

The effects of resistance and endurance training on risk factors of vascular inflammation and atherogenesis in non-athlete men

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Abstract: *Background:* Studies show that different types of training have a significant role in reducing both new and traditional risk factors of cardiovascular diseases, and the new risk factors are more sensitive and accurate in predicting such diseases. *Objective:* The aim of this study was to determine the effects of resistance and endurance exercises on risk factors of vascular inflammation and atherogenesis in non-athlete men. *Methods:* Thirty-six non-athlete male students (mean age: 20.45 ± 1.20 years; mean body mass index: 23.66 ± 3.65 kg/m²) were randomly assigned into either three groups: control group, resistance training (RT), and endurance training (ET). The training groups exercised for 3 days/week for 8 weeks. ET group performed treadmill-running at 65%–80% of maximum heart rate and with a 16–30 min duration; the task of RT group consisted of three repetition sets, 8–10 per set, at 60%–80% of one repetition maximum, with 2-min recesses. Blood samples were taken before and after the training program. Data were analyzed by Shapiro–Wilk test, one-way ANOVA, LSD test, and dependent *t*-test ($\alpha \leq 0.05$). *Results:* The results indicated a significant reduction in total cholesterol levels in both RT and ET groups. Also high-density lipoprotein cholesterol significantly increased in both training groups. In addition, following 8 weeks, low-density lipoprotein cholesterol in ET group was significantly decreased, whereas these training methods have had no significant effects on the new cardiovascular biomarkers (hs-CRP, IL-6, and sICAM-1). *Conclusion:* It seems that both ET and RT with improvement in lipid profiles could be effective in prevention and treatment of the cardiovascular disease.

Keywords: cardiovascular diseases, endurance training, resistance training, risk factors, non-athlete men

Introduction

Cardiovascular disease (CVD) remains a leading cause of morbidity and mortality affecting approximately 84 million people in the United States [1]. Atherosclerosis is a developing heart disease, which starts at childhood and its signs appear at adulthood. This disease is also the main cause of mortality in the industrial world [2–4]. Therefore, predicting coronary heart disease (CHD) has a vital role in preventing and treating this disease [3, 5]. Since

long ago, lipid profile has been recognized as the biomarker of CVDs. Although the increase of low-density lipoprotein cholesterol (LDL-C) and decrease of high-density lipoprotein cholesterol (HDL-C) have been known as the markers and factors of CVDs, the reports reveal that the individuals who suffer from cardiovascular problems have a natural HDL-C and LDL-C. Studies have shown that traditional factors of CVDs are of no use in detecting the individuals who are exposed by such diseases [6–9], so in order to detect such people, we have

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to seek other useful biomarkers [9]. According to the researches carried out over this issue, development of cardiovascular problems, such as atherosclerosis, has inflammatory causes [2, 6, 7, 10, 11]. Various inflammatory biomarkers have been identified, but scientific observations show that soluble intercellular adhesion molecule-1 (sICAM-1), interleukine-6 (IL-6), and high-sensitivity C-reactive protein (hs-CRP) are identified as the most sensitive inflammatory biomarkers, the predictors of CVDs, and the new biomarkers of cardiovascular problems, which have a significant role in pathogenesis of atherosclerosis [3, 7, 12–14]. Hence, any action that results in decrease of inflammatory biomarkers will lead to the reduction of the cardiovascular problems as well [5, 15, 16]. Thus, regarding the effective role of physical activities in preventing and decreasing the cardiovascular problems, researchers have worked on the effects of various physical activities on the new (inflammatory biomarkers) and traditional (lipid profile) cardiovascular biomarkers. Pitsavos et al. [17] studied the effects of physical activity on inflammatory biomarkers in 1,528 male and female individuals all of whom were above the age of 18, and found that physical activity diminishes the inflammatory biomarkers, such as IL-6 and hs-CRP. In another research, Rosa et al. [16] studied the interrelation between inflammation biomarkers and the VO_{2max} in 172 asymptomatic men and discovered that the high levels of IL-6 and hs-CRP are associated with the low levels of cardiovascular fitness. In addition, Baptista et al. [18] discovered that intensive swimming and treadmill-running of rats leads to the increase in HDL-C and decrease in lipid profile of them, and suggested that despite the significant lipid profile reduction as a result of these two exercising methods, running on treadmill, due to its type of exercising, intensity, and duration is much more useful. Saxton et al. [19] surveyed the effects of slow pedaling with hands and feet for 24 weeks, and observed a significant decrease in the amount of sICAM-1 and hs-CRP. In a similar study, Mogharnasi et al. [20] also found that treadmill-running of rats, for 12 weeks, three sessions per week, will result in a significant increase in HDL-C and decrease in the new biomarker, sICAM-1 and traditional biomarkers, total cholesterol (TC), triglycerides (TG), LDL-C; and also, it will immune the cardiovascular system against heart and vascular risks. Whereas Guerra et al. [21] and Ghanbari-Niaki et al. [22] discovered that 8 weeks of swimming and 6 weeks of treadmill-running had not changed the lipid profiles of the rats. Other studies over the effects of physical training on the new cardiovascular biomarkers showed that running on treadmill for 30 min/day, for 1–3 weeks, will result in a great sICAM-1 and IL-6 reduction, and also will protect the brain from damage and inflammation [23–25]. Nevertheless, Nassis et al. [26] and Hammett et al. [27] reported that physical training is not associated with inflammatory biomarkers and claimed that

continuous endurance training (ET) has no significant effect on the new cardiovascular biomarkers, such as sICAM-1 and hs-CRP, although they have increased the insulin sensitivity in overweight girls and have increased physical fitness in smoking men. Nicklas et al. [28] showed that physical training does not have a considerable impact on inflammatory biomarkers (hs-CRP and IL-6), while the weight loss caused by diets will reduce the concentration of such biomarkers. Because of the contradictory results of the mentioned studies, it is necessary to examine the effect of two types of resistance and resistance training on the prevention of CVD. Therefore, this study was carried out in order to determine the effects of endurance and resistance exercises on the new (hs-CRP, IL-6, and sICAM-1) and traditional (TC, TG, LDL-C, and HDL-C) cardiovascular biomarkers that predict the CHDs in non-athlete men.

Materials and Methods

Participants

Thirty-six young men [mean age: 20.45 ± 1.20 years; mean body mass index (BMI): 23.66 ± 3.65 kg/m²] from the Islamic Azad University (Iran) participated in this study. They were assigned into either resistance training (RT), ET, or control group (CG) (12 participants in each group) through simple randomization method. All participants provided written informed consent after awareness of benefits and risks. Individuals with a history of regular exercise in the last year and cardiovascular, liver, kidney, and lung diseases and diabetes as well as serious physical trauma were excluded from the study. In order to make the subjects' condition more equal regarding the amount of their activities, the Baecke Questionnaire of the physical activities was used. In addition, it was suggested that all participants just use the university food, so that their conditions would be equal. Before and after the 8-week training period, body weight and BMI were measured. The characteristics of each group are presented in *Table 1*.

Exercise training programs

The ET program

The endurance group's program included running on treadmill at 65% of maximum heart rate, for 16 min during the first week; these features changed to 30-min durations and 80% of maximum heart rate till the eighth week (every week they added two more minutes to the exercise duration and 5% to the intensity of the activities).

The RT program

Ten days prior to the trial, the subjects participated in the briefing session, and the correct form of exercises was

Table I The anthropometric features of the subjects of the study

Group	Age (years)	Weight (kg)	Variables	
			Height (cm)	BMI (kg/m ²)
Control (<i>n</i> = 12)	1.76 ± 23.7	3.17 ± 176.6	6.36 ± 73.8	1.30 ± 20.3
Resistance training (<i>n</i> = 12)	1.13 ± 23.7	5.09 ± 178.7	6.68 ± 75.7	1.01 ± 20.5
Endurance training (<i>n</i> = 12)	1.07 ± 23.5	5.53 ± 177.7	7.34 ± 74.6	0.99 ± 20.1

Data are presented as mean ± SD. BMI: body mass index; SD: standard deviation

explained to them; then, they performed several under-maximum repetitions for each activity. After all, there was another session held before initiating the main training schedule during which one repetition maximum (1RM) of planned activities was assessed according to Willoughby et al.'s protocol. The training process was carried out in an 8-week period according to Kramer et al.'s protocol. The training schedule included 3 sets (8–10 repetition) at 60%–80% of 1RM, with 2-min recesses. These tasks were done three sessions per week. The RT included leg-press, hamstrings and quadriceps leg exercise, bench-press with barbell, forearm, and lateral pull-downs, which covered all the large muscles of the upper and lower parts of the body. In order to observe the overload principle and gradual progression, 1RM of the activities was assessed in the 2nd, 4th, and 6th weeks. The subjects were asked to avoid any other resistance exercises during the experiment.

Sample collection and biochemical determination

Twenty-four hours before the first training session and 48 h after the protocol, fasting blood samples were drawn. Serum samples were centrifuged for 15 min (3,000 rpm, 4 °C). Serum sICAM-1 concentrations were determined using the Soluble ICAM-1/CD54 (Human) ELISA Kit (EIA-SK00250-02, Aviscera Bioscience, Santa Clara, CA, USA) with the sensitivity of 4.88 pg/ml. Serum IL-6 concentrations were determined using the ELISA Kit (EA550799-02, Aviscera Bioscience) with the sensitivity of 0.5 pg/ml. The HDL-C, LDL-C, TG, TC, and hs-CRP were assessed using the Pars Azmoon Company kits (Tehran, Iran) with help of the automatic analysis machine, Prestige 24i.

Statistical analysis

Results are presented as means ± SD. Normality of distribution was assessed by the Shapiro–Wilk test. Given the normality of data distribution, the baseline and endpoint continuous values were compared within groups by paired samples *t*-test. Comparison between RT, ET, and CG groups was performed using one-way ANOVA. *p* < 0.05 was considered to be statistically significant.

Results

Table I shows the anthropometric features of the subjects of the study; no significant difference was observed between the preliminary data of the subjects. *Table II* shows the mean variation and standard deviation of the variables of the study. After 8 weeks of training, the TC levels in the ET and RT groups were significantly decreased (*p* = 0.009 and 0.022, respectively); the LDL-C level in ET group was significantly decreased (*p* = 0.006), and the HDL-C level of both ET and RT groups was significantly increased (*p* = 0.020 and 0.044, respectively). Although comparing two groups at the end of the study, the only distinction between them was over their LDL-C (*p* = 0.038), and other factors did not appear to be meaningfully different (*Table II*).

Discussion

The results of the study revealed that both of the endurance and resistance exercises lead to a great reduction of TC, which is a traditional factor of CVDs, but the LDL-C had diminished only in endurance group. These results agree with the former reports about decrease of the cardiovascular biomarkers due to regular physical exercises [7, 20]. On the other hand, there was no noticeable change in the new cardiovascular biomarkers, IL-6, hs-CRP, and ICAM-1 after the 8-week period of the study. The results of this study are in accordance with some studies [7, 22, 26–28], and disagree with the other studies [3, 12, 18, 25]. Mogharnasi et al. [20] after performing their 8-week study on endurance exercises (three sessions per week) at 55%–85% of VO_{2max} and 15–60 min running of the male Wistar rats on treadmill did not see any significant changes in the mount of adhesion molecules but after extending the study period, in the twelfth week, they found a significant reduction of adhesion molecules. In addition, Simpson et al. [29] studied on the effects of different exercises at the average intensity of 60% of VO_{2max}, intensity of 80% of VO_{2max} and running on a steep path with a 10% slope and 80% VO_{2max} on adhesion molecules activity, and found that the density of ICAM-1 will greatly increase after an intensive physical activity; moreover, the increase of lymphocyte leads to the increase of the adhesion molecules of

Table II | Comparison of the variables between the groups of the study in different stages

Variable	Group	Pretest	Posttest	Within-group P	Between-group P
sICAM-1 (pg/ml)	ET	323.00 ± 91.53	334.00 ± 110.84	0.501	0.472
	RT	342.75 ± 88.33	333.67 ± 77.24	0.499	
	Control	316.67 ± 72.69	32.75 ± 73.29	0.556	
IL-6 (pg/ml)	ET	1.88 ± 0.36	1.79 ± 0.20	0.358	0.835
	RT	2.02 ± 0.40	2.01 ± 0.37	0.900	
	Control	1.79 ± 0.26	1.98 ± 0.32	0.858	
hs-CRP (mg/dl)	ET	9.33 ± 4.32	7.33 ± 2.53	0.169	0.370
	RT	8.50 ± 3.73	8.33 ± 4.38	0.778	
	Control	7.75 ± 3.72	7.75 ± 2.60	1.000	
TC (mg/dl)	ET	188.75 ± 51.32	181.50 ± 41.28	0.834	0.115
	RT	199.42 ± 70.93	175.08 ± 58.68	0.009*	
	Control	162.40 ± 30.77	158.20 ± 24.25	0.022*	
TG (mg/dl)	ET	130.00 ± 13.81	123.00 ± 40.98	0.834	0.977
	RT	140.08 ± 106.31	120.75 ± 67.98	0.433	
	Control	113.58 ± 56.02	93.42 ± 30.28	0.063	
LDL-C (mg/dl)	ET	88.83 ± 24.86	88.92 ± 16.65	0.623	0.038**
	RT	69.00 ± 16.68	79.17 ± 22.85	0.006*	
	Control	77.67 ± 15.54	47.75 ± 14.85	0.471	
HDL-C (mg/dl)	ET	41.25 ± 14.06	39.92 ± 10.93	0.785	0.239
	RT	35.08 ± 13.25	45.75 ± 12.77	0.020*	
	Control	36.00 ± 9.43	41.50 ± 7.22	0.040*	

Within-group P: paired *t*-test. Between-group P: one-way ANOVA, all others were presented as mean ± SD. sICAM-1: soluble intercellular adhesion molecule-1; IL-6: interleukin-6; hs-CRP: high-sensitivity C-reactive protein; TC: total cholesterol; TG: triglycerides; LDL-C: low-density lipoprotein cholesterol; HDL-C: high-density lipoprotein cholesterol; ET: endurance training; RT: resistance training; SD: standard deviation

**p* < 0.05 significant difference compared to pretest

***p* < 0.05 significant difference between the three groups

endothelial cells. Finally, when the lymphocytes enter the tissues, the speed of the atherogenesis will increase too. These phenomena occur in order to adapt the body to the density of physical activities, not because of muscular injuries.

Since the majority of the studies reported an increase in inflammatory biomarkers after the intensive, resistance, extrovert activities, regarding the short period of the study (three sessions per week, for 8 weeks), there was no significant change in the level of ICAM-1, IL-6, hs-CRP, and TG, which shows compatibility with the studies of Guerra et al. [21], Ghanbari-Niaki et al. [22], Nassis et al. [26], and Hammett et al. [27]; these results may reveal the effects of training period, and the intensity and duration of the schedule on these variables. Some studies, also, have looked on the direct relationship between affectability of physical activities and the basic amount of cardiovascular biomarkers [2, 7, 20]. Moreover, since the subjects of the study were healthy and non-symptomatic, there is a possibility that the basic amount of these biomarkers had been lower than necessary to

make the study effective after only 24 sessions. Goldhammer et al. [30] studied the effects of endurance exercises on the activities of cytokines in 28 CHD patients. The 45-min ET at 70%–80% of HR_{max} for three sessions per week resulted in a significant reduction of IL-6 and hs-CRP, whereas the IL-10, which is an inflammatory cytokine, increased, and diminished the inflammation and inflammatory biomarkers. Other researchers have reported similar results [3, 6, 31]. In addition, this study showed that the endurance and resistance activities of the subjected groups have caused the amounts of HDL-C to increase as a good cardiovascular and anti-atherogenic factor. Ghanbari-Niaki et al. [22], after 6 weeks of ET and treadmill-running applied to rats, reported a great increase in HDL-C of rats and pointed that increasing of HDL-C, as a result of regular exercises and increasing of enzyme lipoprotein lipase, will increase the catabolism of lipoproteins and will lessen the chance of CVDs. Perhaps, the training schedule of this study can reduce the risk of CVDs by increasing the HDL-C, as an anti-atherogenic factor, and reducing the fat-mass. Other

studies have also reported the reduction of harmful fats (LDL-C, TC, and TG) and increase the rate of useful blood fat (HDL-C), after a period of regular training and physical activities [3, 23, 25], the performed studies about the effects of other physical trainings on CVDs indicate that intensive resistance and extrovert exercises that increase the sympathetic stimuli and decrease anti-inflammatory cytokines, will increase the release of mediating IL-1 β and TNF- α from fat tissues, which intensifies the density of ICAM-1 and transfers the monocytes to the vascular endothelium; therefore, the atherosclerosis will increase [3, 23, 25]. Baptista et al. [18] claimed that the rats' endurance exercises, such as swimming and treadmill-running leads to a significant increase in HDL-C and a great decrease in lipid profiles, though they believed treadmill-running to be more effective due to its type, intensity, and duration. Nevertheless, some studies have not shown any association between physical activities and cardiovascular biomarkers [12, 22, 26, 27]. There is a possibility that physical trainings have a protective role against CVDs by increasing blood and plasma mass, decreasing blood density, increasing stroke volume, and increasing VO_{2max}. Studies have shown that physical training will enhance the antioxidant defense. In this study, we have decreased the cardiovascular risk factors by enhancing antioxidant defense and decreasing free radicals [2, 6, 20]. Hence, regarding the relationship between physical activities and cardiovascular fitness, and the relationship between the new and traditional cardiovascular biomarkers, we can say that the methods applied in this study have been effective in reducing the traditional risk factors of CVDs, while they have had no effects on inflammatory biomarkers. It seems that the lack of change in these variables in this study is due to short duration and low intensity of exercise training protocols. However, more experiments should be performed over such subjects with different duration and intensity.

Conclusions

Both endurance and resistance exercises caused the traditional risk factors of CVDs, such as TC, LDL-C to diminish and led HDL-C to increase; however, this study has had no significant effect on the new CVD biomarkers (sICAM-1, IL-6, and hs-CRP). Regarding the pivotal role of the elements influencing cardiovascular biomarkers, putting more effort and allocating more researches on this field is highly recommended.

* * *

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Furthermore, all authors read and approved the final version of the manuscript, and agreed with the order of presentation of the authors.

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