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The Effect of a Ten-Week Aerobic Training on Atherogenic Indices, Lipid Profile, and Body Composition in Postmenopausal Women with Type II Diabetes

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Abstract

Background: Atherogenic indices are among risk factors of diabetes which can cause cardiovascular diseases. The purpose of this study was to examine the effect of a 10-week aerobic training on atherogenic indices, lipid profile, and body composition in women with type II diabetes.

Methods: In this quasi-experimental study, 40 postmenopausal women with type II diabetes (aged 40 to 60 years) were selected using convenience sampling method and were randomly assigned to experimental (n = 20) and control (n = 20) groups. The exercise protocol included a 10-week aerobic training [aerobic exercise and walking for 3d/wk, 45 to 60 min/d with 45 to 60% heart rate reserve (HRR)]. The atherogenic indices of non-HDL cholesterol (non-HDL-c), atherogenic index of plasma (AIP), low-density lipoprotein cholesterol to high-density lipoprotein ratio (LDL-c/HDL-c ratio), total cholesterol to high-density lipoprotein ratio (TC/HDL-c), lipid product index (LPA), lipid profile, and body composition were measured before and after the intervention. The obtained data were analyzed using t-test. The statistical significance criterion was set at $P < 0.05$.

Results: The results showed that the levels of TG, LDL-c/HDL-c, and TC/HDL-c significantly decreased as a result of the intervention. However, the changes of LPA, AIP, HDL-c, LDL-c, TC, non-HDL-c, and body composition indices were not significant.

Conclusions: Considering the results of the current study, it seems that aerobic exercise and walking with appropriate volume and intensity can affect atherogenic indices, lipid profile, and body composition in diabetic patients and can reduce the risk of cardiovascular diseases, especially atherosclerosis, among these patients. Further studies are needed to achieve more accurate results.

Keywords: Aerobics and Walking, Atherogenic Indices, Lipid Profile, Body Composition, Type II Diabetes, Women

1. Background

Type II diabetes is among metabolic diseases associated with absolute or relative insulin deficiency, increased blood glucose, and impaired metabolism of carbohydrate, fat, and protein (1). Studies have shown that from 2005 to 2011, nearly 6.8% of the world population had suffered from diabetes (2). In Iran, the latest findings have indicated that 7.7% of the general population aged 25 to 64 years (comprising about 2 million people) suffer from diabetes and 16.8% of these people suffer from impaired glucose tolerance (3).

Cardiovascular diseases are the most important cause of morbidity and mortality in diabetic patients (2, 3). The prevalence of cardiovascular diseases in patients with type II diabetes is 2 to 4 times higher than that in non-diabetic people.

In addition, dyslipidemia is one of the most prevalent disorders among patients with type II diabetes leading to the emergence and intensification of its short-term and long-term complications (4). An increase in the levels of triglyceride (TG), total cholesterol, and LDL along with a decrease in HDL levels are the most common lipid disorders associated with this disease that increase the prevalence of cardiovascular diseases, especially atherosclerosis, in these patients (5, 6).

In relation to atherogenic lipid indices, recent studies have demonstrated that non-HDL-c, which can be easily calculated from lipid profile (TC minus HDL-c), is a significant indicator for diagnosing cardiovascular diseases, particularly in diabetic patients (7, 8). Compared to LDL, non-HDL-c is a more reliable indicator for predicting cardiovascular diseases since it includes all atherogenic lipids [very low density lipoprotein (VLDL), LDL, Intermediate density lipoprotein (IDL), and Lipoprotein(a) (LPa)] (9). A number of indices, including TC/HDL-c, LDL-c/HDL-c, and LAP (an indicator for determining the accumulation of excessive body fat in adults) and API (a new index for predicting the risk of cardiovascular diseases), has recently attracted much attention (10).

Changes in the number of factors such as body composition indices and lipid profiles, especially atherogenic indices, as a result of physical activity can be good clues aiding people to realize the beneficial effects of physical activity for patients with type II diabetes (11). Regular physical activity improves lipid and glucose metabolism by increasing insulin sensitivity and HDL-c and decreasing TG and LDL-c. It is often acknowledged that long-term exercise training can improve the body's response to insulin by elevating the entry of glucose into muscle cells and insulin receptor substrates through increasing glucose transporters (GLUT4) as well as by enhancing muscle mass. Moreover, long-term exercise training can enhance insulin sensitivity and prevent obesity and its subsequent complications including type II diabetes (12).

Moreover, several previously conducted studies have revealed that regular physical activity can result in 5 to 10% reduction in LDL that consequently can increase HDL by 3 to 6% (8). Examining the effects of endurance or resistance training on key health indicators including weight, body fat percentage (PBF), and atherogenic and lipid profiles in different studies has led to the publication of various results (11, 13-15). Additionally, the effects of training, especially aerobic exercise accompanied with joy and fun on atherogenic indices, particularly non-HDL-c, LAP, and API, have not been evaluated. Therefore, given the importance of physical activity in controlling body composition and lipid profile and reducing the risk of suffering from metabolic syndrome, especially cardiovascular diseases, in diabetic patients, the current study aimed to examine the effect of a 10-week aerobic training on atherogenic indices, particularly non-HDL-c, LAP, and API indices, lipid profile, and body composition in postmenopausal women with type II diabetes.

2. Methods

This was a clinical quasi-experimental study. The statistical population of the study included all patients with type II diabetes in AjabShir county. Among these patients, 40 postmenopausal women with type II diabetes were selected based on the criteria proposed by the American Diabetes Association (ADA) (16). The subjects were in the age range of 40 to 60 years and their disease was diagnosed in the past 10 years. To control the disease, metformin was administered to these patients. The subjects had not participated in any regular physical activity programs in the past year. Consumption of abusing drugs, dealing with complications of diabetes or other chronic diseases, receiving insulin, receiving drugs affecting bone metabolism, and using any type of nutritional supplements were the exclusion criteria of the study. After confirming the research design in the ethics committee of Tabriz University of Medical Sciences under the code IR.TBZMED.REC.1395.741, obtaining the written consent from the subjects, and briefing the main objectives of the study, the subjects were randomly assigned to aerobic training (n = 20) and control (n = 20) groups. While the aerobic training group took part in a 10-week progressive aerobic training, the subjects assigned to the control group continued their normal lives. Before carrying out the aerobic training, some anthropometric and physiological indices of the subjects, including height and weight, body mass index (BMI), waist-hip ratio or waist-to-hip ratio (WHR), and PBF [(examined by a Caliper (Yagami, Japan, with an accuracy of 0.2 mm) and by using the Jackson and Pollock three-site equation (17)] were measured. Furthermore, the subjects' maximum oxygen consumption was examined using the one-mile walk test (Rockport's test) and the related formula (17).

2.1. Aerobic Training Program

The exercise training protocol included a 10-week aerobic training (aerobic exercise and walking for 3d/wk, 45 to 60 min/d with 45 to 60% HRR). This exercise training was designed based on the recommendations provided by the American College of Sports Medicine (ACSM); it was a progressive training in which the volume and intensity increased gradually. The subjects' heartbeat was monitored using the Polar heart rate monitor ((Polar Electro, Kempele, Finland)).

Each session contained the following sections: warm-up (including 10 minutes of walking, stretching, and jogging), main part, including 15 to 20 minutes of walking and 20 to 25 minutes of performing aerobic exercise (both with intensity of 45 to 60% HRR), and cool-down (including 5 minutes of walking and stretching to achieve the normal heart rate). The aerobic exercise was accompanied with rhythmic music and it included aerobic blocks (each block contained several exercises such as marching in a place, V-step, step, step-touch, reverse V-step, diagonal, and the like and each of these exercises was repeated 9 times) and floor exercises (including a wide range of sit-ups and plank and different types of stretching, flexibility, and two-person moves).

2.2. Measurement of Blood Parameters

To measure blood parameters, the blood samples (10 mL) were taken in two steps from the vein in the subjects' arms while they were seated. The first step was conducted a day before initiating the aerobic training (pretest) and the second step administered 48 hours after the last training session held in the 10th week of training. All the blood samples were taken after 10 to 12 hours of fasting. Afterwards, by centrifugation at 15,000 - 30,000 rpm, the serum was separated and frozen at -80°C for subsequent analyses.

TC levels were measured by the enzymatic photometric method (Pars Azmoon Co, Iran), TG levels were evaluated by the enzymatic calorimetric method (Pars Azmoon Co, Iran), and HDL levels were examined by the enzymatic calorimetric method (Pars Azmoon Co, Iran). LDL levels of the sera were calculated using the Friedewald et al. equation (12). This equation is as follows:

LDL = TC-HDL-TG/0.5

The levels of non-HDL were obtained through applying the following formula: non-HDL=TC-HDL (12). To measure the lipid accumulation production and AIP, the following formulas were applied (18).

LAP = [concentration of TG (mmol/L)] × [58-Waist circumference (cm)]

AIP = Log TG/HDL

2.3. Statistical Methods

To analyze the obtained data and to compare the results between the groups, after confirming the normal distribution of the data through applying Kolmogorov-Smirnov test (KS), the paired t-test and independent t-test were used. All the results were presented as mean ± standard deviation; all the calculations were carried out in SPSS software, version 20 (SPSS Inc., Chicago, IL, USA). The statistical significance criterion was set at $P \leq 0.05$.

3. Results

The results of paired t-test indicated that there were no significant differences between the mean values of the control group obtained from the pretest and posttest; however, there were significant differences between the mean values of the experimental group on body weight, PBF, BMI, WHR, AIP, LAP, TG, TC, LDL-c, HDL-c, and LDL-c/HDL-c ratio obtained from the pretest and posttest ($P < 0.05$) (Table 1).

Moreover, the results of independent t-test showed that after 10 weeks of performing aerobic exercise, only the levels of TG, LDL-c/HDL-c, and TC/HDL-c decreased ($P < 0.05$) and the changes in other variables were not significant ($P > 0.05$) (Table 2).

4. Discussion

The results of the current study demonstrated that by comparing the mean values of the experimental group in the pretest with those obtained from the posttest (the paired t-test), some significant changes were observed in the mean values of these subjects on most of the variables under study as a result of the aerobic training. However, these changes, compared to the control group (the independent t-test), were only significant in terms of TG, TC/HDL-c, and LDL-c/HDL-c. Considering the other variables under study, the changes were not significant. It seems that normal levels of lipid profiles, especially TC, TG, and LDL-c, among the subjects under study were the main reasons for these insignificant changes particularly in atherogenic indices. The results of some studies have shown that the higher the primary levels of blood lipid profiles, the greater the changes due to exercise (19, 20). Additionally, training volume and intensity and number of training sessions per week are among the factors affecting the outcome. Since the training volume and training intensity were selected based on the subjects' conditions and according to the recommendations provided by ACSM, it seems that the volume and intensity of aerobic exercise and walking were not enough. Although the within-group comparison indicated some positive effects of the aerobic training on the variables under study, these effects were not significant compared to the control group. It seems that through increasing the number of training sessions per week, this training can lead to better results compared to what was achieved from this study. According to William (2002) and Shearman et al. (2010), exercise performed with high volume and high intensity, especially with high volume, highly affects blood lipid profiles and body composition indices (19, 20).

In the current study, after 10 weeks of aerobic exercise and walking, no significant changes were observed in the levels of TC, LDL-c, and HDL-c; however, the levels of TG, LDL-c/HDL-c ratio, and TC/HDL-c significantly decreased. These results are consistent with the results of some previous studies (21, 22) and they are not in line with the results of some other studies (13-15). Some researchers have stated that enhancement of blood TG in response to exercise with a moderate intensity can be considered as a natural pattern of responding to blood lipids during puberty (13). However, it seems that normal lipid levels before the training could moderate the effects of exercise. The best improvement created as a result of the training in lipid profiles was observed in people who had high lipid levels (10). Nevertheless, other studies attributed these contradicting results related to lipid and blood profiles to differences in diet, training program, and subjects' status. One of the main reasons for the significant reductions in TG, LDL-c/HDL-c, and TC/HDL-c was probably improving the mechanism of fatty acids and cholesterol uptake in muscle tissues occurred as a result of the exercise (23).

Years ago, physical education and sports medicine specialists forbade doing exercise after dealing with the dis-

Table 1. The Results of Paired T-Test Conducted Before and After the Intervention in the Groups Under Study[a]

Variables	Control Group (n = 20)		P Value	Experimental Group (n = 20)		P Value
	Pretest	Posttest		Pretest	Posttest	
Age, y	53.40 ± 3.67	-	51.95 ± 6.12	-		
Height, cm	156.95 ± 4.44	-	156.95 ± 6.86	-		
Weight, kg	79.95 ± 5.78	79.99 ± 6.06	0.81	76.80 ± 8.01	74.2 ± 8.19	0.001[b]
PBF	46.39 ± 3.67	36.37 ± 3.93	0.89	44.25 ± 4.05	32.94 ± 3.74	0.002[b]
BMI, kg/m^2	32.46 ± 2.57	32.45 ± 2.95	0.89	31.31 ± 3.32	30.21 ± 3.03	0.001[b]
WHR	0.93 ± 0.05	0.93 ± 0.02	0.24	0.92 ± 0.04	0.9 ± 0.05	0.038[b]
AIP	.03 ± 0.005	0.03 ± 0.011	0.06	0.03 ± 0.008	0.04 ± 0.017	0.037[b]
LAP	6392.9 ± 536.45	6324.6 ± 361.0	0.9	6972.3 ± 456.6	5775.5 ± 362.57	0.02[b]
TC/HDL-c	2.40 ± 0.74	2.51 ± 0.37	0.689	2.76 ± 0.87	3.22 ± 0.70	0.026[b]
LDL-c/HDL-c	1.35 ± 0.66	1.58 ± 0.87	0.18	2.16 ± 0.75	2.75 ± 0.87	0.04[b]
HDL-c, mg/dL	54.10 ± 10.94	52.25 ± 15.11	0.59	43.45 ± 11.24	49.15 ± 12.54	0.043[b]
LDL-c, mg/dL	155.59 ± 36.00	147.9 ± 46.35	0.33	118.75 ± 30.9	v102.7 ± 24.94	0.001[b]
TC, mg/dL	173.40 ± 38.79	163.3 ± 23.90	.66	184.55 ± 42.0	148.85 ± 25.42	0.007[b]
TG, mg/dL	144.75 ± 30.95	136.7 ± 34.66	0.86	39.05 ± 30.8	120.55 ± 18.34	0.005[b]
Non-HDL-c, mg/dL	97.30 ± 44.06	100.94 ± 24.5	v0.78	120.70 ± 43.7	108.99 ± 27.1	0.45

[a] Values are expressed as mean ± standard deviation.
[b] Indicates the significance of the results obtained from the posttest compared to those obtained from the pretest. The level of significance was set at $P < 0.05$.

Table 2. The Results of Independent T-Test Conducted Before and After the Intervention in the Groups Under Study[a]

Variables	Pretest		P Value	Posttest		P Value
	Control Group (n = 20)	Experimental Group (n = 20)		Control Group (n = 20)	Experimental Group (n = 20)	
Age, y	76.80 ± 8.01	79.95 ± 10.28	0.24	79.99 ± 6.06	74.2 ± 8.19	0.38
Height, cm	44.25 ± 4.04	46.39 ± 3.67	0.21	36.37 ± 3.93	32.94 ± 3.74	0.42
Weight, kg	31.31 ± 3.32	32.46 ± 2.57	0.20	32.45 ± 2.95	30.21 ± 3.03	0.38
PBF	0.92 ± 0.04	0.93 ± 0.05	0.91	0.93 ± 0.05	0.9 ± 0.05	0.49
BMI, kg/m^2	0.03 ± 0.005	0.03 ± 0.008	0.76	0.03 ± 0.011	0.04 ± 0.01	0.477
WHR	6392.9 ± 456.4	6972.3 ± 536.4	0.971	6324.6 ± 361.0	5775.5 ± 362.5	0.297
AIP	2.40 ± 0.74	2.76 ± 0.87	0.84	2.51 ± 0.37	3.22 ± 0.70	0.01[b]
LAP	1.35 ± 0.66	2.16 ± 0.75	0.898	1.58 ± 0.87	2.75 ± 0.87	0.008[b]
TC/HDL-c	48.45 ± 11.24	49.15 ± 12.54	0.43	52.25 ± 15.11	54.10 ± 10.94	0.33
LDL-c/HDL-c	118.7 ± 30.9	155.59 ± 36.00	0.42	147.94 ± 46.35	102.7 ± 24.94	0.42
HDL-c, (mg/dL	184.7 ± 42.0	173.40 ± 38.79	0.78	163.3 ± 23.90	148.85 ± 25.42	0.8
LDL-c, (mg/dL	139.0 ± 30.8	144.75 ± 30.95	0.991	136.7 ± 34.66	120.55 ± 18.34	0.002[b]
TC, mg/dL	97.30 ± 44.06	120.0 ± 43.72	0.83	100.94 ± 24.54	108.99 ± 27.14	.496

[a] Values are expressed as mean ± standard deviation.
[b] Indicates the significance of the difference between the mean values of the control group and experimental group in the pretest and posttest. The level of significance was set at $P < 0.05$.

ease of obesity; however, nowadays, they have found that regular physical activity after dealing with the disease of obesity causes the heart muscle to function normally. Therefore, these specialists considered exercise as the least expensive and the best way to prevent heart diseases (20). In the present study, no significant changes were observed in the levels of HDL-c. Since a major part of HDL-c is constituted of protein, a reduction in the protein synthesis probably made the levels of this lipoprotein remain stable. For this reason, it seems that since women have moderate aerobic capacity, they cannot increase the intensity and duration of exercise in a way that exercise can affect their HDL-c levels. Additionally, most researchers believe that exercise threshold needs to increase the effect of exercise on HDL-c. Moreover, the primary level of HDL-c determines the effects of exercise. In this regard, the differences among the results obtained from various studies conducted to examine blood lipid indices are due to the type, intensity, and duration of the exercise performed and the gender of the subjects under study. In addition, the observed positive changes in blood lipid levels occurred as a result of body composition and consequently, physical activity. To indicate positive effects, both aerobic and resistance exercises should be performed for more than 8 weeks (24).

Another finding of this study was that although the level of non-HDL-c decreased, this reduction was not significant. According to the guidelines of national counselor examination (NCE) provided by the University of Iowa, below 130 mg/dL is considered as an ideal level of non-HDL-c, 130 - 159 mg/dL is regarded as borderline high, 160 - 189 mg/dL is considered high, and above 190 mg/dL is considered very high (23).

Recently carried out studies have revealed that non-HDL-c is a good indicator for predicting cardiovascular diseases and causes of death in adults. Evidence has suggested that there is an association between non-HDL-c and atherosclerosis even in young people (25, 26). As an instance, the results of a study, which was lasted for 10 years focusing more on reducing the level of non-HDL-c rather than decreasing the level of LDL-c, indicated that a non-HDL-c strategy would prevent 300,000 events of cardiovascular diseases (27). Accordingly, high levels of non-HDL-c in patients, particularly diabetic patients, can be used as an important marker for predicting cardiovascular diseases (25, 26).

In addition, the level of non-HDL-c of the subjects in the experimental group was 120.0 ± 43.72 in basal condition. This decreased to 108.99 ± 27.14 after the training intervention. One of the main reasons for the lack of a significant change in non-HDL-c was that no significant changes were observed in HDL-c and TC levels after the training intervention. Enhancing the activity of the enzyme lipoprotein lipase is mentioned as the most important mechanism in consuming and decreasing lipoproteins (23).

Among other findings of this study, the insignificant changes in lipid accumulation production LAP and API after the intervention can be mentioned. Until now, no specific studies have been conducted to determine factors contributing to cardiovascular diseases. Examining the results of the present study showed that to have significant changes in these two variables, like other atherogenic indices, it is necessary for the aerobic training to have sufficient volume and intensity. Further studies need to be carried out to achieve more accurate results.

In this study, although significant reductions in some anthropometric indices, including weight, PBF, and WHR, were observed within the experimental group, these changes were not significant compared to the control group. While these findings are not in line with the results of some previously conducted studies (28, 29), they are consistent with the results of some other studies (10, 11). It was mentioned that regular physical activity leads to some changes in the amount and flow rate of energy in the body that is effective in reducing body weight and preventing obesity. Moreover, it was also indicated that when performing aerobic exercise, the glands of the endocrine system increase the amount of lipids by increasing the levels of epinephrine, norepinephrine, growth hormone, and cortisol oxidation. By enhancing the recruitment and use of free fatty acids, the need for energy is provided; thus, this leads to a reduction in the amount of body fat mass (29). Therefore, it seems that in addition to increasing energy consumption and enhancing fat oxidation, the intracellular changes of muscles and capillary network are effective (10). Accordingly, it seems that the volume and intensity of the aerobic training carried out in the current study were not enough to bring about significant changes in anthropometric indices.

4.1. Conclusions

Considering the results of the current study, it seems that performing aerobic exercise along with walking with appropriate volume and intensity can affect atherogenic indices, lipid profile, and body composition in diabetic patients and can reduce the risk of cardiovascular diseases, especially atherosclerosis, among these patients.

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