Effect of circuit resistance and jogging exercise training on the markers of metabolic syndrome in women with type 2 diabetes

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ABSTRACT:

Introduction: Although the effectiveness of exercise in improving the markers of metabolic syndrome in diabetes is well documented, there is less certainty about the relative effectiveness of different types of exercise. Therefore, this study aimed to investigate the effect of circuit resistance training (CRT) and jogging exercise training on lipid profile, glycosylated hemoglobin (HbA1c), fasting blood sugar (FBS), blood pressure, and waist circumference (WC) in female subjects with type 2 diabetes.

Material and methods: Thirty obese and overweight women with type 2 diabetes with a (mean ± SD: age, 51.37±5.56 years and body mass index (BMI), 31.34±3.09 kg/m^2 were randomized to CRT (n=10) (8 stations with 40- 65% 1RM), jogging training (n=10) (25-50 min with 45-75% of target heart rate) or control group (n=10). Exercise training was performed three times a week for 12 weeks. Anthropometric measures, blood samples, and blood pressure were recorded before and after the exercise intervention and for the control group. A covariance analysis test was used to compare the groups to analyze the influences of exercise training on MS markers.

Results: HbA1c in the circuit resistance training group was significantly improved compared to the control group (P = 0.01), but no significant difference was observed in the jogging group. Additionally, a decrease in total cholesterol (TC) was observed in both CRT (P = 0.01) and jogging groups (P = 0.01). Both training groups differed significantly from the control group (P <0.05). No significant improvement was observed in FBS, LDL-cholesterol, HDL-cholesterol, triglycerides (TG), waist circumference, and blood pressure (P >0.05).

Conclusions: It can be concluded that twelve-week circuit resistance training with moderate intensity significantly improved HbA1c and total cholesterol and that jogging exercise training was practical for total cholesterol. It is recommended that patients with type 2 diabetes are

encouraged to perform both jogging and circuit resistance training with moderate frequency, duration, and intensity.
Keywords: Resistance training, Aerobic training, Gogging training, Glycemic control, Lipid profile, Diabetes mellitus

1. Introduction

The global prevalence of type 2 diabetes continues to rise, and the highest prevalence rates are found among women aged 45–64 years (1). Metabolic syndrome is one of the most hazardous risk factors for cardiovascular disease and diabetes (2). Metabolic syndrome (MS) is accompanied by abdominal obesity, dyslipidemia, hyperglycemia, and hypertension (3). According to definitions proposed by the International Diabetes Federation (IDF) and Adult Treatment Panel (ATPIII), these definitions are more functional and do not need to measure insulin resistance (4). Because people with diabetes are at high risk of cardiovascular disease (CVD), it is essential to keep blood sugar levels close to normal to prevent this disease and other serious complications. By its function as an indicator for the mean blood glucose level, HbA1c predicts the risk of developing diabetic complications in diabetic patients. Apart from classical risk factors like dyslipidemia, elevated HbA1c has now been regarded as an independent risk factor for cardiovascular disease in participants with or without diabetes. On the other hand, lipid patterns such as high triglyceride levels, low HDL levels, and small, dense LDL particles are connected with central obesity and insulin resistance (5). On the other hand, it was shown that MS may occur more frequently among women than among men (6, 7). The declining level of estrogen and the variation of its ratio with testosterone have been mentioned as a cause of the emergence of MS as a menopausal transition (8). However, estrogen deficiency indirectly influences body fat distribution (central obesity), insulin action, the arterial wall, and fibrinolysis, which may affect cardiovascular risk. These factors result in a more widespread prevalence of the markers of MS in postmenopausal women as compared with premenopausal women (9).

Exercise is an integral component of the treatment for people who have type 2 diabetes. Although the effectiveness of exercise in improving the markers of metabolic syndrome (fasting blood glucose, waist circumference, systolic blood pressure, diastolic blood pressure, and triglycerides) in this group is well documented (10), there is less certainty about the relative effectiveness of different types of exercise. The American Heart Association, the American College of Sports Medicine, and the American Diabetes Association have all supported integrating resistance training (RT) with an exercise program that includes aerobic or combined exercise (11, 12). Also, most studies on the therapeutic impact of exercise on type 2 diabetes have applied continuous, low- to moderate-intensity exercises such as walking and jogging (13, 14). Notably, women who did more than 150 min/week of these types of exercise had a 40% lower risk of developing diabetes than those who did not (15).

Studies have proved the potential role of resistance training in improving lipid profile. Given the elevated free fatty acid uptake by skeletal muscle during muscle contraction (16), it is likely that resistance training plays a role in lipidemia. In addition to its capacity to increase muscle fiber size and strength, resistance training improves lipid metabolism by reducing the synthesis of free fatty acids and stimulating lipid oxidation (17). Evidence shows that RT promotes

increased muscle mass, glucose transporter (GLUT-4), protein kinase B, and glycogen synthase in obese and diabetic individuals (9). It has been shown that circuit training can effectively reduce the markers of metabolic syndrome as compared to traditional strength training (18). However, the evidence about the effect of exercise training on markers of metabolic syndrome needs to be clarified, and the available data are conflicting. It has been known that resistance training interventions for patients with MS can decrease systolic blood pressure. Still, it does not change fasting plasma glucose, HDL cholesterol, triglycerides, diastolic blood pressure, or waist circumference (19). Many studies evaluating resistance exercise with combined and aerobic exercise sessions reported significant decreases in HbA1c (20, 21). In contrast, they did not find favorable changes in fasting blood sugar (FBS) in patients with type 2 diabetes (22). Also, the effect of aerobic training in terms of lipid, glucose control, and pressure showed improvements (23-26) or no changes in patients. On the other hand, there is no consensus on the comparative effect of CRT and jogging exercise training on MS markers in women with type 2 diabetes. The present study hypothesizes that circuit resistance training and jogging exercise training with moderate intensity differently improve MS markers in women with type 2 diabetes.

2. Material & Methods

Participants

The research population was composed of 120 people who had visited the clinic of Ansari Hospital in Roudsar, out of which 30 obese and overweight women with type 2 diabetes (mean ± SD: age, 51.37±5.56 years) with a body mass index (BMI) of (mean ± SD) 31.34±3.09 $kg \cdot m^{-2}$, and mean diabetes duration of 10.8±3.5 years were the qualified volunteers for the study. They were randomly assigned to three groups: circuit resistance training (CRT), jogging exercise training, and control group. Exercise training included the training of CRT and jogging exercises for about 12 weeks. All the patients used blood glucose-lowering drugs, including metformin and glibenclamide. Also, they had no vascular complications of diabetes, and some were taking blood lipid and blood pressure-lowering drugs. The inclusion criteria were the lack of exercise training in the prior year and the maximum age of 60 years. Also, patients with MS markers were according to guidelines from the Adult Treatment Panel III (27), as presented in Table 1. The samples of this research had three symptoms of metabolic syndrome out of 5 symptoms.

Table 1. Inclusion criteria for the diagnosis of metabolic syndrome

The presence of at least three of the five diagnostic criteria	Categorical cut points
Elevated waist circumference	≥102 cm in men and ≥88 cm in women
Elevated triglyceride level	≥150 mg/dL (>1.7 mmol/L)
Elevated fasting glucose	≥l00 mg/dL (≥5.5 mmol/L)
Reduced high-density lipoprotein cholesterol	<40 mg/dL (<1.03 mmol/L) in men and <50 mg/dL

	(<1.3 mmol/L) in women
Blood pressure	≥130 mm Hg systolic blood pressure and≥85 mm Hg diastolic blood pressure

Adapted from Grundy et al. [1]

The exclusion criteria included patients with acute cardiovascular joint and bone diseases. We used a 3-day food recall questionnaire at the beginning of the study and one month later. Then, junk foods were removed from the food list. The daily dietary regime was 500 calories less than the energy requirement (28). DASH diet was recommended (Dietary Approaches to Stop Hypertension). A DASH eating plan is an acceptable eating pattern for diabetic people. This eating pattern has been shown to improve insulin resistance, hyperlipidemia, and even overweight/obesity. Dietary recommendations were made with an emphasis on using a variety of foods (e.g., whole grains, fat-free or low-fat dairy products, fruits, vegetables, poultry, fish, and nuts) (29). Despite this recommendation, the effect of the food regime was not studied in the end, which is a limitation of our study, as mentioned in the list of study limitations.

The Human Studies Review Committee approved the study at Islamic Azad University, Rasht branch. The Ethics Committee recorded in the IRCT system is IRCT2015111122498N3.

Anthropometric measures and blood analysis

Height, body weight, and waist circumference were measured during enrollment and the study. A standard calibrated scale and stadiometer were used to determine weight and height. Body mass index (BMI) was calculated as (body weight [kg] / (height [meter] ^{2}). Waist circumference was measured midway between the lowest rib and the iliac crest with the participant standing. At the beginning and end of the study, the patient's blood glycemic tests of the brachial vein were collected after 12 hours of fasting. Baseline blood glycemic tests were measured, including HbA1c and fasting blood sugar (FBS) (mg/dl). FBS and blood lipid tests such as HDL-cholesterol, LDL-cholesterol, total cholesterol, and triglycerides were estimated by Pars Azmoon enzyme kits (Tehran, Iran). HbA1c was determined by Biosystem auto‑analyzer devices (Barcelona, Spanish).

Measures of blood pressure

Blood pressure was measured seated after a minimum 5-min rest with a calibrated aneroid sphygmomanometer with an adequate cuff size.

Circuit resistance training protocol

We used a one-repetition maximum (1RM) to determine the intensity of strength training. 1RM is the maximum force that can be generated in one maximal contraction. Two briefing sessions

were designed to train participants about the test procedures. The main aim of these sessions was to familiarize participants with different resistance exercises using weight-training machines. CRT protocol was initiated at three days/week for 12 weeks. The training consisted of 10 min warm-up (stretching of upper and lower limbs) and cool-down (low-intensity dynamic exercise and stretching of upper and lower limbs). During the first 1–6 weeks, participants were involved in six stations with 40–50% 1‑RM intensity. Then, for the remaining period (7–12 weeks), eight stations with the 50–65% 1‑RM were indicated. This program included eight different circuit exercises with 8–12 repetitions in each set and 3 min rest between sets. Exercises included bench press, seated row, lateral pull down, biceps curl, leg extension machine, leg curl machine, leg press, and rowing (30, 31).

2.5. Jogging exercise training protocol

The protocol included 36 sessions held three days per week. The training sessions had a 10-min warm-up and a 10-min cool-down. Jogging training was composed of walking and jogging for the first 12 weeks of the training period. Participants were trained with loads of 60% of the individual target heart rate for 25-30 min. For the last 12 weeks of training, the loads were 75% of the target heart rate for 45-50 min (32) .Target heart rate (HR) was measured using Karvonenn as below.

$$\text{Target HR} = ((\text{max HR} - \text{resting HR}) \times \%\text{Intensity}) + \text{resting HR example}$$

Statistical analysis

All data are presented as mean ± SD. The Shapiro-Wilk test was applied to determine if the sample had a normal distribution. In the present study, a covariance analysis test was used to compare the groups to analyze the influences of exercise training on MS markers (SPSS version 19, SPCC Inc. Chicago, IL, USA) by choosing covariance method, annoying and effective factors such as pretest values were controlled. When a significant rate was found, Fisher's LSD post hoc analysis was used to distinguish differences among means. The significance level was set at $P < 0.05$ for all statistical analyses.

3. Results

Results of descriptive analysis (n=30) are presented in Table 2. It shows the distribution of body composition before and after the 12-week intervention period.

Variable	**CRT (n=10)**		**Jogging(n =10)**		**Control(n =10**	
	Before	After	Before	After	Before	After
Age (year)	50.20±4.89	----	52.60±5.33	----	51.30±65.63	----

Weight (kg)	75.5±10.6	74.9±10.4	75.90±6.04	75.7±6.1	74.70±2.94	75.5±3.3
BMI ($kg.m^{-2}$)	30.19±3.59	29.9±3.5	31.43±2.73	31.3±2.7	32.32±2.42	32.6±2. 4

*Significant difference at P<0.05

The results of covariance analysis (Table 3) revealed significant differences in HbA1c and cholesterol-C between the three groups (P < 0.05).

Table 3. The results of analysis of covariance to compare levels of markers of metabolic syndrome between groups (comparison within groups) (means±SDs).

Variable	Group	Before	After	F	p-Value
Waist circumference (cm)[a]	CRT	96.10±8.39	95.9±8.5	0.32	0.7
	Jogging	94.70±3.26	94.9±2.9		
	Control	95.50±9.34	96.7±9.5		
FBS ($mg.dl^{-1}$)[a]	CRT	159.30±3.02	158.3±4.9	0.01	0.9
	Jogging	158.80±4.68	158.0±4.5		
	Control	158.70±1.94	158.7±2.2		
HbA1c (%)	CRT	7.19±0.4	6.1±0.5	4.64	0.01*
	Jogging	7.33±0.6	7.2±0.7		
	Control	7.03±0.4	7.0±0.4		
Triglyceride ($mg.dl^{-1}$)[a]	CRT	159.80±17.60	159.7±20.5	0.006	0.9
	Jogging	160.90±6.45	160.6±6.1		
	Control	160.40±43.60	161.5±57.1		
HDL ($mg.dl^{-1}$)[a]	CRT	46.40±9.40	46.3±8.3	0.29	0.7
	Jogging	47.30±3.74	47.6±3.5		
	Control	47.10±8.26	45.9±6.2		
LDL ($mg.dl^{-1}$)	CRT	84.70±22.53	89.2±24.9	0.18	0.8
	Jogging	90.00±5.94	90.6±3.7		
	Control	111.10±34.96	105.1±29.8		
Total cholesterol ($mg.dl^{-1}$)	CRT	166.90±7.03	158.1±5.7	10.91	0.000*
	Jogging	167.30±7.11	155..8±5.7		
	Control	167.20±5.32	167.1 ±5.2		
Systolic (mm Hg)[a]	CRT	124.12±5.19	123.2±4.9	0.18	0.8
	Jogging	125.32±5.19	125.2±5.1		
	Control	125.13±5.24	125.1±5.3		
Diastolic (mm Hg)[a]	CRT	86.20±5.01	84.1±5.0	0.3	0.7
	Jogging	85.35±5.22	85.2±5.3		
	Control	84.10±5.18	84.0±5.1		

[a] Metabolic syndrome according to NCEP ATP III criteria

LSD post-hoc test (Table 4) showed a significant improvement (P <0.001) in HbA1c in the CRT group (-1.09 %, 95% CI = 0.73 to 1.42), which was also crucial as compared to control (P < 0.05). Also, a significant reduction (P < 0.001) was found in cholesterol-C in the CRT group (8.80 mg/dl, 95% CI = 4.72 to 12.87) and jogging group (11.50 mg/ dl, 95% CI = 7.62 to 15.37, P <0.001). These training groups showed significant differences with control (P < 0.05). We observed no significant improvement in other MS markers.

Table 4. The results of LSD post-hoc test to paired comparison of markers of metabolic syndrome (comparison between groups). (n=30)

Variables	Groups	CRT		Jogging		Control	
		MD	p-value	MD	p-value	MD	p-value
HbA1c (%)	CRT	----	----	-0.96	0.000*	-1.11	0.000**
	Jogging	0.96	0.000*	----	----	-0.15	0.9
	Control	-1.11	0.000*	-0.15	0.9	-----	-----
Total cholesterol(mg.dl^{-1})	CRT	-----	-----	2.55	0.4	-8.81	0.000*
	Jogging	-2.55	0.4	----	----	-11.36	0.000*
	Control	-8.81	0.000*	-11.36	0.000*	----	----

Values are mean±SD, MD: Mean difference
*Significant difference at P < 0.05.

4. Discussion

In the present study, we compared the effects of CRT and jogging training on MS markers of women with type 2 diabetes. We observed a significant reduction in HbA1c and TC. No significant differences were found in other MS markers.

HbA1c exhibited a significant reduction during the circuit resistance training but not during the jogging exercise training. These findings agree with other studies (20, 31, 33) showing that CRT for 12 weeks can reduce HbA1c. Cauza et al. (34) also examined the relative benefits of endurance and strength training on the metabolic factors and muscle function of people with type 2 diabetes for four months. The results indicated a significant decline in HbA1c only in the ST group (34).

It is postulated that resistance training improves glycemic control by a different mechanism than aerobic training, mainly through an increase in muscle mass (since skeletal muscle is the central glucose for the body) and by increasing the expression of glucose transporter type 4 (GLUT-4) (35). The study shows that the increases in skeletal muscle mass are related to decreases in HbA1c, supporting the hypothesis that resistance training improves glycemic control by increasing the lean muscle storage of glucose. It is still unclear, however, if this effect is due to increased muscle size and qualitative changes in certain muscular functions.

But findings by Moradian et al. (36), Church et al. (37), and Jorge et al. (23) were inconsistent with our study. Church et al. (37) showed that the effect of resistance and aerobic exercise on glycemic control in 30 to 75-year-old men and women was not associated with the decline in absolute HbA1c in aerobic or resistance training alone. They did not find significant reductions in HbA1c within any of the exercise groups compared to the control group after 12 weeks of training. It seems that factors like lower intensity and duration, age, and gender were the reasons for the consistency of these studies.

The results of the present study indicate that total cholesterol was reduced by circuit resistance training and jogging exercise training. Risk factors or postulated mechanisms for the rapid development of vascular disease in diabetes include hyperglycemia, hypertension, low HDL-C, high triglyceride levels, small dense LDL-C, a procoagulant state, and a pro-inflammatory milieu (38). It stands to reason, therefore, that lipid management is an essential part of diabetes care. Previous findings have shown decreased total cholesterol after six months of aerobic training (24, 25). Dunn et al. reported a decrease in total cholesterol after six months of aerobic exercise training with 50 to 85 % of maximum aerobic power for 20–60 min three times a week (39). In addition, a study showed that the effect of circuit resistance training (CRT) on blood biomarkers of cardiovascular disease risk in older women was associated with the decline in TC, HDL-c, LDLc, VLDL-c, and TG (40). Other studies have reported that resistance and aerobic training did not improve total cholesterol (41-43). Training volume, as opposed to the training intensity, is the key to improving the lipid profile, and there may be a relationship between body fat (which decreased only in the prolonged exercise) and cholesterol levels, whereby a volume sufficient to elicit changes in fat mass is required to alter the lipid profile (40) favorably.

In the present study, no significant improvement was seen in systole blood pressure, diastole blood pressure, FBS, and waist circumference. FBS did not significantly differ in circuit and aerobic training, consistent with Hazley et al. [41] and Lokard et al. (43), showing that exercise training was practical for improving FBS. However, our study needed to be more consistent with Tomar et al. (41), according to which exercise training effectively improved FBS. This inconsistency can be explained by the fact that we did not control the diet of the intervention group on the one hand, and the age of the subjects and exercise methods were different in these studies on the other hand.

A study by Tibana et al. (44) showed that eight weeks of resistance exercise for type 2 diabetes female subjects aged 33.9±8.6 years did not significantly improve waist circumference. This result agrees with our study, but Kang et al. reported how 12-week circuit weight training and aerobic exercise of obese women aged 21–23 years significantly reduced waist circumference (42). Potteiger et al. (45)compared the effects of aerobic exercise at 65–80% of maximum heart rate and RT at 5-10 RM with caloric restriction on the cardiovascular risk factor of MS. The authors stated that aerobic training decreased WC after six months. This result is inconsistent with our study, which may be associated with the differences in age and training methods. A study has shown the effect of exercise training on reducing blood pressure in the participants (43). Still, some researchers have stated that exercise training does not significantly affect blood pressure in type 2 diabetes (25, 44, 46). In a study, 6-month aerobic training did not considerably reduce ambulatory blood pressure(46). Another study reported that 26-week resistance and aerobic training failed to cause a significant reduction in blood pressure of

diabetes. So, exercise seems to take a long time before it can influence blood pressure. Hypertension can cause metabolic syndromes, such as insulin resistance and glucose intolerance. Therefore, exercise to reduce fat and improve hormones epinephrine and norepinephrine can improve blood pressure disorders (44). Exercise training with high frequency, duration, and intensity could be associated with more significant benefits in patients with type 2 diabetes. Also, individuals with type 2 diabetes can improve their lipid control, blood glucose, and blood pressure through physical activity.

The present study has some limitations that should be considered, such as the low number of participants, the need for more control on diet, and the inclusion of only women in a specific age group.

5. Conclusions

In conclusion, the results of this study showed that circuit resistance training with moderate intensity significantly improved HbA1c and total cholesterol and that jogging exercise training was practical for total cholesterol. Therefore, patients with type 2 diabetes should be encouraged to perform jogging and circuit resistance training with higher frequency, longer duration, and moderate intensity.

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