and effective regulators of inflammatory responses stimulates the production of inflammatory markers including FIB from the liver (14). By affecting plasma viscosity, platelet aggregation, and the amount of formed fibrin, FIB paves the ground for coronary artery disease (6). Today, it is known that, although symptoms of such diseases as coronary obstruction appear in adulthood, these diseases begin to develop in adolescence and young ages (7). In healthy individuals, FIB levels increase in each age decade, which may explain the increased cardiovascular risk observed in the elderly (10). Based on the existing evidence, elevated levels of inflammatory markers are associated with a two- to five-fold increase in the risk of cardiovascular events, and adipose tissue is generally higher in women than in men. Besides, there is a strong evidence indicating that blood levels of inflammatory markers are linked to general obesity and abdominal obesity, thus, it may render women more susceptible to chronic inflammation (47). CK is another inflammatory marker that affects the immune system and its increase was reported to be directly related to cardiovascular disease (45). Additionally, one of the most important causes of cardiovascular disease development is lipid disorders and oxidation, including inappropriate concentrations of some cardiovascular risk factors (e.g. TG, LDL, HDL, and TC) (39). Therefore, the regulation of blood lipids is an important health factor due to the direct relationship between fats and myocardial infarction, and undoubtedly the habit of proper exercise activity plays an important role in this regard. Odenvan et al. (2005) investigated the effect of exercise intensity on causes of cardiovascular disease and found that changes in TC, LDL, HDL, and FIB levels were favorable in training groups, but only high-intensity training led to significant changes in TC, LDL, and LDH concentrations (11). On the other hand, favorable changes in blood lipoprotein concentrations as a result of exercise activities are the main factors considered in the relationship between exercise and reduced risk of cardiovascular disease. As such, regular exercise and physical activity reduce the risk of cardiovascular disease by creating desired changes in the concentration of different lipid and lipoprotein sections (32). Previous studies generally demonstrate that greater amount and intensity of exercise will lead to better improvement than exercise with lower values and intensity (23, 22). On the other hand, high-intensity strength training is not recommended for a specific group of people, such as women, patients, and the elderly, and the individuals that do not usually perform such training (25). Therefore, it is necessary to use a low-intensity, low-loading exercise method that can be used to achieve the same results as high-intensity exercise. Researchers have, therefore, suggested some form of exercise like resistance training with vascular occlusion. Strength training with vascular occlusion is a low-intensity strength training with a flexible lightweight stretching around the (upper) proximal arm or thigh to achieve an appropriate surface pressure. The intensity of such training is usually 20-30% of one-repetition maximum, which is roughly equivalent to daily activities of people and therefore tolerable for most people with different physical characteristics (8). Some studies indicate that blocking exercise have the same benefits and even more than exercise without occlusion (9). The age of cardiovascular disease has declined in recent years and become widespread among children and young people (26). Moreover, there is little evidence on the effect of resistance training on cardiovascular markers in girls who are not very interested and enthusiastic thereto, and most research has focused on aerobic exercise in men or on specific people or patients. Therefore, there is a need for further research on the effect of resistance training on cardiovascular markers in young girls. Furthermore, determining the effect, type, intensity, and duration of regular and controlled exercise, in particular strength training, on these indices in young people can have an important role in preventing the progression of this complication and enhancing the health and useful life of the community. Additionally, the assessment of cardiovascular disease risk makers can improve our knowledge about the cardiovascular disease at an older age. Therefore, the present study was designed and performed to compare a six-week resistance training with and without vascular occlusion hand on changes in FIB, CK, lipid, and lipoprotein levels in young girls.

Method

The statistical population of this study consisted of female undergraduates (physically active) in physical education with a mean age of 20.51 ± 1.31 years, weight of 59.76 ± 7.04 kg, height of 158.88 ± 3.82 cm, and BMI of 23.2 ± 32.79 kg/m^2 from Shahid Chamran University, Ahvaz. The participants completed medical questionnaire forms and were prepared for physical activity after obtaining written consent along with the mutual ethical commitments of the subjects and the researchers. Thereby, the volunteers agreed to participate according to the selection criteria, namely diet observation, no use of medication and supplements, no smoking, no history of illness and infection affecting immunity factors, and familiarity with weights. Then, 36 subjects as the statistical sample were selected among the volunteers based on the VO2max (over 39 ml/kg/min) and, after necessary analyses, they were assigned into three groups of resistance training based on questionnaire information, including resistance training with vascular occlusion (n = 12), resistance training without arm vascular obstruction (n = 12), and a control group (n = 12). The control group engaged in daily activities (such as study) at the faculty. One week before the start of training sessions, the subjects performed light movements with the halter in the dormitory gym in three sessions for primary preparation and familiarity with the protocols. To this end, all subjects were asked not to perform heavy physical activity for two days before blood sampling. The subjects were subjected to anthropometric (body weight and height), body composition, maximal oxygen consumption, and one-repetition maximum (1 RM) measurements. In order to calculate maximum strength, the subjects selected the weights by their initial estimation and performed the movement until fatigue (stall). Then, maximum strength was estimated through the moved weight level and number of repetitions by the following formula:

$$1\text{RM} = \frac{\text{Moved weight (kg)}}{1.028 - (\text{fatigue repetition} \times \%0278)}$$

Subjects in each group performed the training for 6 weeks (three sessions per week) and a total of 18 sessions of strength training with a halter was performed at the dormitory in the afternoon. The training session started with 5 minutes of hand-stretching warm-up exercises. For training in the occlusion group, a pre-designed rubber tourniquet was initially fastened around each proximal arm. The cuff pressure was constant (100 mm Hg). Three sets each with 10 movements with one-minute rest between sets were considered for both groups. The occlusion hand group performed forward arm, chest and armpit press, and trunk and arm extension by halters with a cuff pressure of 100 mm Hg with 30% of 1 RM, and the other group executed the movements without vascular occlusion, with 75% of 1 RM. To collect data, the subjects were fasted for 12 hours and attended at the Physical Education Laboratory of the university. For biochemical tests, blood samples (5 ml) were taken from the subjects, centrifuged at 3500 rpm for 15 min, and then stored at −20 °C. Blood FIB and serum CK levels were measured with the GmbH kit (Germany) and using the Pars Test Kit (Iran), respectively, through photometry (I/U precision). Total COL, TG, HDL-C, and LDL-C concentrations were assayed enzymatically using the Pars test kit (Iran) with an accuracy of mg/dL. Descriptive statistics were used to calculate the mean and standard deviation of the data. The normal distribution of the study variables was verified using the Shapiro-Wilk test. Statistical analysis of data and intergroup comparisons were made by parametric inferential tests including one-way analysis of variance (ANOVA). Within-group differences were investigated with a dependent t-test. All statistical analyses were performed using SPSS-16 software at a significance level of $p < 0.05$.

Result

Individual data of the subjects are listed in Table 1. The results in Table 2 indicate that the amounts of FIB, CK, LDL-C, TG, and TC decreased in both groups and serum HDL-C levels increased significantly in both groups compared to the control ($p < 0.05$). In addition, the three training groups were not significantly different in terms of lipid and FIB profiles ($p < 0.05$).

Table 1: Anthropometric indices and physical and physiological composition of subjects (mean ± SD)

Group / Variables	With occlusion	Without occlusion	Control
Age (year)	39·1±77·20	85·1±21·20	69±·55·20
Height (cm)	4·3±156	93·4±64·158	14·3±4·161
Weight (kg)	8·9±59	89·6±03·58	45·4±25·62
BMI (kg/m2)	4±23	99·1±09·23	4·2±89·23
Max. O2 consumption (ml/kg/min)	46·5±23·41	94·4±15·39	77·1±29·40

Table 2: Intragroup and intergroup comparisons of pre- and post-test fibrinogen, creatine kinase, lipids, and lipoprotein variables

	Control		Intragroup P	With occlusion training		Intragroup P	Without occlusion training		Intragroup P	Intergroup P
	Before activity	After activity		Before activity	After activity		Before activity	After activity		
FIB	86±54·25 4	34±68·24 6	32·0	77±52·26 8	249±43	00·0*	52±47·26 5	40±50·25 1	04·0*	4·0
TC	35±11·16 2	86±11·16 1	11·0	23±13·16 5	47±11·16 1	01·0*	67±12·18 5	04±14·18 3	05·0*	08·0
HDL -C	43±7·40	00±6·40	18·0	55±6·38	58±4·41	046·0*	39±4·40	28±4·42	00·0*	11·0
LDL -C	65±5·93	51±5·93	54·0	11±7·87	94±5·83	05·0*	92±8·90	80±9·88	002·0	07·0
CK	96±7·81	06±8·82	77·0	27±11·97	72±12·88	002·0*	68±14·84	12±15·78	004·0	01·0*
TG	54±9·191	39±8·191	50·0	77±9·188	58±10·18 5	057·0*	88±7·192	72±8·190	02·0*	10·0

- Data are presented as mean ± standard deviation.
- Intragroup p results are based on a dependent t-test.
- Intergroup p results are based on one-way ANOVA.
- Significance level is considered at $p < 0.05$.

Table 3: Comparison of serum creatine kinase index between three study groups (Bonferroni follow-up test)

Variables	Groups		Sig.
Creatine kinase	With occlusion	Without occlusion	1
		Control	*0.003
	Without occlusion	Control	*0.025

Significance level is considered at $p < 0.05$.

Discussion

At least in Iran, the present study is the first to investigate the effect of low-intensity occlusion exercise as an effective alternative to high-intensity exercise on cardiovascular factors. Our results showed that a six-week resistance training course with and without vascular occlusion hand affected blood FIB levels in the experimental group. After 6 weeks of resistance training with and without vascular obstruction, FIB circulatory levels decreased significantly in the three experimental groups. Research reported that FIB is more specific to cardiovascular disease than other inflammatory markers (37). FIB accounts for an important component of blood coagulation, and it is a determinant of blood adhesion and flow, and its elevated levels in the blood increase the risk of coagulation and heart failure (20). Fontaine et al. (2003) conducted an extensive research and concluded that regular especially high-intensity, long-term physical activity was associated with reduced cardiovascular risk factors (28). Moreover, FIB levels were found to increase with age, and this age-dependent elevation might be due to its slower destruction relative to increased FIB production (27). Additionally, extensive research on physical activity and its effect on FIB levels revealed that higher levels of physical activity can be associated with fitness and lower inflammatory markers, including FIB (18). A higher positive and direct relationship with FIB was reported in women than in men (17), which is in line with the present findings as all the subjects were girl students. In a similar study, Tomohiro et al. (2014) observed no significant changes after 12 weeks of resistance training in an occlusion group. The main reason for such a discrepancy can be related to the differences in the readiness and ages of subjects in the two studies as inactive elderly people were the subjects in their research. A bulk of literature suggests an increase in FIB and a decrease in HDL levels with physical activity and exercise. In general, an increase in blood lipids, particularly low-density lipoprotein (LDL) leads to damages and alterations in the vessel wall, and ultimately increases inflammatory markers (19). On the other hand, exercise and physical activity decrease the production and release of FIB by affecting stress indices and antioxidant defense of the body, inhibiting pro-inflammatory mononuclear cell production, and decreasing serum uric acid and IL-1B gene expression (38). Mousavi and Habibian (2009) investigated the effects of aerobic and resistance training types on blood FIB in active female students and concluded that resistance training led to increased FIB concentration (29), which is inconsistent with results the present study. This can be attributed to differences in training protocol, training intensity and duration, and blood sampling time. It should be noted that in most studies reporting an increase in FIB after exercise, blood was sampled almost immediately after activity, whereas our blood samples were collected 24 h after the last training session. The reduced FIB synthesis from hepatocytes may be assigned to adaptation in the musculoskeletal system to resistance training, probably reducing the activity of proinflammatory cytokines, which may, in turn, influence the reduction of FIB resulting from hepatic synthesis (41). Alsida et al. (1995) examined the impact of a training program on 25 subjects (12 weeks, three sessions per week) and observed a nonsignificant 6% reduction in FIB (2). Many factors affect blood FIB concentrations. In this study, factors such as age, gender, BMI, medication, and dietary supplements related to cardiovascular disease (e.g. diabetes and hypertension) and its components were controlled through the questionnaire as far as possible. Ahmadizad et al. reported that physical exercise and training resulted in decreased blood FIB concentrations by declining plasma volume, increasing blood rheology, and decreasing blood flowing (5). Studies generally indicate that rising mean arterial pressure during heavy resistance training results in blood fluid filtration into the interstitial space. On the other hand, increases in lactate levels and peripheral vascular resistance, elevate blood viscosity, which is temporarily increased by FIB since it is one of the major determinants of blood viscosity (13). The mechanism of its decrease is likely related to elevated fibrinolysis process resulting from regular training and exercise (15) with reduced catecholamine stimulation, increased blood flow in the muscles, and overall elevation of blood volume (16). CK levels decreased significantly after resistance exercise in both training groups compared to the control group. Kakhak et al. (2013) compared the effect of a single resistance occlusion training session with traditional resistance training on the CK index in healthy girls. It was concluded that resistance exercises had no significant effect on CK in both groups and that the two training methods could be used interchangeably, which is not in line with the results of the present study. The difference between our observation and that of Sharifian et al. may be related to differences in the type and duration of training as well as in the contractions and muscles involved in the applied activity since upper-trunk resistance training was used in this study rather than the lower-trunk one. In addition to the protective effect of estrogen on the muscle cell membrane in preventing an increase in serum enzymes, a decrease in CK secretion under the influence of reduced levels of inflammatory markers seems to be one of the mechanisms representing the CK changes in the girls of the training group (44, 46). Additionally, TG, LDL-C, and TC levels decreased significantly after the resistance exercise in both experimental groups compared to the control group, and HDL-C increased significantly, but these changes were not statistically significant between the three study groups. The effect of physical exercise on TG concentrations was found to depend on pre-exercise concentrations so that individuals with lower concentrations did not show significant changes with activity and exercise, whereas TG declined significantly in those with high concentrations (43). Ibrahim et al. showed that duration, intensity, and type of training were effective in decreasing fat levels and also believed that moderate and medium intensity training could not produce oxidative stress to increase the oxidation capacity of LDL-C (42). Sato (2011) studied the effect of occlusion training on patients with metabolic syndrome and found a significant decrease in LDL concentrations after four months, which is different from our research possibly due to the longer duration and the differences in the health condition of the subjects. Lemura et al. examined the effects of aerobic, resistance, and combination training on serum lipid and lipoprotein levels, and reported no significant changes in concentrations of TG to LDL and HDL in resistance training groups (31), which corresponds to our findings. However, further studies are needed to elucidate the effect of resistance training on fat metabolism. According to the results of this study, the significant increase in HDL indicates that this type of exercise improves cardiovascular health and changes HDL metabolism. It is also believed that elevated serum HDL-C levels after training are responsible for the prevention and protection of cardiovascular disease development in physically active individuals (30). Edonon et al. found unchanged HDL levels due to such factors as their initial concentrations, HDL dependence on TGs, and no reduction of HDL (11). Moreover, changes in lipids and lipoproteins are often dependent on lipoprotein lipase (LPL) activity, a key enzyme in the catabolism of TG-rich lipoproteins, which is thought to accelerate the transfer of lipids from chylomicrons and VLDL to HDL alteration. Other potential mechanisms for enhancement of HDL production could be through training-induced increase in lecithin cholesterol acyl transferase (LCAT) activity and a decrease in HDL clearance through the exercise-related decrease in hepatic lipase activity (33). Another reason for the non-significant increase in HDL-c levels among the three study groups in this study was probably the normal levels of initial HDL2 and HDL3 values in our subjects and no significant changes as a result of executed training. This is because most studies that reported changes in HDL-C and its subclasses after training used samples who had high LDL-C and low HDL-C levels (34, 35). On the other hand, women were detected to respond to training with slight changes in concentrations of lipids and lipoproteins compared to those of men (12). Non-significant changes in the above parameters among women in some studies may result from the fact that the initial concentrations of total COL are lower in women than in men while their HDL concentration is higher, or it may be due to the effect of estrogen (40,36). This is because the feminine estrogen hormone reportedly raises good cholesterol (HDL-c), which transports bad COL (LDL-c) to the liver and discharges it in the form of bile into the intestines. In other words, estrogen somehow reduces LDL-c levels in the blood and partially prevents fat deposition in the artery wall. Regular training and physical activity can induce anti-inflammatory effects and thus protect against cardiovascular disease in a variety of ways, including increasing HDL-C (8, 9). The present findings are in line with those of Qari Arefi et al. (2014) who reported positive non-significant changes in lipid profile due to small sample size and the short duration of the training program (41). Physical exercises rarely affect lipid profile levels unless they are accompanied by a diet and exercise program for over eight weeks. On the other hand, training was more effective in reducing these factors in people with higher normal and baseline levels of lipid profile (21). Since the subjects in the present study were in the normal range of serum lipid profile and also our training protocol duration was less than eight weeks, it is inferred that these factors can explain the non-significant differences between the study groups. Limitations and shortcomings of this study include single-sex subjects and impossible examination of sex-related changes in research variables (our findings may not apply to male subjects) as well as the impossibility of sampling at different times after completing the activity in the female subjects since many cardiovascular events occur within hours of physical activity. There is no doubt that tracking these changes can open a new window to the field of cardiovascular accident prevention. As mentioned above, the main findings in the reviewed literature correspond to the overall results of the present study, and inconsistent investigations are mostly cross-sectional consisting of one-session intense exercise with older subjects. A longer training program with a higher volume or with nutritional intervention may exert more favorable effects on cardiovascular risk factors in girls. Therefore, given limited studies on the effect of regular and controlled resistance training on lipid profile and FIB indices, the present findings should be reconsidered in the future regardless of the limitations of the present study.

Conclusion

Altogether, based on the results of this research, the pattern of changes in levels of FIB, CK, lipids, and lipoproteins was similar in both training groups. However, low-intensity resistance training with vascular occlusion seems to result in greater changes in cardiovascular risk factors in young girls than the training without vascular occlusion. It should be noted, however, that this type of training by patients requires further investigations, and the results of this study can only be generalized to this type of training protocol with healthy and active subjects.

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