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Investigating the effect of 12 weeks of aerobic exercise on fasting glucose and several serum indicators of cardiovascular disease in women with type 2 diabetes

Shahab Roozbahani[1]
Department of Physical Education, Islamic Azad University, Borujerd Branch, Borujerd, Iran

Yaghob Changizi
Department of Physical Education, Islamic Azad University, Borujerd Branch, Borujerd, Iran

Mohammad Ahadiyan
Department of Physical Education, Islamic Azad University, Borujerd Branch, Borujerd, Iran

Nastaran Zarezade
Department of Physical Education, Islamic Azad University, Borujerd Branch, Borujerd, Iran

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Abstract

Purpose: Type 2 diabetes is one of the most important metabolic disorders that different societies are facing with increasing prevalence. Aerobic exercises are a common type of exercise that reduces the levels of triglycerides and low-density lipoproteins and regulates blood pressure. The purpose of the research is to investigate the effect of 12 weeks of aerobic exercise on fasting glucose and several serum indicators of cardiovascular disease, in women with type 2 diabetes. **Methods:** In 2023, 20 women who referred to the Hamadan Diabetes Association voluntarily participated as subjects in this research and were randomly assigned to aerobic (10 people) and control (10 people) groups. The exercise program of the aerobic group included 3 running sessions per week with an intensity of 60-70% of the maximum heart rate for 12 weeks. In order to measure fasting blood glucose, glycosylated hemoglobin (HbA1c) and lipid profile [low-density lipoprotein (LDL-c), triglycerides (TG), High-density lipoprotein (HDL-c)], blood sampling was done before and after 12 weeks of exercise program. SPSS software and Kologrov Smirnov and Student's t test were used to check and analyze the data. **Results:** The results indicated that after 12 weeks of aerobic exercise, HbA1c (P=0/027), LDL-c (P=0/012) and fasting blood glucose (P=0/043) decreased significantly in the aerobic group. But no significant changes were observed in HDL-c and BMI. **Conclusion:** The

[*]**Author's e-mail:** shahab1roozbahani@gmail.com **(Corresponding Author)**; yaghobchangizi810@gmail.com, mohammad.ahadiyan@yahoo.com, n.zarezade123456@gmail.com

results of this research showed that performing aerobic exercises leads to a decrease in HbA1c, fasting blood glucose and improvement in lipid profile, so it can probably be a useful way of treatment and prevention of cardiovascular diseases in type 2 diabetic patients.

***Keywords*:** cardiovascular disease, diabetes, aerobic exercise, HbA1c

Introduction

Type 2 diabetes is the most common type of diabetes and includes about 90-95% of all types of diabetes (Kaur, Kaur, & Singh, 2018). Type 2 diabetes is associated with increased risk factors for cardiovascular disorders, including obesity, high blood pressure, hyperlipidemia, lack of physical activity, increased fasting blood glucose, and glycosylated hemoglobin (Krist et al., 2020). Cardiovascular disorders in type 2 diabetic patients are about 2 to 4 times more than other people and it is the main cause of death in this category of patients (Einarson, Acs, Ludwig, & Panton, 2018). Some studies have introduced risk factors for the spread of cardiovascular diseases caused by type 2 diabetes, dyslipidemia, increased triglycerides, LDL and HDL (Lorber, 2014). Among the important therapeutic goals in the control of diabetic disease is improving the control of metabolic factors, which includes a series of tests and investigations related to diabetes (Ji et al., 2013). Among the most important of these tests, we can mention the measurement of glycosylated hemoglobin, LDL-c, HDL-c, cholesterol, TG, blood pressure and body composition (Nyangasa et al., 2019). The most common test for grading metabolic control is the measurement of glycosylated hemoglobin and the best therapeutic goal in people with diabetes is the modulation of glycosylated hemoglobin (Sánchez-Domínguez et al., 2015). Reducing the levels of glycosylated hemoglobin A1c has many benefits in reducing cardiovascular complications, according to research conducted in relation to glycosylated hemoglobin, every 1% increase in glycosylated hemoglobin is equal to an 18% increase in the risk of cerebrovascular diseases and each Its reduction is associated with a 37% reduction in the risk of microvascular

complications and a 20% reduction in macrovascular complications (Zhang, Hu, Yuan, & Chen, 2012). The incidence of type 2 diabetes increases with increasing factors such as obesity, dietary changes and reduced physical activity. Sports activity helps in primary and secondary prevention of cardiovascular diseases and prevention of special complications of diabetes (Group, 2016). The goal of most medical centers is to prevent the occurrence of diabetes and cardiovascular risk factors and its treatment, which are caused by obesity and inactivity (Wu, Ding, Tanaka, & Zhang, 2014). Sports activity with weight loss reduces the levels of triglycerides and low-density lipoproteins, eliminates excess body fat, and regulates blood pressure (Herzig et al., 2014). Aerobic exercise is a common type of exercise in the treatment of type 2 diabetics, which improves glycemic control, lipid status, body fat reduction, and fasting blood glucose reduction (Jiang et al., 2020). Exercises cause changes in fat profile and reduce excess body fat by reducing low-density lipoproteins (LDL-c) and increasing high-density lipoproteins (HDL-c) (Gilmore et al., 2013). The American Diabetes Association recommends that type 2 diabetic patients do at least 656 minutes per week of moderate intensity aerobic exercise or 86 minutes per week of vigorous aerobic activity (Padayachee & Coombes, 2015). These exercises improve maximal oxygen consumption by 10% (due to improvement in the system cardiovascular-respiratory) in type 2 diabetic patients and with this amount of change it is expected that the risk of cardiovascular diseases will decrease significantly (Nery et al., 2017). Although many studies have shown the effects of aerobic exercise in this category of Patients have been examined, but the existence of conflicting and heterogeneous results of these studies can be a reason for further investigations (Cai, Li, Zhang, Xu, & Chen, 2017). In the study of Georgiou et al., there was no significant change in HbA1c levels after aerobic exercise on type 2 diabetic subjects (Unsworth et al., 2023). and on the other hand, Kadoglo et al. and Maiorana et al., reported a significant decrease in HbA1c after aerobic exercise (N. P. Kadoglou et al.,

2007; Maiorana, O'Driscoll, Goodman, Taylor, & Green, 2002). Also, some studies showed improvement and others did not observe any significant change in glycemic control and lipid profile (Jafarnejad, Mahboobi, McFarland, Taghizadeh, & Rahimi, 2019). Therefore, considering to the beneficial effects of aerobic exercise on glycemic control factors, glycosylated hemoglobin, cardiovascular risk factors and also the presence of heterogeneous results in connection with aerobic exercise activities on type 2 diabetic subjects, the purpose of this research is to investigate the effect of aerobic exercise activity on blood sugar control and risk factors Cardiovascular in men with type 2 diabetes.

Methods:

In this applied and semi-experimental research, 20 people who referred to the Hamedan Diabetes Association and were suffering from type 2 diabetes were selected voluntarily with the supervision and cooperation of the attending physician and were randomly assigned to two control and exercise groups. In the coordination meeting, the goals and steps of the research were explained and written consent was obtained from the subjects to participate in the research. In order to control the effect of sex hormones on the level of the studied biochemical variables, all subjects were in the follicular phase of the menstrual cycle in the sampling at the beginning and end of the research. Weight and fat percentage were measured using a body composition analyzer (model 3.0 Inbody manufactured by Biospace Korea). Waist circumference and hip circumference were also measured with a tape measure with an accuracy of 0.1 cm. Maximum oxygen consumption was also measured by Cooper's 12-minute test. All subjects were asked not to do heavy physical activity at least 48 hours before the pre-test blood collection. The experimental group started their aerobic exercise program for 12 weeks and 3 sessions per week. This program included 8 minutes of warm-up (in the form of walking and stretching and movement) and 8 minutes of running with an intensity of 60 to 75% of the maximum heart rate in the first session. Every two sessions, one minute was added to the subjects' running time. The last 5 minutes of each session

was for cooling down. The maximum heart rate was obtained from the age-220 formula. No exercise was considered for the control group. 24 hours before the start of the training program and 48 hours after the last training session and following 12 hours of fasting, five milliliters of blood was taken from the brachial vein of the subjects. In order to separate the serum, the blood clots were centrifuged for 10 minutes at a speed of 2000 rpm. Then the resulting serum was kept in a freezer at -80°C until the variables were measured. Serum insulin level was measured using Demeditec laboratory kit made in Germany by ELISA method with a sensitivity of 0.15 micrograms/liter. Insulin resistance with the homeostasis model evaluation method and based on the equation:

HOMA-IR = [fasting glucose (mmol/L) × fasting insulin (mU/L) / 22.5] was calculated.

Descriptive statistics (mean and standard deviation) were used to describe the results of the research. The normality of the data distribution was checked using the Kolmogorov Smirnov test, and according to the normality of the data distribution, the paired and independent t-test and SPSS 26 statistical software were used to analyze the results. The significance level of the tests was considered $P<0.05$.

Results

Descriptive information about the age, height and weight of the subjects is .given in Table 1

Table 1. Anthropometric information of subjects

Variables	mean and standard deviation	
	experimental group	control group
Age (year)	65.36 ± 9.74	66.34 ± 8.76
Height (cm)	155.67 ± 8.36	154.87 ± 7.35
Weight (kg)	71.83 ± 12.76	72.55 ± 10.64
duration of the disease (year)	5.25 ± 2.05	5.45 ± 2.19

The mean and standard deviation of HbA1c (%), age, height, weight, body mass index, blood pressure, LDL-c, HDL-c, subjects are presented in Table 2. At the beginning of the study, there was no significant difference in any of the above indicators between the aerobic exercise and control groups. By examining the findings between the groups, no significant changes were observed in the subjects' body weight and body mass index. Findings within the group showed that HbA1c (%), weight, body mass index, LDL-c, subjects' post-test compared to pre-test in the training group significantly decreased. In the control group, there was no significant change in any of the indicators in the post-test compared to the pre-test. Findings between groups showed that after 12 weeks of insulin resistance training, fasting glucose decreased significantly compared to the control group (Table 2).

Table 2: Changes in blood index levels in the research groups.

Variables	**group**	**steps**	**Mean ± standard deviation**	**P valiu**
HbA1c(%)	control	pre-test	6.03±1.12	0/415
		Post-test	6.67±11.1	
	Exercise	pre-test	7.36±1.6	0/027
		Post-test	7.1±1.48	
fasting blood glucose (mg/dl)	control	pre-test	123.77±42.818	0/458
		Post-test	132.11±44.95	
	Exercise	pre-test	164±63.765	0/043
		Post-test	142.66±52.199	
BMI (kg/m^2)	control	pre-test	29.24±4.91	0/826
		Post-test	29.35±4.69	
	Exercise	pre-test	30.99±4.25	0.139
		Post-test	30.24±4.54	
LDL-c	control	pre-test	89.54±15.68	0/266
		Post-test	90.23±22.69	
	Exercise	pre-test	86.24±14.54	0/012
		Post-test	72.13±24.66	
HDL-c	control	pre-test	56.66±65.28	P=0/501
		Post-test	58/12±65.26	

	Exercise	pre-test Post-test	51.12±64.85 50/62±35/38	P=0/317

The significant level was measured using the analysis of variance test with repeated measurements

Discuss

An important finding of the present study showed that performing 12 weeks of aerobic exercise significantly reduces serum levels of HbA1c, LDL-c and fasting blood glucose. HDL-c and BMI did not change significantly in any of the groups. The results confirm the beneficial effects of exercise for cardiovascular diseases in type 2 diabetic patients.

Exercises increase the uptake of glucose in the body's muscles, and these changes are dependent on functional changes in insulin signals and related to the increase in GLUT-4 protein content (Venojärvi, Lindström, Aunola, Nuutila, & Atalay, 2022). These results were in line with the results of Takmakidis, et al (Tokmakidis, Zois, Volaklis, Kotsa, & Touvra, 2004). and Louisa et al. Takmakidis et al observed a significant decrease in fasting blood glucose and improved insulin sensitivity in type 2 diabetic subjects after 4 and 16 weeks of exercise (Tokmakidis et al., 2004). The results of some studies contradicted the results of this study. Cauza et al (Cauza et al., 2005). did not observe any significant reduction in blood glucose after 4 months of aerobic exercise on type 2 diabetic subjects, and Bilou et al. did not observe any significant reduction in blood glucose after 12 weeks of aerobic exercise (Katz, Yuen, Bijou, & Lejemtel, 1997). In the study by Bello et al., both the intensity and duration (50 to 75% of the maximum heart rate for 30 minutes in each session) of the exercises were relatively low, and maybe this is the reason for the lack of significant change in fasting blood glucose, because the duration and intensity are sufficient Exercise is one of the effective factors in reducing blood glucose (Bello, Owusu-Boakye, Adegoke, & Adjei, 2011).

Another result of this study was that HbA1c decreased significantly in the aerobic group after 12 weeks of aerobic exercise, but no significant change was observed in the control group. These results are in line with the results of the present study, Kadogloul et al. reported a significant decrease in HbA1c levels after 16 weeks of aerobic exercise with an intensity of 50 to 85% of maximum oxygen consumption (N. Kadoglou et al., 2010). Maiorana et al. after 8 weeks of aerobic exercise in type 2 diabetic subjects Improvement in glycosylated hemoglobin levels and lipid profile as a result of aerobic exercise also causes a decrease in inflammatory markers (secreted from adipose tissue) and considering that these inflammatory markers cause insulin resistance, therefore It is associated with a decrease in insulin resistance and reducing HbA1c and lipid profile (Maiorana et al., 2002). These results were also contrary to the results of some studies. Luisa et al. later, from 12 weeks of aerobic exercise training, they did not observe any significant changes in HbA1c and BMI levels, which was not consistent with the results of the above study (van der Heijden et al., 2010). In their research, the subjects had an average age of 30 to 70 years and a BMI of 25 to 40, which can be said to be the reason for the non-homogeneity of these changes in HbA1c levels with the present study.

In the present study, a significant decrease in LDL-c was observed in the aerobic group. In line with the present study, Eberbach et al reported a significant decrease in triglycerides and LDL-c after 4 weeks of aerobic exercise (Chen et al., 2020). An increase in the concentration of LDL-c and a further decrease in HDL-c in this category of patients are among the factors that make diabetics suffer from cardiovascular disorders. LDL-c accumulates more in the walls of blood vessels and causes disorders in cardiovascular activity, while HDL-c causes the transfer of cholesterol from blood vessels to the liver and prevents the accumulation of fats in blood vessels. The mechanism that improves fat metabolism through exercise can usually be caused by changes in the activity of lipase enzymes, such as lipoprotein lipase LPL and hormone-sensitive lipase HL. Contrary to these results, Cauza et al. did not observe any significant changes in

triglycerides and LDL-c after 4 months of aerobic exercise training (vo2max 60% intensity, 3 sessions per week and each session lasting 15 to 30 minutes). This discrepancy can be attributed to The reason may be the age or gender of the subjects (Cauza et al., 2005). Finally, considering the improvement of lipid profile and HbA1c, sports activity can probably be a useful way of treatment and prevention of cardiovascular diseases in type 2 diabetic patients. But significant changes in body composition and BMI seem to require a longer period of time with dietary control.

Conclusion:

In general, from the results obtained from this research, it can be concluded that regular aerobic exercises can play an important role in reducing the risks of cardiovascular diseases and improving the glucose metabolism process due to reducing insulin resistance and increasing glucose metabolism.

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