Ilam University of Medical Sciences

Journal of Basic Research in Medical Sciences

Online ISSN: 2383-0972
Print ISSN: 2383-0506

Homepage: https://jbrms.medilam.ac.ir

The effect of 24 weeks of resistance training on lipid profile, HBA1c, and insulin resistance in middle-aged women with type 1 diabetes

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Article Info

Article type:
Research Article

Article history:
Received: 6 Jan. 2023
Revised: 25 Feb. 2023
Accepted: 20 Mar. 2023
Published online: 8 Jun. 2023

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ABSTRACT

Introduction: Exercise training has been associated with health outcomes in diabetes, but the effect of long-term resistance training on HBA1c is largely unknown. Therefore, the present study was conducted to determine the effects of resistance training on lipid profile, HBA1c, and insulin in women with type 1 diabetes

Materials and Methods: In this semi-experimental study, 20 women (n =10, with an average age of 54.50 ± 8.16 years, a height of 158.16 ± 5.36 cm) were randomly assigned into two control and experimental groups. A pre-test of the desired indicators (weight, height, waist circumference, hip circumference, fat percentage, fasting blood sugar, and glycosylated hemoglobin level) was performed for both groups. The experimental group performed a circuit resistance activity course (12 stations, 4 rounds, three days a week for 24 weeks). At the end of this period, the desired indicators were evaluated again as a post-test. To interpret the data, analysis of covariance (ANCOA) was used, considering the pre-test as a covariate.

Results: Resistance training for 24 weeks reduced LDL level (P = 0.001), TG (P = 0.001), BF (P = 0.002), WHR (P = 0.033), FBS (P = 0.001), HBA1c (P = 0.001), Insulin (P = 0.001), HOMA-IR (P = 0.001), and increased VO_2max (P = 0.001) and average HDL-C (P = 0.001) in the experimental group compared to the control group. However, there was no significant difference in average BMI (P = 0.129), TG (P = 0.073), and Waist circumstance (P = 0.195) in the control and experimental groups.

Conclusion: Based on the results of the present study, long-term resistance training improves lipid profile, HBA1c, and insulin levels in middle-aged women with type 1 diabetes.

Keywords: Diabetes mellitus, Resistance training, HBA1c, Indicators related to diabetes

How to cite this article: Gharani H, Rahmati M, Mansouri R. The effect of 24 weeks of resistance training on lipid profile, HBA1c, and insulin resistance in middle-aged women with type 1 diabetes. J Bas Res Med Sci. 2022; 9(4) :45-56.

 Publisher: Ilam University of Medical Sciences

Introduction

Diabetes is the most common endocrine disease in humans, which is the top of non-communicable diseases and one of the major causes of death in most societies. The prevalence of diabetes in Iran is estimated between 3 and 4 percent (29). Along with the progress of diabetes, the possibility of complications such as retinopathy, nephropathy, neuropathy, and atherosclerosis increases. In most cases, complete and accurate control of diabetes is impossible, therefore efforts are being made to find better ways to control this disease. Diabetes is known as a debilitating disease due to its many consequences and the creation of various disabilities among people, so more attention should be paid to healthcare cost-reduction programs that are related to diabetes (25). Exercise has a visible effect on food metabolism, especially in reducing blood sugar concentration, which has an important therapeutic value for diabetic patients (25). Type 1 diabetes is caused by the autoimmune destruction of pancreatic beta cells and as a result insulin deficiency. In these patients, the lack of secretion with the decrease in insulin function leads to carbohydrate, fat, and protein metabolism disorder.

The annual incidence of type 1 diabetes in Iran has been estimated at 3.7 cases per hundred thousand people. This figure varies worldwide from 1 to 35 cases per hundred thousand population under 14 years of age, type 1 diabetes which includes about 5 to 10% of cases (15). Genetic and environmental factors are strongly involved in the development of type 2 diabetes, genetic defects are complex and not well defined, but the risk of type 2 diabetes increases with age, obesity, and inactivity (28). While type 1 diabetes is the result of defects in the immune system of insulin-producing cells in the pancreas. Therefore, considering that exercise is associated with a reduction in the symptoms of metabolic syndrome, the effects of exercise on improving the condition of diabetic patients are likely to be more evident (26). Meanwhile, the effect of exercise on type 1 diabetic patients has contradictions. The presence of these contradictions on the one hand and the lack of familiarity with how to prescribe exercise to these patients, on the other hand, make type 1 diabetic patients less likely to benefit from the benefits of participating in sports activities (21). Studies show that it is possible for uncomplicated type 1 diabetes sufferers who have good metabolic control to participate in all levels of sports, regular sports activity increases the rate of metabolism and the speed of glucose transfer and transport in the body and causes improvement in the sensitivity of cells to injected insulin (26). Also, regular exercise activity reduces coronary heart disease by affecting blood lipids. The most common cause of death of diabetics is coronary heart disease. Research shows that regular exercise reduces this risk by 50% (11).

For this reason, the American Diabetes Association (ADA) has identified lack of regular exercise as the fourth risk factor for coronary artery disease, and the other three risk factors include high blood pressure, smoking, and high cholesterol (15). Considering the importance of prevention, control, and side effects of medicinal methods in diabetic people, there has always been an effort to use optimal strategies with low side effects, effective and useful. In recent years, physical activity (endurance and resistance) has been considered for these people as a low-cost strategy without side effects; For example, physical activities control the glycemic status of diabetics (9).

In a study, Sigal et al. reported that increasing the time of physical activity to 150 minutes per week reduces the incidence of diabetes by 5-7% (5). Also, studies have shown that controlling diet and physical activity in diabetic patients have an equal and complementary role in controlling diabetes (24).

Various types of exercise are recommended for people with diabetes, as recommended by the Canadian Diabetes Association (International Diabetes Federation) and the American College of Sports Medicine in their guidelines for the prevention and management of diabetes, respectively Diabetic patients should participate in moderate-intensity physical activity such as brisk walking, swimming, and cycling for at least 150 minutes a week for at least 3 non-consecutive days, and increasing resistance exercises should be part of their physical activity program, because the intensity of the activity Resistance exercises affect improving blood sugar control, and when the intensity of these types of activities reaches 70-90% of a background repetition, the effect of these activities doubles(8,20).

Probably, physical activity through the effect on isoform-4, glucose transporters (4 Glucose Transporter Type) in skeletal muscles and insulin receptor substrates (1-Insulin Receptor Substrate I, IRS) and increasing muscle mass (more than 75% of glucose uptake caused by the stimulation of insulin related to muscle tissue), improves the body's sensitivity to insulin (3).

It has been found that resistance activity improves the body's sensitivity to insulin through skeletal muscle growth; Because following the performance of resistance activity due to the increase in pure muscle mass, glucose uptake also increases (14). Movements in different stations by performing resistance activities can have health benefits in addition to sports benefits; Because in such wellness programs, a large number of stations with various resistance movements can be programmed at the same time, and for this reason, a large number of people can be included in a physical activity program. (9).

In this research, the effect of resistance activities on some indicators of middle-aged female patients with type 1 diabetes was investigated. One of the important aspects of conducting this research is that no study has been conducted for 24 weeks on women with type 2 diabetes with progressive resistance exercises, and no study has definitively shown the beneficial effects of resistance exercises on patients with type 2 diabetes. They have not mentioned one. Therefore, in this research, the researcher intends to investigate the effect of resistance training on the levels of factors (HBA1c, Insulin, FBS, LDL, TC, WHR, HOMA-IR, VO2max, HDL-C, BMI, TG, Waist) in women with type 2 diabetes. Check one.

Materials and Methods

The current research is cross-sectional. The statistical population of the current research was made up of women with type 1 diabetes who had a history of diabetes for more than 12 years living in West Azarbaijan province with an age range of 54-60. First, the necessary information about the importance and method of the research was given to diabetic patients and after obtaining their informed consent, 20 of them were selected and randomly divided into two control groups (10 people) and experimental (10 people) (with code of ethics no. IR.LUMS.REC.1401.293) were divided. The eligibility of the subjects includes not using alcohol, drugs, and food conditions and not having diabetic foot ulcers at the time of evaluation, not having amputations or neurological and orthopedic disorders caused by other diseases, not having Arthritis and joint rheumatism, no severe retinopathy, no abnormalities in the lower and upper limbs, no history of neurological and orthopedic disorders, and no history of surgery in the lower and upper limbs were confirmed by the doctor before entering the study.

Blood Sampling Protocol

Measurement of anthropometric parameters, including height, weight, subcutaneous fat (at three points of the chest, abdomen, and thigh), and estimation through the Jackson-Pollack three-point formula was done during a briefing session along with the explanation of the research objectives.

BMI was calculated through the relevant formula (weight divided by height to the power of 2). The number of calories consumed by the subjects was recorded and calculated using a food memory form at the beginning and end of the exercise program and 24 hours before blood sampling. Finally, according to the evaluation of the calorie intake of the subjects in both groups, in the pre-test and post-test and using the one-way ANOVA test, in addition, to measure the research variables, 48 hours before the start of the plan and again 48 hours One hour after the end of the 24-week training period, blood was taken at rest at 8:00 am and after about 10 hours of fasting at night, blood samples were taken from the antecubital vein while sitting.

After blood collection, the samples were stored in a Bain-Marie incubator at 37°C for 30 minutes and then placed in a centrifuge at a speed of 3000 rpm for 10 minutes to separate the serum. It was extracted, then 2 cc of serum samples were separated and frozen at 20°C to measure insulin hormone indices. The rest of the isolated serum was used to measure FBS, HOMA-IR, HbA1C, Pmol/l, glucose, total cholesterol, triglyceride, HDL, and LDL variables on the same day, biochemical measurements to measure glucose, cholesterol, HDL triglyceride, and LDL was used from Tactitiat RA-XT 1000 autoanalyzer made in America and BioSystems kits made in Spain.

And to measure glucose, the enzymatic glucose oxidase/peroxidase method was used to measure total cholesterol levels, the enzymatic method (cholesterol oxidase reaction with cholesterol esterase and peroxidase reaction) was used, to measure triglycerides, the enzymatic method (lipase hydrolysis, glycerol) was used. kinase) was used. The homogenization method was used to measure HDL and direct measurement and homogenization methods were used to measure LDL.

Weight and body mass index (BMI) measurements of diabetic subjects were measured by the in-body composition device model 570, and body fat percentage (BFP) was measured by the three-point method (brachial, thigh, and upper arm) using the Harinden metal caliper (with (accuracy 0.05 mm) was measured and calculated by Jackson and Pollock's formula. To calculate (WHR), waist circumference was measured at the midpoint between the iliac crest and lower rib margin and hip circumference at the point of maximum gluteal protrusion from the side view to the nearest centimeter. Subjects were introduced to the laboratory for the analysis of blood factors before and after the training intervention (14).

Resistance Training Protocol

After evaluating the level of physical fitness of the subjects of the experimental group for 24 weeks, they participated in resistance exercises four sessions a week and each session lasted about 60 minutes.

The training program includes a 10-minute warm-up with a variety of stretching and softening movements and then performing 12 stationary movements in a circle in 30 to 45 minutes. In the end, 10 minutes of cooling is considered. The stations include 12 types of resistance exercises (leg press, chest press, chest press, shoulder press, forearm, back arm, let and row, squat, knee extension (quadriceps), knee bends (hamstrings, glutes, and hamstrings), sitting leg and (strengthening the twin muscle), plank and crunch. The exercise program in each session consisted of 4 rounds with 10-12 repetitions and with an intensity of 40-65% of a maximum repetition, the rest time between sets was 45-60 seconds and the rest time between each round was 90 seconds. The principle of overload was designed in such a way that after every six training sessions, a test of one maximum repetition was performed for each person at each station, and 5% weight was added to it. The following formula was used to determine a maximum repetition (2).

It should be mentioned that the exercise program of this research will be designed according to Kanoureh et al.'s program which was used in elderly and middle-aged people. Also, in this research, attention was paid to the special recommendations of the American College of Sports Medicine for elderly and middle-aged people (Jan Grestn Li et al 1997). During the training, all the training steps were carried out under the direct supervision of the physical fitness and bodybuilding trainer. The limitations of this research included two categories: controllable limitations and uncontrollable limitations, controlled limitations include gender, age, and general health. All subjects were in the age group of 50 to 65 years and had no history of acute illness and were relatively healthy.

Uncontrollable limitations also include subjects not controlling their excitement and anxiety, individual differences in terms of genetic characteristics and their hereditary characteristics in measuring some indicators, individual differences in subjects in terms of mental and psychological status during training sessions and the impossibility of fully controlling the possibility of contracting a disease or the injury was during the execution of the research. It should be noted that the selected people had no history of participating in any resistance training and were not suffering from heart diseases or special diseases. After filling out the consent form, the subjects were randomly divided into 2 resistance training groups (10 people) and a control group (10 people). First, the general health questionnaire, physical activity level, and medical background were completed by the subjects to evaluate their initial condition. Then the body mass index was calculated using the ratio of weight to kilograms per square of height to meters, and the daily average of systolic and diastolic blood pressure was measured, and the doctor measured the resting heart rate of all of them at 8 to 9 in the morning, using a Beurer machine made in Germany with an accuracy of 1. 0 mm of mercury was measured at the training venue.

It is worth mentioning that a preliminary session of one repetition maximum test (IRM) was performed using the Berziski method for all resistance movements so that finally the intensity of the exercise was performed based on the determined percentage of one repetition maximum for each person (Berziski et al 2010). Also, to control and equalize the amount of exercise, some of the subjects worked in one session two weeks before the start of the exercise program, according to the routine set in the sessions. Then, the maximum repetitions of the individuals in all the movements were recorded and the number of sets and repetitions specified for each training movement was multiplied and the training volume was calculated (ACSM).

Statistical Analysis

Data analysis using SPSS version 22 and Excel software, the analysis of covariance (ANCOA) test was used considering the pre-test as the co-variance (to evaluate between the control and experimental groups).

Results

The information in Table 1 shows that based on the results of the statistical tests used, there is a significant difference in the general and physiological variables of the subjects such as age, weight, height, body mass index, body fat percentage, and waist to hip ratio before from the beginning of the exercises.

Table 1. General and physiological characteristics of subjects in two groups before starting the resistance training program.

Variable	Experimental group (n=10)	Control group (n=10)	P value
Age (year)	54.50 ± 2.55	53.00 ± 1.70	0.098
Weight (kg)	62.01 ± 1.45	63.08 ± 7.48	0.66
Height (meter)	1.57 ± 0.04	1.58 ± 0.05	0.28
Body mass index (kg/m2)	25.27 ± 1.53	25.15 ± 2.07	0.88
Body fat percentage	26.38 ± 1.77	31.22 ± 1.31	0.33
Waist to hip (ratio)	0.77 ± 0.06	0.86 ± 0.03	0.468
Maximum oxygen consumption (ml/kg)	26.21± 2.61	25.14 ± 1.94	0.783

There was no difference between the two experimental and control groups (P > 0.05) and these results showed that the studied groups were homogeneous.

To compare the effect of strength training on diabetes indicators in middle-aged women with type 1 diabetes, an analysis of covariance (ANCOA) test was used, considering the pre-test as a Corit. The results of this test are reported in Tables 2, 3, and 4. The results of the analysis of covariance of the anthropometric indicators in Table .2 showed that after controlling for the pre-test effect, there is a significant difference between the two groups in the amount of body fat percentage, waist-to-hip ratio, and oxygen consumption after the test (P < 0.05) while this difference in weight and body mass index is not significant (P < 0.05).

Also, the results of the analysis of covariance of diabetes indicators in Table 3. showed that after controlling for the pre-test effect, there is a significant difference between the two groups in the amount of glucose, insulin, insulin resistance, and glycosylated hemoglobin in the post-test (P < 0.05).

Table 2. Covariance analysis on the mean post-test scores of anthropometric indices.

Definition	Source of changes	Sum of squares	DF	Mean square	F ratio	Significance level	Eta squared
weight (kg)	pre-test	8.18	1	8.18	0.433	0.519	0.25
	group	34.31	1	34.31	1.82	0.195	0.097
	error	320.32	17	18.84			
Body mass index (kg/m^2)	pre-test	1.13	1	1.13	0.280	0.604	0.016
	group	10.36	1	10.36	2.55	0.129	0.130
	error	69.09	17	4.06			
Body fat percentage	pre-test	30.63	1	30.63	49.46	0.000	0.744
	group	8.09	1	8.09	13.071	0.002*	0.435
	error	10.53	17	0.619			
Waist to hip (ratio)	pre-test	0.002	1	0.002	0.581	0.456	0.033
	group	0.018	1	0.018	5.41	0.033*	0.241
	error	0.057	17	0.003			
VO_2max (ml/kg/min)	pre-test	0.226	1	0.226	0.039	0.846	0.002
	group	156.46	1	156.46	26.92	0.001*	0.613
	error	98.81	17	5.81		0.519	

VO2max: Maximum oxygen consumption.

* It indicates the significance of the variable between the two groups at the level P < 0.05.

Table 3. Covariance analysis on the average post-test scores of diabetes indicators.

Definition	Source of changes	Sum of squares	DF	Mean square	F ratio	Significance level	Eta squared
Glucose (ml/dl)	pre-test	190826.05	1	190826.05	5.58	0.030	0.25
	group	190826.05	1	190826.05	10.88	0.001*	0.864
	error	30071.55	17	1768.91			
Insulin (µU.ml)	pre-test	28.05	1	28.05	5.27	0.035	0.237
	group	309.96	1	309.96	58.21	0.001*	0.774
	error	90.52	17	5.32			
Insulin resistance	pre-test	17.07	1	17.07	2.29	0.148	0.119
	group	938.06	1	938.08	125.91	0.001*	0.881
	error	126.65	17	7.45			
Glycated Hb (ml/dl)	pre-test	27.38	1	27.38	35.87	0.001	0.678
	group	113.46	1	113.46	148.60	0.001*	0.897
	error	12.98	17	0.76			

Hb: Glycated hemoglobin

* It indicates the significance of the variable between the two groups at the level P < 0.05.

Also, the results of the covariance analysis of lipid profile indicators in Table 4 showed that after controlling the effect of the pre-test (Corit), there is a significant difference between the two groups in the amount of total cholesterol, high-density lipoprotein, and low-density lipoprotein in the post-test (P < 0.05) while this difference in triglyceride level is not significant (P < 0.05).

Table 4. Covariance analysis on the average post-test scores of lipid profile indicators.

Definition	Source of changes	Sum of squares	DF	Mean square	F ratio	Significance level	Eta squared
Cholesterol (ml/dl)	pre-test	58.04	1	58.04	0.123	0.730	0.007
	group	11006.68	1	11006.68	23.37	0.001*	0.579
	error	8006.96	17	470.99			
Triglycerides (ml/dl)	pre-test	2.60	1	2.60	0.001	0.927	0.001
	group	7232.30	1	7232.30	3.64	0.073	0.176
	error	33777.89	17	1986.93			
HDL (ml/dl)	pre-test	224.76	1	224.76	2.96	0.0103	0.148
	group	1866.21	1	1866.21	24.59	0.001*	0.0591
	error	1290.14	17	75.89			
LDL (ml/dl)	pre-test	674.31	1	674.31	2.41	0.139	0.124
	group	10912.08	1	10912.08	39.04	0.001*	0.697
	error	4752.19	17	279.54			

HDL: High density lipoprotein (ml/dl), LDL: Low density lipoprotein.
* It indicates the significance of the variable between the two groups at the level P < 0.05.

Discussion

Considering the increasing prevalence of type 1 diabetes around the world and the fact that diabetes is one of the diseases in which the immune system is activated; Now this theory has been strengthened that one of the main factors of the close relationship between cardiovascular diseases and diabetes is the activation of the immune system and inflammation. The present study investigated the effect of six months of resistance training on the levels of indicators of type 1 diabetic patients (15,25).
Based on the findings of the present study, resistance training on type 1 diabetic patients after 24 weeks of training led to a significant increase in HDL-C level and a decrease in LDL, total cholesterol, fat percentage, WHR, and triglyceride levels, However, this decrease in weight, triglyceride, and BMI were not significant, but the level of glucose, HBA1c, plasma insulin, and insulin resistance index in patients decreased significantly. Several factors can justify these effects in the way that physical activities cause changes in body composition, and some of these changes include reducing the percentage of fat, increasing energy consumption at rest, increasing bone density, increasing the volume of lean muscle mass, and reducing risk Diseases come back (6, 21).
The results of this research were consistent with the initial studies by Patterson et al., which showed a significant reduction in A1C levels (from 10.3% to 7.6%), reduction in blood pressure, heart rate, and average body fat in 10 adults with type 1 diabetes. Similarly, a study by Mosher et al. showed an increase in lean body mass and a significant improvement in A1C levels (from 7.72% 1.26% to 6.76% 1.07%) in 10 adolescents with type 1 diabetes after 12 weeks of exercise. It became circular (6,16, 25).
And also, in the study of Salem et al. in Egyptian children and adolescents with type 1 diabetes, including a combination of aerobic and resistance exercises, the results published in the group that regularly performed sports exercises, more improvements were observed than in the control group, so that improvements in waist circumference, lipid profile, and insulin dose were observed in both exercise groups, which were associated with an increase in training volume. Plasma glucose levels decreased rapidly during aerobic exercise, and as a result, within 10 minutes

after exercise, glucose levels were significantly lower than in the control group. While the reduction of glucose levels during resistance training was more gradual, with the difference that it became significant after 45 minutes of training compared to the control group (23).

Contrary to previous studies, a small study by D'Hooge et al showed that a combination of aerobic exercise (30 minutes) and strength training (30 minutes) performed twice a week improves muscle strength and endurance and reduces insulin dosage, It did not have a significant effect on body composition or A1C levels in patients with type 1 diabetes, however, participants in the D'Hooge et al. study were less cooperative and did not control their diet during the study, both of which could negatively affect the result (5).

Also, Durak et al. divided 8 people into 2 random groups in a cross-over design: 1 group that had no activity for 6 weeks before participating in a 10-week resistance training program, and the second group after the implementation of the 10-week resistance training program. They rested completely for 6 weeks. This exercise consisted of 3 sessions per week (each session approximately one hour) of resistance exercises. After 6 weeks of the non-exercise group, the mean A1C was 6.9% 1.4%, while immediately after the exercise it was measured at 5.8% 0.9% (p¼ 0.05) and also reduced serum cholesterol and blood glucose levels (7).

In a separate study, Ramalho et al randomized 16 previously sedentary participants with type 1 diabetes to 12 weeks of aerobic exercise 3 times per week, and 12 weeks of resistance exercise 3 times per week. Although the reduction in A1C level found in the resistance training group was not statistically significant, aerobic training caused a significant increase in A1C (19).

It should be noted that the benefits of resistance exercise in type 1 diabetes are less clear, but clinical trials show improved body composition and strength, increased insulin sensitivity, and possibly modest reductions in A1C. Compared to aerobic exercise, resistance exercise is associated with a lower risk of hypoglycemia for people with type 1 diabetes (3,17).

Resistance training in adults with diabetes improves glycemic control (reflected by lowering A1C), It reduces insulin resistance and increases muscle strength, lean muscle mass, and bone mineral density, leading to improved functional status and prevention of sarcopenia and osteoporosis. Physical activity along with diet and drug therapy is one of the three cornerstones of type 1 diabetes treatment and care (25, 27, 28).

Several factors can justify these effects in such a way that physical activities cause changes in body composition, and part of these changes are related to the reduction of fat percentage and increase in muscle mass. Blood lipid disorders are among the adverse changes in diabetic patients, which cause the spread of vascular complications and increase the risk of cardiovascular diseases in these people, therefore, one of the treatment goals is to improve blood lipid disorders in patients with this disease (6,18).

Physical activity and exercise have been considered one of the basic pillars of diabetes care and management for several decades, and the low cost and non-pharmacological nature of physical activity increase its therapeutic importance. Previous findings indicate improvement in insulin sensitivity and resistance and a reduction in the use of hypoglycemic drugs after exercise (28).

Exercise significantly increases the effect of insulin on skeletal muscle. The mechanism related to adaptive changes such as increased capillary density, increased growth rate of glucose carriers especially (GLUT4), and shift to insulin-sensitive fibers and possible changes in the composition of sarcolemma phospholipids, increased glycolytic enzyme activity and increased glycogen activities It is synthetase (26).

Exercise increases AMP-activated protein kinase, which is caused by increased translocation of GLUT4 to surface membranes. AMPK activity also increases glucose transport by increasing the amount of cell surface GLUT4 in insulin-resistant skeletal muscle and mediates the effects of GLUT4 expression. Positive changes in blood sugar are mainly caused by the cumulative effects of reducing blood sugar levels several times with each exercise session (4).

Aerobic exercise can alter the effect of insulin on each muscle fiber without increasing fiber size, while resistance training preferentially improves glucose uptake by increasing the size of each muscle fiber. Frequent muscle contractions during sports activities have an insulin-like effect and send a large amount of glucose into the cells to be used for energy production. These repeated contractions increase the number of GLUT4 and increase the permeability of the membrane to glucose (12,13).

It also allows the muscle fibers during activity to have a relatively long period of low glycogen concentration, which can result in a decrease in blood sugar and fructosamine after a period of training. Also, Hal et al., in a study reported a decrease in insulin levels and an improvement in insulin sensitivity in patients with type 1 diabetes following aerobic and resistance training (10).

Anaerobic exercises with resistance can improve the size, strength, and power of muscles, and hence it is used as a healthy therapeutic tool in elderly and sick people. Strength exercises can increase insulin sensitivity and daily energy consumption to improve the quality of life (21).

Muscle contraction has an insulin-like role and sends a large amount of glucose into the cell to be used for energy production.

Also, exercise leads to a decrease in the amount of mRNA necessary for the production of proinsulin and glucokinase in the pancreas. So, it appears that there are at least two cellular mechanisms to reduce insulin secretion. First, a decrease in proinsulin mRNA indicates a decrease in insulin synthesis in the liver. Second, since the presence of glucokinase in the liver is necessary for the sensitivity of pancreatic beta cells to insulin, Therefore, the reduction of glucokinase mRNA may lead to a decrease in the sensitivity of these cells to insulin and decrease its secretion (22).

Also, among other possible reasons for positive changes in glycemic control in diabetic patients, it can be pointed out that after physical exercises, the protein content of insulin receptors and also the activity of protein kinase B, which plays an essential role in the transmission of insulin signals, increases, which can lead to a decrease in blood sugar. There is also the possibility that exercise causes changes in some cytokines, including the reduction of (retinol bound to protein 4), which as an adipokine is involved in regulating insulin action and carbohydrate metabolism, and is one of the effective factors in the occurrence of impaired glucose tolerance and its consequences, it has been identified as diabetes. As mentioned, exercise can be effective in reducing RBP4 and subsequently in insulin sensitivity and reducing glycemia in diabetics (13).

In the present study, although an attempt was made to control the diet of the patients, it seems that there were limitations such as the lack of complete monitoring of the diet in the entire period, and also no complete control was performed on other non-sports physical activities. To fully understand the mechanisms involved in the results observed in this study, more detailed investigations are needed in the future. Overall, the findings of the present study confirm the undeniable beneficial effects of exercise in patients with type 1 diabetes (21).

The mental condition and motivation of the subjects during the tests were beyond the control of the researcher, but the researcher tried to increase the motivation among the subjects. Furthermore, the subjects' training level in the past and the subjects' genetic characteristics were uncontrollable.

Conclusion

It seems that regular resistance training for six months on diabetic patients, which has not been researched on type 1 diabetic patients for 24 weeks, has a positive role in controlling glycemic status, lipid profile, and body composition and improving insulin resistance, and preventing cardiovascular disease risk factors (27,28).

Acknowledgments

This article is taken from a student's dissertation in the Ph.D. in exercise physiology (with code of ethics no. IR.LUMS.REC.1401.293) in the Faculty of Physical Education of Lorestan University. The researchers express their utmost gratitude and appreciation to the officials of Lorestan University who helped us in conducting this research with our own participation, and to all the people who collaborated in this study.

References

1. American Diabetes Association. (2011). Standards of medical care in diabetes. Diabetes Care, 34: 11-61. American.
2. Behjati Ardakani A, Qassemian A, Koushki M, Shakour E, Mehrez A. The Effect of a Resistance Training Course on Blood Pressure and Nitric Oxide Levels in Elderly Women. Salmand: Ira J Age. 2018; 13 (1):16-27.
3. Chimen M, Kennedy A, Nirantharakumar K, Pang TT, Andrews R, Narendran P. What are the health benefits of physical activity in type 1 diabetes mellitus? A literature review. Diabetologia. 2012;55(3):542-51. doi: 10.1007/s00125-011-2403-2.
4. Codella R, Ialacqua M, Terruzzi I, Luzi L. May the force be with you: why resistance training is essential for subjects with type 2 diabetes mellitus without complications. Endocrine. 2018 Oct;62(1):14-25. doi: 10.1007/s12020-018-1603-7.
5. D'Hooge R, Hellinckx T, Van Laethem C, et al. Influence of combined aerobic and resistance training on metabolic control, cardiovascular fitness and quality of life in adolescents with type 1 diabetes: a randomized controlled trial. Clin Rehabil. 2011;25:349e59.
6. Diabetes Canada Clinical Practice Guidelines Expert Committee. Sigal RJ, Armstrong MJ, Bacon SL, Boulé NG, Dasgupta K, Kenny GP, et al. Physical Activity and Diabetes. Can J Diabetes. 2018 Apr;42 Suppl 1: S54-S63. doi: 10.1016/j.jcjd.2017.10.008.
7. Donges CE, Duffield R, Drinkwater EJ. Effects of resistance or aerobic exercise training on interleukin-6, C-reactive protein, and body composition. Med Sci Sports Exerc. 2010;42:304e13.
8. Exercise training on insulin sensitivity measures in stz-induced type 1 diabetic rodents. metabolism 2013
9. Ezenwaka C, Eckel J. Prevention of diabetes complications in developing countries: time to intensify self-management education. Arch Physiol Biochem. 2011;117(5):251-3.
10. Fathi M, Rahmani M, Rahmati M, Valipour V. The Effect of Resistance Activity on Diabetes Indicators in Women with Type 2 Diabetes. Qom Uni Med Sci J. 2018;12(7): 41-50.
11. Hall KE, McDonald MW, Grisé KN, Campos OA, Noble EG, Melling CJ. The role of resistance and aerobic
12. Iguro H, Kodama S, Horikawa C, et al. In search of the ideal resistance training program to improve glycemic control and its indication for patients with type 2 diabetes mellitus: A systematic review and meta-analysis. Sports Med. 2016; 46:67-77.
13. International Diabetes Federation (IDF), World diabetic pre valence

(2017).
14. International Diabetes Federation (IDF). Diabetes Atlas. 9th ed. https://www.diabetesatlas.org/en/sections/demographicand-geographic-outline.html; 2019 [accessed 16 May 2020].
15. Jafarnezhadgero Amir Ali. Effect of Combined Trainings (Rom improvement, Muscle Strengthening, Balance Training, and Gait Training) on Balance and Risk for Falling in Older Women with Diabetic Peripheral Neuropathy. J Rehabil Med. 2019;8(2):97-105.
16. Moghaddasi Y, Ghazalian F, Abediankenari S, Ebrahim K, Abednatanzi H. Effect of Aerobic and Resistance Training on GDF-15 Levels in Patients with Type 1 Diabetes. J Mazandaran Univ Med Sci. 2020; 30 (186) :123-132.
17. Moore J, Mitchell N, Bibeau W, Bartholomew J. Effects of a 12-week resistance exercise program on physical self-perceptions in college students. Res Q Exerc Sport. 2011; 82:291.Oct; 62(10):1485-94
18. Pesta, DH, Goncalves RLS, Madiraju AK. Resistance training to improve type 2 diabetes: working toward a prescription for the future. Nutr Metab (Lond). (2017;14(24). doi:10.1186/s12986-017-0173-7.
19. Rahimi N, Marandi SM, Kargarfard M. Effect of 8 weeks of water-based exercise on lipidprofile in patients.
20. Ramalho AC, de Lourdes Lima M, Nunes F, et al. The effect of resistance versus aerobic training on metabolic control in patients with type-1 diabetes mellitus. Diabetes Res Clin Pract. 2006;72:271e6.
21. Rawal LB, Tapp RJ, Williams ED, Chan C, Yasin S, Oldenburg B. Prevention of type 2 diabetes and its complications in developing countries: a review. Int J Behav Med. 2012;19(2):121-33.
22. Reddy R, Wittenberg A, Castle JR, El Youssef J, Winters-Stone K, Gillingham M, Jacobs PG. Effect of Aerobic and Resistance Exercise on Glycemic Control in Adults with Type 1 Diabetes. Can J Diabetes. 2019;43(6):406-414. doi: 10.1016/j.jcjd.2018.08.193.
23. Colberg SR, Sigal RJ, Yardley JE, Riddell MC, Dunstan DW, Dempsey PC, et al. Physical activity/exercise and diabetes: a position statement of the american diabetes association. Diabetes Care 2016; 39:2065-79.
24. Salem MA, AboElAsrar MA, Elbarbary NS, ElHilaly RA, Refaat YM. Is exercise a therapeutic tool for improvement of cardiovascular risk factors in adolescents with type 1 diabetes mellitus? A randomised controlled trial. Diabetol Metab Syndr. 2010;2(1):47. doi: 10.1186/1758-5996-2-47.
25. Sigal RJ, Kenny GP, Wasserman DH, Castaneda-Sceppa C. Physical activity/exercise and type 2 diabetes. Diabetes Care. 2004;27(10):2518-39. doi: 10.2337/diacare.27.10.2518.
26. Sun H, Saeedi P, Karuranga S, Pinkepank M, Ogurtsova K, Duncan BB, et al. IDF Diabetes Atlas: Global, regional and country-level diabetes prevalence estimates for 2021 and projections for 2045. Diabetes Res Clin Pract. 2022; 183:109119. doi: 10.1016/j.diabres.2021.109119.
27. Yardley JE, Kenny GP, Perkins BA, Riddell MC, Balaa N, Malcolm J, et al. Resistance versus aerobic exercise: acute effects on glycemia in type 1 diabetes. Diabetes Care. 2013 Mar;36(3):537-42. doi: 10.2337/dc12-0963.
28. Yen FS, Lo YR, Hwu CM, Hsu CC. Early-onset type 2 diabetes <60 years and risk of vascular complications. Diabetes Res Clin Pract. 2021; 182:109129. doi: 10.1016/j.diabres.2021.109129.
29. NeamŢu MC, Avramescu ET, Marcu IR, Turcu-Ştiolică A, Boldeanu MV,

NeamŢu OM, et al. The correlation between insulin-like growth factor with glycemic control, glomerular filtration rate, blood pressure, hematological changes or body mass index in patients with type 2 diabetes mellitus. Rom J Morphol Embryol. 2017;58(3):857-861.