

The Effect of Resistance Training on Cardio-Metabolic Factors in Males with Type 2 Diabetes

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Background: Diabetes is one of the most important metabolic diseases in the world and exercise is a common advice to manage diabetes and reduce its complications.

Objectives: The aim of this study was to investigate the effect of resistance training on blood glucose, blood pressure and resting heart rate in males with type 2 diabetes.

Materials and Methods: In this semi-experimental study, 20 males with type 2 diabetes with mean age of 46 ± 3.4 years old who met the inclusion criteria were selected. The participants were randomly assigned into resistance training ($n = 10$) and control ($n = 10$) groups. Resistance exercise training program was performed for eight weeks, three sessions per week. Cardiovascular and biochemical parameters were measured before and after the intervention. To analyze the measured parameters changes t-test was used at $P \leq 0.05$ significance level.

Results: After eight weeks, a significant decrease in fasting blood sugar ($P = 0.002$), glycosylated hemoglobin ($P = 0.025$) and systolic blood pressure ($P = 0.022$) was observed in the resistance group. In addition, there was a significant difference in blood sugar ($P = 0.003$) and glycosylated hemoglobin ($P = 0.031$) between the two groups.

Conclusions: Findings of this study confirmed the positive influence of resistance training to control blood glucose and blood pressure in males with type 2 diabetes.

Keywords: Type 2 Diabetes; Resistance Training; Blood Sugar; Blood Pressure

1. Background

Diabetes mellitus is one of the most common and important metabolic diseases in the world which is resulted from interference in secretion of insulin, resistance to insulin, and increase in production of hepatic glucose. Metabolic disorders resulting from diabetes lead to many cardiovascular complications, which will be followed by frequent problems for patients as well as the health system of society. Type 2 diabetes elevates the risk of microvascular complications such as retinopathy and nephropathy. These patients often die because of macrovascular complications, including coronary artery disease and stroke (1, 2). Cardiovascular complications are the most prevalent problems in patients with type 2 diabetes; therefore, a therapeutic attitude can control cardio-metabolic risk factors and have helpful effects on diabetic patients (3). For many years, exercise with diet and pharmacological treatments have been regarded as three therapeutic methods for diabetes (2, 4). Research has indicated that low physical activity leads to metabolic disorders, which is an accelerating factor to cause and exacerbate diabetes. Therefore, regular exer-

cise and high physical activity can decrease and control metabolic syndromes (5). The exclusive value of exercise for patients with type 2 diabetes can be strengthening of skeletal muscles for glucose uptake without need for insulin; thus, regular physical activity due to its important effect on managing type 2 diabetes has been recommended by experts (6). Furthermore, exercise can help prevent long-term complications of diabetes, so that exercise has been suggested as one of the therapeutic methods in diabetic patients (7). Many studies have examined the effects of exercise and physical activity on glycemic control and blood pressure in patients with type 2 diabetes. Research indicates that glucose and blood pressure decrease by exercise. Regular physical activity can help to decrease blood pressure to 8-10 mmHg. Diet with exercise is the best Nonpharmacologic treatment to prevent and treat hypertension in most patients (8). Most of the studies have shown the positive effects of physical activity on public health and type 2 diabetes. However, there are deep gaps in interaction between type 2 diabetes and physical activity. These gaps are associated with the

program of various exercises, to which the patients are bound (9).

2. Objectives

The aim of this study was to investigate the effects of regular resistance exercise on glycemic control, blood pressure and resting heart rate in males with type 2 diabetes.

3. Materials and Methods

3.1. Sample Selection

In this quasi-experimental study, 20 males with type 2 diabetes were selected from patients of Gholeshtan Hospital Diabetes Clinic in Ahvaz, using available sampling method, and were randomly divided into two groups: resistance exercise group (n=10) and control group (n=10).

Inclusion criteria were: type 2 diabetic males, 30 to 50 years old, fasting blood sugar (FBS) < 200 mg/dL, no smoking, no insulin injection, no history of cardiovascular or respiratory diseases or muscular and skeletal problems, inactive life style and VO₂ max < 40 mL/kg/minute, no regular exercise within six months prior to the study, no hypoglycemia background at rest or exercise. Excluding criteria were: being absent from exercise sessions for more than two successive sessions, no regular participation in an exercise program except for this study exercise sessions for the exercise group and no regular exercise for the control group. The subjects became familiar with the purposes of the study and received required educations about the study. After that, all participants signed the informed consent form.

Volunteers were examined by endocrinology and metabolism super specialists. After basic measurement, exercise intervention was performed for eight weeks under the researcher's supervision and after the intervention (post-test), the parameters were measured again.

3.2. Anthropometric Indices

Weight, body mass index (BMI), and percent body fat (PBF) were measured by body composition analyzer machine, Olympic model 3/3, made in Korea. In this respect, the patients, while fasting, referred to physiology laboratory of Shahid Chamran University and stepped on the analyzer machine with bare feet; the analyzer machine gave the researcher a print of their anthropometric information via sensors on the soles and handles, which were in the hands of the patients.

3.3. Biochemical Indices

Blood sample after 10 to 12 hours of fasting was taken from left antecubital vein for measuring biochemical parameters. To measure glycated hemoglobin (HbA_{1c}), 2 mL of the blood sample was poured to complete blood

count (CBC) container containing anticoagulant ethylenediaminetetraacetic acid. FBS was measured in the biochemistry laboratory; serum and red globules of the blood sample were separated with centrifuge and the blood serum was used to measure blood sugar.

3.4. Cardiac Indices

Systolic and diastolic blood pressures were measured by Hansen mercury barometer made in Germany and Litmann stethoscope made in USA. To measure heart beat by Litmann stethoscope, the number of heart beats of optical pulse was counted for 60 seconds. Rakport test was used to measure aerobic capacity (VO₂ max) of the patients (10).

3.5. Exercise Training

Exercise training intervention included a resistance training program, which was performed by the patients under the supervision of the researcher. There was a 10-minute warm-up in the beginning of every exercise session, which included aerobic exercise in two ways (two three-minute stages, quick walking and jogging, respectively) and then static stretching exercises (2). Work out exercises were performed for different muscle groups (including chest, deltoid, big back, biceps, triceps, thighs, legs and trunk muscles; muscles of the abdomen and back) in three sets; each set included the abovementioned muscles, which was designed according to the recommendations of American Diabetes Association (4). The intensity of exercise was calculated based on the percentage of maximum strength, using Brzycki equation (10); in the first week, patients started exercise with 30-40% of a one-repetition maximum; in the last week, the exercise intensity increased to 60-70% of a one-repetition maximum, given the principle of overload. Each exercise started with 15-20 repetitions in the first week, and the number of repetitions decreased to 8-10 in the last week by gradually increasing the intensity. Duration of the inactive relaxation between the exercises was 40-60 seconds and relaxation between the sets was three to five minutes. Work out was followed by cool down, which included walking quickly for five minutes and stretching exercise (2). The exercise sessions were held in the presence of a nurse. Moreover, the patients were advised to bring sweet snacks to have in case of probable hypoglycemia. Before every session of exercise, the patient's blood sugar and blood pressure were checked using glucometer and digital barometer, respectively.

3.6. Statistical Methods

SPSS 19.0 Software was used for analyzing the data. Normality of data distribution was assessed by Kolmogorov Smirnov test, which indicated that all the data had a normal distribution. The data of the subjects before and after the eight-week training were compared between the

training and the control group and were analyzed with paired and independent samples t-test. The Significance level in all the tests was $P \leq 0.05$.

4. Results

This study investigated the effects of resistance training on FBS, HbA1C, systolic blood pressure (SBP), diastolic blood pressure (DBP) and resting heart rate (RHR) in males

with type 2 diabetes who resided in Ahvaz. Table 1 shows the demographic characteristics of patents in pretest. After eight weeks of resistance training, a significant decrease was observed in FBS ($P = 0.002$), HbA1C ($P = 0.025$) and SBP ($P = 0.022$), in the resistance training group (Table 2). There was a significant difference between FBS ($P = 0.003$) and HbA1C ($P = 0.031$) between the two groups (Table 3).

Table 1. Comparison of Characteristics of the Exercise and Control Groups ^a

Variables	Exercise Group	Control Group	P Value
Age, y	46.5 ± 3.0	45.6 ± 3.9	0.613
Height, cm	171.6 ± 6.0	170.6 ± 5.3	0.692
Weight, kg	73.4 ± 8.2	76.0 ± 10.5	0.548
BMI, kg.m ⁻¹	24.9 ± 2.4	26.1 ± 3.0	0.351
PBF	24.5 ± 3.5	26.7 ± 1.6	0.092
VO2 max	36.1 ± 2.0	36.0 ± 1.6	0.837
Disease duration	4.2 ± 2.2	6.1 ± 1.7	0.542

^a Abbreviations: BMI, body mass index; PBF, Percent body fat; VO2max: Maximal oxygen uptake.

Table 2. Preintervention and Postintervention Values for FBS, HbA1C, SBP, DBP and RHR ^{a,b,c}

Variable	Exercise Group			Control Group		
	Pretest	Post-test	P value	Pretest	Post-test	P value
FBS, mg/dL	146.3 ± 35.3	124.2 ± 28.2	0.002 c	151.2 ± 28.8	152.5 ± 21.0	0.761
HbA1C, %	6.4 ± 0.7	5.8 ± 1.0	0.025 c	6.4 ± 0.7	6.4 ± 0.7	0.764
SBP, mmHg	133.5 ± 8.8	126.9 ± 4.5	0.022 c	136.4 ± 6.7	133.2 ± 5.0	0.267
DBP, mmHg	86.5 ± 7.6	84.7 ± 4.5	0.239	90.7 ± 7.3	91.1 ± 7.1	0.269
RHR, bpm	88.5 ± 4.2	86.2 ± 2.6	0.055	84.1 ± 5.5	83.3 ± 5.5	0.290

^a Abbreviations: FBS = fasting blood glucose, HbA1C = glycosylated hemoglobin, SBP = systolic blood pressure, DBP = diastolic Blood Pressure, RHR = resting heart rate.

^b Data are presented as mean ± SD.

^c There was a significant difference between pre and post interventions at $P < 0.05$.

Table 3. Comparison of the Mean Differences of Investigated Variables Between the Exercise and Control Groups ^{a,b}

Variables	Exercise Group	Control Group	P value
FBS, mg/dL	-22.1 ± 16.7	+1.3 ± 13.1	0.003 ^c
HbA1C, %	-0.6 ± 0.7	-0.2 ± 0.2	0.031 ^c
SBP, mmHg	-6.6 ± 7.6	-3.2 ± 8.6	0.359
DBP, mmHg	-1.8 ± 4.5	+0.4 ± 1.1	0.165
RHR, bpm	-2.3 ± 3.3	-0.8 ± 2.3	0.251

^a Abbreviations: FBS = fasting blood sugar, HbA1C = glycosylated, hemoglobin, SBP = systolic blood pressure, DBP = diastolic Blood Pressure, RHR = resting heart rate.

^b Data are presented as mean ± SD.

^c There is a significant difference between the exercise and control groups at $P < 0.05$.

5. Discussion

Exercise or physical activity is a common advice to manage diabetes and reduce its complications through blood glycemic control and to decrease cardiovascular risk factors. In general, in many studies, exercise has been investigated as a therapeutic mediator for controlling cardio-metabolic indices; however, more research is required to provide the best exercise method for diabetes management. Therefore, the present study was designed to investigate the effects of resistance training (circuit weight training) on cardio-metabolic indices in male patients with type 2 diabetes.

5.1. Blood Glycemic Control

A significant decrease was observed in FBS and HbA1C in the resistance group after eight weeks of exercise. Findings of previous studies have shown that resistance training leads to decrease in FBS and HbA1C in patients with type 2 diabetes (11, 12), the results of which were consistent with those from the present study. Actually, positive change in blood sugar level is mostly resulted from collective effect of several blood sugar reductions after each session of exercise (13, 14). Research indicates that muscular contraction has an insulin-like effect and helps with diffusion of glucose from blood into cells to be consumed for energy production (15). Muscular contraction results in a higher membrane permeability to glucose, due to an increase in the number of glucose transporters (GLUT4) in plasma membrane. Exercise can increase the number of GLUT4s in a muscle; furthermore, it improves glucose metabolism and can help lower FBS and HbA1C (16). It is said that accumulation of free fatty acids in muscular cells interferes in transportation of GLUT4 to the cells surfaces. Exercise may prevent the accumulation of fatty acids in muscular cells via increasing their oxidation (17). Increase in insulin action and insulin signals can be mentioned as the other positive mechanism for adjusting glucose metabolism (18, 19). Moreover, one of the other possible reasons for favorable changes in glycemic control is that the protein content of insulin receptor as well as the activity of protein kinase B, which plays a crucial role in transporting insulin signals, increase after exercise, which in turn, can lead to decrease in blood sugar in patients (18). In addition, it is possible that exercise or the weight loss resulting from exercise improve beta cells function, indirectly and through other biochemical mediators or peptide hormones which are reported by expressing genes and their receptors in pancreas cells, which is followed by decrease in the level of blood glucose in diabetic patients (20-24).

After exercise, muscular cells replenish their glycogen stores; therefore, blood glucose concentration remains at a low level for some hours after physical activity (17). By increasing the muscular mass, resistance training causes more glucose to be uptaken by muscular cells. Therefore, if resistance training increases the muscular mass, it is

likely that it can have a significant effect on glycosylated hemoglobin (blood sugar control) (16). Since skeletal muscle is an important factor in insulin resistance, fatty acid metabolism and basal metabolism, increased muscular mass through strength exercise may be helpful in improvement of insulin resistance and other metabolic syndrome indices (25).

5.2. Cardiac Indices

A significant decrease was observed in systolic blood pressure in the exercise group after eight weeks, which was in consistent with some studies (26-28). It is in line with meta-analysis of Strasser et al. (29) which showed the significant effect of resistance training on systolic blood pressure without significant effect on diastolic blood pressure. However, findings of De Feyter et al. (30) indicated no significant effect of resistance exercise on systolic blood pressures, which was inconsistent with findings of the present study. This difference probably was associated with different exercise protocols.

In the present study, no significant decrease was observed in resting heart rate, which showed similarities with the results of some studies (26, 31), while the results of Shenoy et al. (32) were not similar. This difference may be related to differences in subjects or duration of exercise protocols. The duration of exercise protocol in Shenoy et al. study was 16 weeks.

Hypertension in Type 2 diabetes patients results in disorders of central and peripheral parameters of cardiovascular function (33). Regular exercise is one of the nonpharmacologic treatments of hypertension (34). Maintaining systolic blood pressure at about 140 mmHg, depending on age, can decrease stroke by 28-44% and ischemic heart diseases by 20-30% (35). There is valid evidence concerning the effectiveness of exercise in improving endothelial function and ventricular contractility, left ventricular diastolic function, and ventricular stroke volume (26, 33), which can have an effective influence on blood pressure decrease.

The results of this study confirmed the positive effects of resistance training on blood glucose control cardiovascular factors in patients with type 2 diabetes. Diabetic patients should consult with their doctor and perform these trainings under the supervision of an exercise expert to control the blood glucose and improve cardiovascular factors. If these trainings are done regularly for a long time, they would increase the health level.

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