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Evaluation of the Effect of Eight Weeks of Moderate-Intensity Intermittent and Resistance Exercise on Blood Sugar and Blood Pressure Indices (SBP, DBP) in People with Type 2 Diabetes

Abstract

This research showed that eight weeks of resistance training caused significant changes in serum HBA1C, insulin resistance, cholesterol, TG, HDL, and LDL in type 2 diabetic women. Impaired glycemic balance due to diabetes increases the risk of cardiovascular disease. Exercise can improve glucose metabolism and regulate glycemic homeostasis with various protective factors. This study investigates the effect of eight weeks of moderate-intensity intermittent and resistance exercise on blood glucose indices in people with type 2 diabetes. Thirty diabetic women (51.9 ±5.09 years) volunteered for the study and were randomly divided into three groups (10 people), resistance training, periodic aerobic training, and control. Periodic aerobic exercise with an intensity of 50-75% MHR and resistance exercise with an intensity of 30-75% 1RM was performed for eight weeks and three sessions per week. For data analysis, we used paired t-test and one-way ANOVA at the significance level (p 0.00.05). The results showed that eight weeks of resistance training caused significant changes in serum HBA1C, insulin resistance, cholesterol, TG, HDL, and LDL in type 2 diabetic women.

Keywords: *Diabetes, Intermittent aerobic exercise, Resistance exercise, Insulin resistance*

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Introduction

Type 2 diabetes is characteristically due to insulin resistance and abnormal insulin secretion. According to many studies, insulin resistance occurs first, and then insulin secretion is impaired. But diabetes develops only when insulin secretion is insufficient. Type 2 diabetes is genetic. Of course, not all genes that predispose a person to diabetes have been identified, but in any case, diabetes is a polygenetic and multifactorial disease that, in addition to genetic predisposition, environmental factors (obesity, nutrition, and physical activity) also are relevant. Four pathophysiological disorders characterize type 2 diabetes. (1) Plasma insulin levels in a person with diabetes may be many times higher than normal. Also, fasting blood glucose concentrations in these patients are almost always above 111 mg/dl and often above 141 mg/dl. Diabetics are much more likely than normal people to develop atherosclerosis, atherosclerosis, coronary heart disease, and multiple small vessel lesions, mainly due to high cholesterol levels and other lipids in the blood (2).

The prevalence of type 2 diabetes in men and women is not significantly different. This rate is about 19.7 million people (8.7%) in men and 184.1 million people (8.1%) in women (3). Risk factors for type 2 diabetes include a set of genetic and environmental factors, including having a family history, Gestational diabetes, Obesity (especially abdominal obesity), Sedentary lifestyle and unhealthy diet, Age over 45 years, Glucose intolerance, blood pressure, Hyperlipidemia, Polycystic ovary syndrome, Metabolic syndrome and race (4). Because bodyweight is highly correlated with insulin resistance, insulin sensitivity is expected to improve with weight loss. Diseases such as diabetes and metabolic control are better (5, 6).

The prevalence of lipid disorders in diabetic patients has increased the incidence and mortality due to cardiovascular diseases in these people. Hypertriglyceridemia and low HDL-C levels are more common in diabetic patients than in non-diabetic. Hypertriglyceridemia is more dangerous in people with diabetes than in non-diabetics and has a higher risk of atherosclerotic (7).

High levels of cholesterol, triglycerides, LDL-C, and low levels of HDL-C may be due to obesity, increased calorie intake, and lack of muscle activity in patients with diabetes mellitus. Estimation of fat peroxide and lipid profile in patients with diabetes mellitus is very useful in diagnosing and predicting the condition of these people. Identifying risk factors in the early stages of the disease will also help improve and reduce the mortality rate. Obesity and a high-fat diet have a negative effect on blood lipoproteins (8). According to research, the best way to treat obesity and improve blood lipoproteins is to eat a proper diet along with regular exercise. Visceral fat is highly associated with the risk of developing type 2 diabetes. Therefore, due to the high ability of exercise to reduce visceral fat, it may significantly improve metabolic parameters. However, most people with type 2 diabetes are unable to do the physical activity needed to lose weight and have an optimal fat percentage (9). Studies have suggested that resistance training improves insulin sensitivity in the liver, muscle, and adipose tissue and reduces visceral fat. Some studies have reported that a 3% reduction in body weight resulted in a 31% reduction in insulin resistance (10).

Therefore, it seems that the greatest effect of exercise is on improving insulin output through weight loss. Weight loss by increasing the first phase of insulin secretion can improve insulin resistance and prevent excessive insulin secretion (11). Magalhães et al. in 2019, designed a study aimed at the effect of high and moderate-intensity intermittent and resistance training on the glycemic index and body fat in type 2 diabetic patients. The study results showed that no significant changes in the glycemic index were observed in any of the groups of high-intensity and moderate-intensity intermittent and resistance training. However, a significant decrease in total body fat index and visceral fat was observed in the intermediate and resistance training groups with moderate intensity compared to other groups (12). A systematic review and meta-analysis conducted by Jing Xin Liu et al. in 2019 to compare the effects of high-intensity and moderate-intensity intermittent exercise on glycemic control and cardiorespiratory function in patients with type 2 diabetes were shown in this study. The high-intensity intermittent exercise led to a significant reduction in patients' body mass index, body fat, HbA1C, and fasting insulin. Periodic exercise with moderate intensity also led to significant changes, but compared to high intensity, these changes were less (13). The meta-analysis by De Nardi et al.in 2018 Showed that high-intensity and moderate-intensity interval training resulted in significant improvements in HbA1C, LDL-C, HDL-C, total cholesterol, triglycerides, systolic and diastolic blood pressure, BMI, and The ratio of waist to hip was. However, no significant difference was observed in any of these indicators between the two training groups (14)**.**

In a study by Madsen et al. on patients with type 2 diabetes, they investigated the effect of high-intensity interval training on glycemic control and pancreatic beta-cell function. The results of the study showed that a significant decrease in fasting blood sugar, 2-hour glucose tolerance test, HbA1c, and insulin resistance was observed in the exercise group compared to the control group. A significant reduction in visceral fat was also seen in both groups (15). In a 2015 study by Shaykh al-Islami et al., they examined the role of 8 weeks of resistance exercise on the concentration of glycation end products in postmenopausal women with type 2 diabetes. The results showed that the final glycation products were significantly reduced due to 8 weeks of resistance exercise (intragroup changes).

This decrease was also quite significant compared to the control group (intergroup changes). Fasting blood sugar and HbA1C levels also decreased significantly due to resistance training (16). In a 2011 study, Jorge et al. investigated the effect of aerobic, resistance, and combination exercise on metabolic control, inflammatory markers, adipocytokines, and muscle insulin pathways in type 2 diabetics. The results of the study showed that serum levels of cholesterol, triglycerides, and HDL-C were significantly reduced by resistance exercise (17).

In addition to resistance training, moderate-intensity interval training can be used as an effective alternative to traditional aerobic training, which causes similar or even greater changes in a range of physiological, functional, and health-related changes in Adults and patients. Recent research has shown that interval training can help improve or equal physical fitness and cardiovascular health more than regular training (18). According to the above, this study aimed to investigate the effect of eight weeks of intermittent and moderate-intensity exercise on blood sugar indices in people with type 2 diabetes.

Materials and methods:

The present study was quasi-experimental. The statistical population of the present study consisted of women with type 2 diabetes in Baneh with a mean age of 51.9. 5.09 years. In this study, 30 women with type 2 diabetes were randomly selected from the diabetic women referred to the health management of Baneh city based on the initial call after completing the consent form and health questionnaire. Subjects in three groups of Resistance exercise (n = 10), Intermittent aerobic exercise (n = 10) and control (n = 10) volunteered to conduct the study. The subjects of the training groups practiced selected exercises for eight weeks and three sessions per week. The control group did not experience any exercise during the eight weeks.

Before starting the study, the research subject was explained to the patients, and written consent was obtained from the patients. Subjects were randomly divided into three groups of 8 people: resistance training group, interval training group, and control group. Before starting the study, a general information questionnaire, including age and sex, marital status, duration of diabetes, type and amount of medication, history of exercise, etc., was completed to collect demographic information. Physical activity was assessed using the International Physical Activity Questionnaire (IPAQ). Also, the food intake of individuals at the beginning and end of the study was determined using a 24-hour recall questionnaire.

Anthropometric measurements, including height and weight, were taken at the beginning and end of the study, and BMI was calculated. cc8 Fasting venous blood samples (12-14 hours) were taken from all subjects before and after the intervention. Biochemical variables including fasting plasma glucose, serum lipid profile (TG), TC, and HDL-C were measured using biochemical analyzers. The LDL-C calculation was also determined using the Fried wald formula.

In this study, after examination and confirmation of unobstructed exercise by the clinic physician and signing of written consent of patients to assess the level of physical fitness at 11-9 am in the pre-test and post-test sessions, and after blood sampling, the following tests were performed(table1).

Table 1: Periodic and resistance aerobic exercise program (8 weeks, three sessions per week)

Cooling down (Minutes)	Periodic aerobic exercise)MHR(	Resistance exercise)1-RM(	Warming up (Minutes)	Week
5	20 minutes Exercise: 60 seconds with 60% MHR Rest: 60 seconds with 50% MHR	first set 30% 1RM up to 10 repetitions Second set 30% 1RM up to 10 repetitions	10	First
5	30 minutes Exercise: 60 seconds with 60% MHR Rest: 60 seconds with 50% MHR	first set 40% 1RM up to 10 repetitions Second set 40% 1RM up to 10 repetitions	10	Second
5	40 minutes Exercise: 60 seconds with 65% MHR Rest: 60 seconds with 50% MHR	first set 40% 1RM up to 10 repetitions Second set 40% 1RM up to 10 repetitions Third set 40% 1RM up to 10 repetitions	10	Third
5	50 minutes Exercise: 60 seconds with 65% MHR Rest: 60 seconds with 50% MHR	first set 50% 1RM up to 10 repetitions Second set 50% 1RM up to 10 repetitions Third set 50% 1RM up to 10 repetitions	10	Fourth
5	50 minutes Exercise: 60 seconds with 70% MHR Rest: 60 seconds with 55% MHR	first set 60% 1RM up to 10 repetitions Second set 60% 1RM up to 10 repetitions Third set 60% 1RM up to 10 repetitions	10	Fifth
5	60 minutes Exercise: 60 seconds with 70% MHR Rest: 60 seconds with 55% MHR	first set 65% 1RM up to 8 repetitions Second set 65% 1RM up to 8 reps Third set 65% 1RM up to 8 reps	10	sixth
5	60 minutes Exercise: 60 seconds with 75% MHR Rest: 60 seconds with 60% MHR	first set 70% 1RM up to 8 repetitions Second set 70% 1RM up to 8 repetitions Third set 70% 1RM up to 8 repetitions	10	Seventh
5	60 minutes Exercise: 60 seconds with 75% MHR Rest: 60 seconds with 60% MHR	first set 75% 1RM up to 8 repetitions Second set 75% 1RM up to 8 reps Third set 75% 1RM up to 8 reps	10	Eighth

Measuring anthropometric variables includes the following: Height (cm, using a tape measure), Weight (kg, with digital scale), Body mass index (BMI, using weight formula in kilograms divided by height squared in meters), Waist to hip ratio (WHR, using a flexible tape measure), Muscle strength and the amount of a maximum repetition (1-RM, using the Brzycki method), Measuring heart rate with a polar heart rate monitor. We used the formula (age-220) to determine the maximum heart rate (MHR).

In the present study, we used the Shapiro-Wilk test to examine the natural distribution of data. Leven test was used to evaluate the homogeneity of variances; a correlated t-test was used to examine pre-test and post-test changes. One-way analysis of variance (ANOVA) and Tukey post hoc test were used to determine the differences between groups. Research data were analyzed using SPSS software version 22. The level of significance was equivalent (P≤0.05).

Findings:

Table 2: Results of dependent t-test (between intragroup pre-test and post-test) of serum HBA1C...

Variable		control group	Resistance exercise group
HBA1C	Pre-test	2.13 ± 8.08	0.77 ± 8.17
	Post-test	2.36 ± 8.37	1.140 ±6.44
	t value	1.061-	4.504
	value P	0.297	0.001*

The results of the correlated t-test for the resistance exercise group showed that the amount of HBA1C post-test compared to the pre-test had a significant decrease with the degree of freedom (df = 9) (p = 0.001). This means that eight weeks of resistance exercise has caused significant changes in serum HBA1C in type 2 diabetic women (Table 2).

Table 3: Results of dependent t-test (between intragroup pre-test and post-test) of Insulin resistance

Variable		control group	Resistance exercise group
Insulin resistance	Pre-test	2.92 ± 5.11	2.48 ± 5.52
	Post-test	3.07 ± 5.15	1.33 ±3.04
	t value	0.238-	5.263
	value P	0.817	0.001*

The results of the correlated t-test for the resistance exercise group showed that post-test insulin resistance compared to pre-test had a significant decrease in the degree of freedom (df = 9) (p = 0.001). This means that eight weeks of resistance exercise has caused significant changes in insulin resistance in type 2 diabetic women (Table 3).

Table 4: Results of dependent t-test (between intragroup pre-test and post-test) of Lipid profile

Variable		control group	Resistance exercise group
TG)mg/dL(	Pre-test	120.50 ±213.6	95.15 ± 214.4
	Post-test	196.74 ± 215.4	64.14 ± 133.64
	t value	0.081-	3.974
	value P	0/937	* 0/003
Cholesterol) mg/dL(	Pre-test	± 42/54174.8	± 46/98174.5
	Post-test	± 35/99173.5	± 39/39151.9
	t value	0.123	3.725
	value P	0.905	0.005*
HDL)mg/dL(	Pre-test	8.71 ±50.2	6.82 ±49.9
	Post-test	10.55 ±49.9	8.18 ± 60.5
	t value	0.136	3.955-
	value P	0.895	0.003*
LDL)mg/dL(	Pre-test	30.31 ± 104.7	32.54 ± 105.8
	Post-test	30.79 ± 105.2	25.87 ± 81.7
	t value	0.122-	5.473
	value P	0.905	0.001*

The results of the correlated t-test for the resistance exercise group showed that TG post-test compared to pre-test had a significant decrease with degree of freedom df = 9 (p = 0.003). This means that eight weeks of resistance exercise have caused significant TG changes in type 2 diabetic women. The results of the correlated t-test for the resistance exercise group showed that post-test cholesterol had a significant decrease compared to the pre-test with a degree of freedom of df = 9 (p = 0.005). Accordingly, eight weeks of resistance exercise has caused significant changes in cholesterol in type 2 diabetic women. The results of the correlated t-test for the resistance exercise group showed that HDL post-test compared to pre-test had a significant increase with freedom of df = 9 (p = 0.003). This means that eight weeks of resistance exercise have caused significant HDL changes in type 2 diabetic women. The results of the correlated t-test for the resistance exercise group showed that LDL post-test compared to pre-test had a significant decrease with freedom of df = 9 (p = 0.001). Eight weeks of resistance exercise have caused significant changes in LDL in type 2 diabetic women (Table 4).

Table 5: Results of dependent t-test (between intragroup pre-test and post-test) of serum HBA1C

Variable		control group	The periodic aerobic exercise group
HBA1C	Pre-test	2.13 ± 8.08	1.20 ± 8.19s
	Post-test	2.36 ± 8.37	1.33 ±3.04
	t value	1.106-	4.882
	value P	0.297	0.001*

The results of the correlated t-test for the periodic aerobic exercise group showed that the amount of HBA1C post-test compared to the pre-test had a significant decrease with a degree of freedom of df = 9 (p = 0.001). This means that eight weeks of intermittent aerobic exercise caused significant changes in serum HBA1C in type 2 diabetic women (Table 5).

Table 6: Results of dependent t-test (between intragroup pre-test and post-test) of Insulin resistance

Variable		control group	The periodic aerobic exercise group
Insulin resistance	Pre-test	2.92 ± 5.11	1.85 ± 5.52
	Post-test	3.07 ± 5.15	0.97 ±2.84
	t value	0.238-	7.070
	value P	0.817	0.001*

The results of the correlated t-test for the periodic aerobic exercise group showed that post-test insulin resistance compared to the pre-test had a significant decrease with a degree of freedom of df = 9 (p = 0.001). Eight weeks of intermittent aerobic exercise have caused significant changes in insulin resistance in type 2 diabetic women (Table 6).

Table 7: Results of dependent t-test (between intragroup pre-test and post-test) of Lipid profile

Variable		control group	Resistance exercise group
TG)mg/dL(	Pre-test	120.50 ±213.6	181.72 ± 213.7
	Post-test	196.74 ± 215.4	104.07 ±144.7
	t value	0.081-	2.668
	value P	0/937	* 0/026
Cholesterol) mg/dL(	Pre-test	±42.54174.8	± 40.67173.8
	Post-test	35.99 ± 173.5	21.71 21.71 ±150.6
	t value	0.123	2.827
	value P	0.905	0.020*
HDL)mg/dL(	Pre-test	8.71 ±50.2	±2.3149.7
	Post-test	10.55 ±49.9	6.73 ± 55.6
	t value	0.136	2.678-
	value P	0.895	0.025*
LDL)mg/dL(	Pre-test	30.31 ± 104.7	42.30 ± 104.2
	Post-test	30.79 ± 105.2	25.87 ± 81.7
	t value	0.122-	3.122

	value P	0.905	0.012*

The results of the correlated t-test for the periodic aerobic exercise group showed that TG post-test compared to pre-test had a significant decrease with a degree of freedom of df = 9 (p = 0.026). Eight weeks of intermittent aerobic exercise have caused significant changes in TG in type 2 diabetic women. The results of the correlated t-test for the periodic aerobic exercise group showed that the post-test cholesterol was significantly lower than the pre-test cholesterol with a degree of freedom of df = 9 (p = 0.020). This means that eight weeks of intermittent aerobic exercise have caused significant changes in cholesterol in type 2 diabetic women. The results of the correlated t-test for the periodic aerobic exercise group showed that the HDL post-test compared to the pre-test had a significant increase with a degree of freedom of df = 9 (p = 0.025). Eight weeks of intermittent aerobic exercise have caused significant changes in HDL in type 2 diabetic women. The results of the correlated t-test for the periodic aerobic exercise group showed that LDL post-test had a significant decrease compared to the pre-test with a degree of freedom of df = 9 (p = 0.012). Accordingly, weeks of intermittent aerobic exercise caused significant changes in LDL in type 2 diabetic women (Table 4-20).

Table 7: ANOVA test results for HBA1C

Variable	Source of change	Squares	Degrees of freedom	average of squares	F	P
HBA1C	Intergroup	20.829	2	10.414	3.584	0.042*
	Interagroup	78.446	27	2.905		
	Total	99.275	29			

The results of the ANOVA test related to HBA1C of different research groups after eight weeks are shown in Table (6). It is observed that the value (p = 0.042) and the degree of freedom (df = 39) are less than the alpha level of 0.05. There is no significant difference between the mean of HBA1C in different research groups. The results of the Tukey follow-up test are shown in Table (8).

Table 8: Results of HBA1C variable Tukey follow-up test

Variable	group	Group	**Sig**
HBA1C	Control	Resistance	**0.045***
		Periodic aerobics	**0.127**
	Resistance	Periodic aerobics	**0.866**

Table 9: ANOVA test results for insulin resistance

Variable	Source of change	Squares	Degrees of freedom	average of squares	F	P
insulin resistance	Intergroup	32.903	2	16.452	4.050	0.029*
	Interagroup	109.667	27	4.062		
	Total	142.570	29			

The results of the ANOVA test related to insulin resistance of different research groups after eight weeks are shown in Table 9. It is observed that the value (p = 0.029) and the degree of freedom (df = 29) are less than the alpha level of 0.05. There is no significant difference between the mean of insulin resistance in different research groups. The results of Tukey's post-follow-up are shown in Table 10.

Table 10: Results of insulin resistance variable Tukey follow-up test

Variable	group	Group	**Sig**
insulin resistance	Control	Resistance	**0.067**
		Periodic aerobics	***0.041**
	Resistance	Periodic aerobics	**0.972**

Table 11: ANOVA test results for lipid profile

Variable	Source of change	Squares	Degrees of freedom	average of squares	F	P
TG)pg/mL(	Intergroup	39500.600	2	19750.300	1.345	0.275
	Interagroup	393834.900	27	14586.478		
	Total	433335.500	29			
cholesterol)pg/mL(	Intergroup	3308.867	2	1654.433	1.495	0.242
	Interagroup	29873.800	27	1106.437		
	Total	33182.667	29			
HDL)pg/mL(	Intergroup	562.867	2	281.434	3.773	0.036*
	Interagroup	2013.800	27	74.858		
	Total	2576.667	29			
LDL)pg/mL(	Intergroup	3531.667	2	1765.833	2.404	0.109
	Interagroup	19831.800	27	734.511		
	Total	23363.467	29			

The results of the ANOVA test related to TG of different research groups after eight weeks are shown in Table (11). As can be seen, the value of p = 0.275 and the degree of freedom df = 29 is greater than the alpha level of 0.05. That is, there is no significant difference between the mean of TG in different research groups.

Based on the results of the cholesterol of different research groups, after eight weeks, we observe that the value of p = 0.242 and the degree of freedom df = 29 is more than the alpha level of 0.05. That is, there is no significant difference between the mean cholesterol in different groups of research.

Based on the results of HDL in different groups of research, after eight weeks, we observe that the value of p = 0.036 and the degree of freedom df = 29 is less than the alpha level of 0.05. That is, there is a significant difference between the mean of HDL in different research groups. The results of the Tukey follow-up test are also shown in Table (12). The results of the ANOVA test related to LDL of different research groups after eight weeks show that the value of p = 0.109 and the degree of freedom df = 29 c is more than the alpha level of 0.05. That is, there is no significant difference between the mean of LDL in different research groups.

Table 12: Results of HDL variable Tukey follow-up test

Variable	group	Group	**Sig**
HDL	Control	Resistance	0.028*
		Periodic aerobics	0.318
	Resistance	Periodic aerobics	0.425

Discussion:

This study investigated the effect of eight weeks of moderate-intensity intermittent and resistance exercise on blood glucose indices in people with type 2 diabetes. The results showed that eight weeks of resistance training caused significant changes in serum HBA1C, insulin resistance, cholesterol, TG, HDL, and LDL in type 2 diabetic women. People with diabetes are significantly at risk for cardiovascular disease and mortality. Improvement in cardiovascular disease is not limited to controlling the risk factors common in type 2 diabetes (lipid disorders, hypertension, obesity, abdominal fat, physical activity, and smoking). The risk of other factors (insulin resistance and increase in insulin, increase in blood glucose 2 hours after glucose uptake, microalbumin in urine, inflammatory factors) may be more important in type 2 diabetes (19).

Exercise is among the factors affecting glucose metabolism and glycemic control. Different types of exercise have different effects on glucose and fat metabolism in the pathological conditions of obesity and type 2 diabetes. It has been stated that endurance exercise effectively controls type 2 diabetes through the following procedures: Improved insulin sensitivity by increasing GLUT-4 [1] expression; it causes glucose to enter muscle tissue and thus reduces dangerous amounts of blood glucose (20). On the other hand, the use of resistance training is also effective in controlling insulin resistance through various mechanisms. However, the widespread effects of intermittent exercise are being studied

[1] Glucose transporter type 4

today. Periodic exercise is one of the most effective exercises in fat metabolism, so this exercise modality is used to control and lose weight and other risk factors for diabetes. However, studies examining the factors in the present study that are associated with glycemic control, inflammation, and cardiovascular disease are limited to different exercise modalities.

In the present study, we observed that eight weeks of intermittent and resistance aerobic exercise significantly reduced body weight, BMI, cholesterol, triglyceride, and LDL. All of these indicate a reduction in body fat mass and a reduction in adipose tissue damage, which can be effective in reducing TNF-α. In the intergroup study, TNF-α levels in the periodic aerobic exercise group showed a significant decrease compared to the control group. Consistent with the results of our study, Mokhtarzadeh et al. (2017) showed that interval aerobic exercise (3 sessions per week for eight weeks, intermittent exercise cycling) effectively improves immune system function with significant effects on inflammation adipokines like TNF-α in women with MS (21).

Conclusion

According to the results of the present study, it seems that in the pathology of diabetes, resistance training methods with control and weight loss, BMI, lipid profile are effective in reducing insulin resistance, glycemic factors and cytological blood pressure. Therefore, it is suggested that diabetic patients use resistance training method to control diabetes and blood pressure. It is also suggested to evaluate the effective factors in the signaling pathway in future research, especially at the gene level. Also, although intermittent aerobic exercises are able to Modulation and control of glucose metabolism and blood pressure reduction. Despite this, the use of resistance exercises has better effects on glycemic control, blood glucose, blood pressure, and ultimately improving cardiovascular conditions in women with type 2 diabetes.

Declaration

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