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The effect of aerobic training on some indicators of vascular endothelial function in none-active adult obese women

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ABSTRACT

Introduction: Clinical evidence has supported vascular endothelial dysfunction in the presence of obesity. The aim of this study was to assess the effect of aerobic training on nitric oxide (NO) level, total antioxidant capacity (TAC) and homocysteine as markers of vascular endothelial function in inactive adult obese females.

Methods: For this purpose, 26 sedentary adult obese females were randomly divided into of aerobic (8 weeks, 3days/weekly, n= 12) and control (no training, n = 12) groups. Fasting serum levels of NO, TAC and homocysteine were measured before training program and 48 hours after lasting exercise session in both groups. Independent t-test was used to compare the pre-tests (baseline) between two groups and paired t-test was used to determine intra-group changes.

Results: No significant difference were observed in each variable between groups at baseline ($p>0.05$). Aerobic training resulted in significant decrease in homocysteine and increase in NO and TAC in aerobic group ($p<0.05$). All variables remained without change in control group ($p>0.05$).

Conclusion: Based on these results, it is concluded that regular aerobic exercise improves vascular endothelial function in obese adult women.

Keywords:

Aerobic training, Obesity, vascular endothelial function, Antioxidant capacity.

1. Introduction

Obesity is associated with endothelial dysfunction due to the damage of endothelium's vasodilating properties, which in turn is the first step in the spread or progression of cardiovascular diseases (1). Although the mechanisms of obesity and endothelial dysfunction are not well defined yet, studies on obese populations have pointed to the effective role of vascular pro-inflammatory factors and oxidative stress on endothelial dysfunction under these conditions. Studies on laboratory mice made obese by a high-fat diet have revealed that endothelial dysfunction occurs in response to a decrease in the capacity of the antioxidant system and an increase in the activity of NF-kB-dependent inflammatory pathways (2). Human and animal studies have revealed that obesity is related to oxidative stress and its agents in the heart muscle and blood vessels (3,4). On the other hand, a decrease in total antioxidant capacity (TAC) has been reported in the presence of obesity and metabolic syndrome (5). As an anti-oxidative stress indicator, its levels have been reported to be inversely and significantly related to glucose levels and cardiovascular risk factors in metabolic syndrome patients (6). On the other hand, clinical studies have also reported homocysteine as one of the cardiovascular risk factors and supported it as an indicator of heart attack. In such a way that the increase in its serum levels, especially in the presence of obesity, is associated with an increase in the incidence of heart diseases such as coronary artery disease and arteriosclerosis (7,8). Homocysteine, as one of the amino acids in blood, is obtained from the demethylation of methionine, which is known as a homologue of cysteine. Its high level is associated with heart

attack and arteriosclerosis, and it is considered a risk factor for coronary and peripheral vascular disease, and due to damage to the inner wall of the arteries, interference in blood clotting pathways and oxidation of lipoproteins, it leads to arteriosclerosis (9).

Apart from homocysteine and total antioxidant capacity or other antioxidant enzymes, clinical studies have also supported nitric oxide as one of the indicators of cardiovascular and vascular endothelial function. Nitric oxide is one of the 10 small molecules in nature with a molecular weight of 30 kilodaltons, which is mainly synthesized by the vascular endothelium under the action of nitric oxide synthetase enzyme on L-arginine and has a key role in maintaining the health of the vascular wall and vascular endothelial function (10,11).

Based on this evidence, researchers of health and wellness sciences are always trying to create solutions to improve the levels of these components, especially in obese populations and related diseases. In this context, the role of exercise training, along with the modification of the nutritional pattern, especially in healthy and sick obese populations, is considered one of the most important options. Thus, in the study of Ficicilar et al (2006), 30 minutes of running on a treadmill for 3 consecutive days led to an increase in TAC and a reduction in oxidative stress (12). Nevertheless, in the study of Azizbeigi et al (2013), 8 weeks of incremental resistance training was associated with a significant increase in superoxidase dismutase (SOD), but did not lead to a significant change in TAC and glutathione peroxidase (GPx) (13). In the study of Eizadi et al (2020), 8 weeks TRX led to an increase in GPx activity and no change in H2O2 in obese women (14).

On the other hand, many researchers have reported a decrease in homocysteine and others have reported no change in response to aerobic training (15,16). Shing et al (2024) also pointed out in their review study that regular exercise leads to a reduction in nitric oxide and improvement of endothelial function in inactive women. (17). The review of the findings somehow pointed to the paradox of response or compatibility of these markers of vascular endothelial function in response to exercise training. On the other hand, studies in this field on obese women are less reported. Therefore, the present study was conducted with the aim of determining the effect of aerobic training on these markers of vascular endothelial function in inactive adult obese women.

2. Materials and Methods

The statistical population of this semi-experimental study with a pre- and post-test design along with the control group consists of sedentary obese adult women ($36 \geq BMI \geq 30$) in the age range of 30 to 40 years. The study sample includes 28 sedentary obese adult women who, after confirming the inclusion criteria, were randomly divided into two aerobic groups (8 weeks of aerobic training, n = 12) and control (no training, n = 12). All the subjects were informed by the presenters about the objectives of the study and possible injuries caused by sports exercises, then they completed and confirmed the consent form.

Inclusion and exclusion criteria: The study subjects were non-athletes and non-smokers. Also, their weight fluctuation in the last 6 months was less than one kilogram and they did not have a defined diet. The studied women were not pregnant and did not intend to become pregnant during the study. The absence of history of chronic diseases such as diabetes, cardiovascular, respiratory and kidney diseases, epilepsy, convulsions, as well as any orthopedic abnormality that makes it difficult to perform sports activities are among the criteria for entering the study. Lack of proper attendance at training sessions, suffering from metabolic diseases, use of pharmaceutical or food supplements to reduce weight or increase physical performance during the study, as well as supplements that disrupt metabolism are among the exclusion criteria.

Anthropometric measurements: Before and after exercise, anthropometric indices were measured in both groups. Weight and height were measured without shoes and with minimal covering. So that people's height was measured using a wall-mounted caliper with an accuracy of 0.1 cm. Weight and body fat percentage were measured by a body composition analyzer (OMRON, Finland). Body mass index was calculated by dividing weight (kilograms) by height (square meters). Abdominal circumference was measured after a normal exhalation in the thickest area by an inflexible tape measure with

an error accuracy of less than 0.1 cm

Aerobic training protocol: The aerobic exercise group performed aerobic exercise every other day for 8 weeks in the form of running on a flat surface with an intensity of 50-70% of the maximum heart rate for 30-40 minutes. Each training session consists of 10 minutes of warm-up, main exercise and 10 minutes of cool-down. The main training starts for 30 minutes and with an intensity of 50-55% of the maximum heart rate in the first and second week, and with an increase of 5% in the intensity of the training every two weeks and an increase of 2-4 minutes in the training time every 2 weeks, to the intensity reaches 65 to 70% of the maximum heart rate and duration of 40 minutes in the last 2 weeks.

Table 1: Distribution of exercise intensity while running during the training program

weeks	Exercise intensity (%HRmax)	Time of running
First and second	%50 ≤ intensity ≤ %55	3 × 7.5 minute
Third and fourth	%55 ≤ intensity ≤ %60	4 × 8 minute
Fifth and Sixth	%60 ≤ intensity ≤ %65	4 × 9 minute
Seventh and eighth	%65 ≤ intensity ≤ %70	4 × 10 minute

Blood sampling and laboratory analyses: Before starting the exercises and also 48 hours after the last exercise session, fasting blood sampling was done from the brachial vein with the aim of measuring homocysteine, NO and TAC. All blood samples were centrifuged immediately after sampling to separate the serum and frozen at minus 80 degrees until the time of measurement. Total antioxidant capacity and nitric oxide were measured by calorimetric method using specialized kit of Nonad Salamat Company (Iran). Serum homocysteine was also measured using the specialized kit of Zelbio (Germany) by ELISA method.

Statistical methods: SPSS version 22 statistical software was used for statistical analysis. Kolmogorov-Smirnov test was used to ensure the normal distribution of the data. Independent t-test was used to compare data in pre-test between two groups. The Paired t-test was used to determine intragroup changes in each group. The significance level of the tests was considered as $p < 0.05$.

3. Results

Table 2 shows the mean and standard deviation of each anthropometric index. At the basic level (pre-test), no significant difference was observed between the two groups in any of the anthropometric indices ($p > 0.05$). On the other hand, when the intra-group changes of each variable in each group were determined by the paired t-test, the findings revealed that aerobic training lead to a significant reduction in body weight, body mass index, abdominal circumference and body fat percentage ($p < 0.05$). But in the control group, there was no significant difference between the pre-test and post-test of any of these indicators ($p > 0.05$).

Table 2: Pre and post-training of anthropometric indexes in the studied groups

Variables	Exercise group		Control group	
	Pre-training	Post-training	Pre-training	Post-training
Weight (kg)	81.4 ± 5.10	77.45 ± 7.14 ***	85 ± 3.95	85.2 ± 4.37
AC (cm)	114.5 ± 4.95	109.92 ± 4.30 ***	115.8 ± 5.26	115.7 ± 5.03
Body fat (%)	42.12 ± 1.55	38.05 ± 1.73 ***	42.67 ± 1.42	42.66 ± 1.37
BMI (kg/m2)	32.03 ± 1.54	30.45 ± 2.38 ***	33.19 ± 3.93	33.27 ± 3.89

AC, abdominal circumference; BMI: body mass index
*** p<0.001 compared to Pre-training group

It was already mentioned that the effect of aerobic training on serum homocysteine, NO and TAC is one of the main objectives of the study. Table 3 shows the mean and standard deviation of these variables in the form of pre- and post-test for both groups. Based on the findings of the independent t-test, in the pre-test conditions, there was no significant difference in the level of all 3 variables between the studied groups ($p > 0.05$). Nevertheless, when the intra-group changes of each variable in each group were compared by the paired t-test, the findings showed a significant decrease in homocysteine and a significant increase in NO and TAC by aerobic training compared to the pre-test in the aerobic group ($p < 0.05$). But these variables did not change significantly in the control group ($p > 0.05$).

Table 3: Pre and post-training of clinical markers of 2 groups

Variables	Exercise group		Control group	
	Pre-training	Post-training	Pre-training	Post-training
NO (µM)	33.03 ± 9.76	34.77 ± 2.13 ***	32.98 ± 2.20	31.64 ± 2.32
TAC (U/mL)	1.473 ± 0.245	1.868 ± 0.278 ***	1.601 ± 0.253	1.494 ± 0.245
Homocysteine (µmol/L)	26.40 ± 9.76	19.90 ± 5.53 ***	23.21 ± 8.24	26.53 ± 3.97

NO, Nitric oxide; TAC: Total antioxidant capacity
*** p<0.001 compared to Pre-training group

4. Discussion

Based on the statistical results, the improvement of each of the markers of vascular endothelial function is one of the main findings of the present study. Thus, 8 weeks of aerobic training every other day led to a significant increase in serum NO and TAC and a decrease in homocysteine in obese women who previously had a sedentary lifestyle. These findings are reported while none of the mentioned indicators changed in the control group that did not participate in the exercise program. Regarding these variables, many studies have been reported so far, which of course have reported contradictory findings.

For example, Nouri et al (2017) reported an increase in NO after 8 weeks of interval and continuous training in obese boys (18). Farahti et al (2012), have mentioned the increase of NO and FMD as indicators of vascular endothelial function following 8 weeks of aerobic training in postmenopausal women(17). On the other hand, Hejazi et al (2014) have pointed to an increase in TAC and a decrease in MDA following 12 weeks of aerobic training in obese women (19). Etamed et al (2016) also mentioned a significant decrease in serum homocysteine in response to 8 weeks of resistance training (20).

Nevertheless, in study by Ghardashi (2016), 10 weeks of interval training was not associated with a change in serum NO in type 2 diabetic patients (21). Usefpor et al (2018) have pointed out that the TAC and MDA of the liver tissue of rats did not change in response to 8 weeks of interval training (22). In Azizbeigi et al.'s study (2013), 8 weeks of progressive resistance training led to an increase in SOD activity and a decrease in MDA in non-athletic men, but no change in GPx activity was observed (13). In the study of Subasi et al (2012), although 3 months of aerobic and resistance training were associated with improvement of body composition in postmenopausal women, homocysteine levels and lipid profile did not change significantly (23).

The effectiveness of aerobic exercise on endothelial function and antioxidant capacity is reported in the present study, while Harvey et al have mentioned the effective role of exercise as an alternative to hormone therapy for the treatment of vascular endothelial function in women (24). This hypothesis is proposed that the increase in blood flow in the vascular channels in response to the increase in pulse pressure and heart rate during exercise by stimulating the activity of nitric oxide synthase acts as a kind of physiological stimulus in the synthesis of NO (25). On the other hand, researchers believe that exercise improves vascular endothelial function by reducing the levels of reactive oxygen species (26,27).

Laboratory studies have also revealed that muscle hypoxia caused by exercise increases the expression and levels of VEGF through angiogenesis and the mobilization of endothelial nitric oxide synthase phosphorylation, leading to an increase in the synthesis and release of NO (26,27). Isko et al. (2002) have also pointed out, citing their laboratory evidence, that the stimulation of heat shock protein 90 in response to exercise training leads to an increase in NO and improvement of vascular endothelial function by increasing the activity of nitric oxide synthase (28). Based on laboratory evidence, sports training probably leads to a decrease in homocysteine synthesis due to processes such as the absorption of vitamins effective in the homocysteine cycle, especially vitamin B, the inhibition of oxidative stress and the increase of effective antioxidant components in homocysteine synthesis pathways, as well as the reduction of methionine due to the catabolism of amino acids.

Clinical studies have revealed that homocysteine acts as a kind of stimulator of mitochondrial biosynthesis of reactive oxygen species. On the other hand, the reduction of oxidative stress caused by antioxidant components leads to the reduction of the harmful

effects of homocysteine in blood vessels (29). In this regard, a negative relationship between homocysteine and vitamin C has been reported as one of the non-enzymatic antioxidants (30). Based on this evidence, the decrease in homocysteine levels in response to aerobic exercise in the present study can be attributed to the increase in TAC in the obese women studied.

5. Conclusion

In summary, the findings of the present study support the antioxidant and endothelial effects of aerobic exercise in obese adult women and indicate that this exercise method improves homocysteine, NO, and TAC levels in obesity. Nevertheless, understanding the mechanisms responsible for these changes highlights the need for more cellular-molecular studies in this field.

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Authors' contributions

All authors equally contributed to preparing this article.

Conflict of interest

The authors declared no conflict of interest.

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