

## Effect of endurance, resistance and combined trainings on glyceimic control and lipid profile of type2 diabetic patients

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### Abstract

*Introduction:* Diabetes is a chronic, metabolic disease characterized by elevated levels of blood glucose (or blood sugar), which leads over time to serious damage to the heart, blood vessels, eyes, kidneys and nerves. The aim of study was to determine the effect of endurance, resistance and combined trainings on glyceimic control and lipid profile in type 2 diabetic patients.

*Material & Methods:* Subjects selected between diabetic clinic patients of Valliasr hospital of Fasa and members of Fasa diabetic association. 40 patients with necessary conditions (medical history) are selected by physician and randomly divided to equal 4 groups: endurance, resistance, combined and control. Patients both received own medications (consuming pills & diet) and did trainings program in 8 weeks (3 sections per week) under trainer consideration. Plasma levels of total cholesterol (TC), triglycerides (TG), LDL, HDL, glycated hemoglobin (HbA<sub>1c</sub>), insulin, fasting

blood sugar (FBS) and insulin resistance were measured before and after the intervention.

*Results:* The results indicated that insulin concentration and HbA<sub>1c</sub> decreases and HDL increases after resistance training ( $P < 0.05$ ). Combined trainings reduced insulin and TC concentration and increased HDL level in compare to the control group ( $P < 0.05$ ). Any changes in lipid profile and glycemc control were observed after the endurance training.

*Conclusion:* Our findings suggested that resistance and combined training improve insulin concentration and lipid profiles rather than endurance training in type 2 diabetic patients.

**Keywords:** Type 2 diabetes, Endurance training, Resistance training, Combined training

## 1. Introduction

Diabetes mellitus, often simply referred to as diabetes, is a group of metabolic diseases in which a person has high blood sugar (hyperglycemia), either because the body does not produce enough insulin by the pancreas, or because cells do not respond to the insulin that is produced (1). Type 1 diabetes is the results from the body's failure to produce insulin from the  $\beta$ -cells in the pancreas. Presently requires the person to inject insulin, thus this type has also referred to as insulin-dependent diabetes mellitus (IDDM) (2). Type 2 diabetes is the results of the ineffectiveness of insulin to facilitate the transport of glucose into the cells and is a result of insulin resistance. This type has also referred to as non-insulin-dependent diabetes mellitus (NIDDM). Type 2 diabetes accounts for 80% to 90% of all cases of diabetes (1,2).

Diabetes complications are common among patients with type 1 or type 2 diabetes but, at the same time, are responsible for significant morbidity and mortality. The chronic complications of diabetes are broadly divided into microvascular and macrovascular, with the former having much higher prevalence than the latter (3). Microvascular complications include neuropathy, nephropathy, and retinopathy, while macrovascular complications consist of cardiovascular disease, stroke, and peripheral artery disease (PAD) (4). Even in people without

diabetes, fasting blood glucose concentration and glycated hemoglobin (HbA<sub>1c</sub>) are associated with the risk of vascular disease (5,6). In type 2 diabetes an increased cardiovascular risk often exists for many years before the onset of biochemical hyperglycemia. During this period obesity and insulin resistance are often present, associated with hypertension and dyslipidemia, usually referred to as metabolic syndrome (7). These risk factors may lead to the early development of cardiac heart diseases and may account for the increased incidence of diabetes in the period following a diagnosis of cardiovascular disease (8).

Several evidence have established that a physically active lifestyle reduces the risk of developing type 2 diabetes, but the effects of aerobic, resistance and combined training on insulin resistance and lipid profile in patients with type 2 diabetes are unclear.

Kelley et al. (2007) reported that LDL was decreased in response to endurance training, but these exercise had not significant effects on HDL, TC, or TG (9). However, Nematollahzadeh and Shirazi-nezhad (2017) indicated that lipid profile and insulin resistance were improved in repose to high intensity endurance training (10). Hamasaki et al. (2015) indicated that plasma HbA<sub>1c</sub> levels were decreased and serum HDL was increased after low-intensity resistance training, but these exercise had not significant effects on fasting plasma glucose, serum total cholesterol, TG, or LDL (11). However, Tavakol and Nematolahzadeh Mahani (2019) reported that insulin resistance improves after 8 weeks resistance training (12). Hojjati and Shahsavari (2015) found that aerobic and combined training lead to decrease TG and TC but these exercise had not significant effects on HDL or LDL (13). According to conflicting results of some studies about the effect of aerobic, resistance and combined training on serum lipids and glucose control in patients with type 2 diabetes; the present study was done to determine the effect of endurance, resistance and combined trainings on glycemic control and lipid profile in type 2 diabetic patients.

## 2. Materials & Methods

### *Subjects*

Forty men with type 2 diabetes (35-55 years of old) admitted to Valliasr hospital of Fasa for glycemic control, volunteered to participate in this semi-quasi study. All the subjects were asked to complete a personal health and medical history questionnaire, which served as a screening tool. All the subjects had slightly insulin resistance and all of them were complete inactive at least 6 month before the study and they were nonsmokers and free from unstable chronic condition including dementia, retinal hemorrhage and detachment; and they have no history of myocardial infarction, stroke, cancer, dialysis, restraining orthopedic or neuromuscular diseases. The subjects were given both verbal and written instructions outlining the experimental procedure, and written informed consent was obtained. Then, the subjects were randomly assigned to endurance group (n=10), resistance group (n=10), combines group (n=10) or control group (n=8).

### *Exercise training*

#### *Endurance training*

The subjects in the endurance group were performed aerobic training 3 days a week for 8 weeks at an intensity corresponding to 70% individual maximum oxygen consumption for 25 to 35 min. Each participant was equipped with a heart rate monitor (Polar, FS3c, Finland) to ensure accuracy of the exercise level.

#### *Resistance training*

Subjects in the resistance group executed eight resistance exercises selected to stress the major muscle groups in the following order: chest press, shoulder press, barbell curls, triceps press, leg extension, leg curls, calf raises and sit-ups. Resistance training consisted of 30-50 min of station weight training per day, 3 days a week, for 8 weeks. This training was performed in 8 stations and included 3 sets with 10-15 maximal repetitions at 60-80% of 1-RM in each station. General and specific warm-up were performed prior to each training session, as explained for the 1-RM determination, and each training session was followed by cool-down.

*Combined training*

Combined training included the same aerobic and resistance training that performed by the endurance and resistance groups, while the aerobic training was performed for 15 min and the resistance training was performed for 15 to 20 min in each session. These training also were performed 3 days a week for 8 weeks.

Control group were instructed not to change their physical activity and diet. All the measurements were repeated 48h after the last session of training.

*Biochemical analyses*

Fasting blood samples were collected at rest (before training) and after training. All the subjects fasted at least for 12 hours and a fasting blood sample was obtained by venipuncture. Plasma glucose was determined by the enzymatic (GOD-PAP, Glucose Oxidase-Amino Antipyrine) colorimetric method (Pars Azmoun, Tehran, Iran). The intra and inter-assay coefficients of variation for glucose were <1.3% and a sensitivity of 1 mg/dl. The serum insulin level was measured by a radioimmunoassay (RIA) method. Serum TC and TG levels were measured by enzymatic kits (Mann Chemical Company) using an auto analyzer. LDL-C and HDL-C were measured by an Auto analyzer using commercial kits (Pars Azema Company, Teheran, Iran). The study protocol is shown in the Table 1.

Table 1. Study protocol

Group	Baseline	8 weeks intervention	48h after
<b>Endurance training</b>	Blood sampling	25 to 35 min running with 70% maximum oxygen consumption 3 days a week	Blood sampling
<b>Resistant training</b>	Blood sampling	30-50 min resistance training at 60-80% of 1-RM with 3 sets and 10-15 maximal repetitions in each station 3 days a week	Blood sampling
<b>Combined trainings</b>	Blood sampling	15 min running with 70% maximum oxygen consumption combined to 15-20 min resistance training at 60-80% of 1-RM with 3 sets and 10-15 maximal repetitions in each station 3 days a week	Blood sampling
<b>Control</b>	Blood sampling	Routine physical activity	Blood sampling

### Statistical analysis

Results were expressed as the mean  $\pm$  SD and distributions of all variables were assessed for normality. Data were analyzed using one-way ANOVA t-test. Post hoc analyses (Bonferroni) were then performed when warranted. The level of significance in all statistical analyses was set at  $P < 0.05$ . Data analysis was performed using SPSS software for windows (version 22, SPSS, Inc., Chicago, IL).

### 3. Results

Changes of fasting blood glucose, fasting insulin and lipid profile of the subjects in response to 8 weeks of endurance, resistance and combined training are presented in the Table 2. The results indicated that insulin concentration and HbA<sub>1c</sub> decreases and HDL increases after resistance training ( $P < 0.05$ ), however for FBS, TC, TG and LDL no significant changes were observed after these training.

The results also revealed that combined trainings reduced insulin and TC concentration and increased HDL level in compare to the control group ( $P < 0.05$ ). These training had not significant effects on FBS, HbA<sub>1c</sub>, TG and LDL. As shown in the Table 2, any changes in lipid profile and glycemic control were observed after the endurance training.

Table 2. Changes of blood glucose, insulin and lipid profile of the subjects (mean  $\pm$  SD)

GroupVariables	Endurance training		Resistance training		Combined training		Control	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
TC(mg.dl)	175.6 $\pm$ 22.1	168.4 $\pm$ 20.1	167.5 $\pm$ 13.4	160 $\pm$ 12.8	166.1 $\pm$ 18.3	155.3 $\pm$ 15.6 <sup>abc</sup>	164.4 $\pm$ 21.8	168.2 $\pm$ 26.1
TG(mg.dl)	189.6 $\pm$ 23.4	187.0 $\pm$ 24.5	219.2 $\pm$ 31.3	217.3 $\pm$ 34.6	174.8 $\pm$ 16.7	172.8 $\pm$ 17.8	191.4 $\pm$ 24.4	201.6 $\pm$ 25.7
HDL (mg.dl)	38.4 $\pm$ 6.8	39.0 $\pm$ 6.1	37.7 $\pm$ 7.9	41.0 $\pm$ 6.5 <sup>ab</sup>	37.3 $\pm$ 7.7	50.5 $\pm$ 8.1 <sup>ab</sup>	39.1 $\pm$ 5.6	38.7 $\pm$ 4.9
LDL(mg.dl)	104.3 $\pm$ 22.5	101.5 $\pm$ 21.0	89.9 $\pm$ 12.4	87.1 $\pm$ 16.5	121.0 $\pm$ 10.2	117.6 $\pm$ 17.4	113.7 $\pm$ 15.7	116.7 $\pm$ 14.8
FBS(mg.dl)	169.9 $\pm$ 31.1	161.2 $\pm$ 30.9	151.9 $\pm$ 23.4	142.1 $\pm$ 22.1	184.9 $\pm$ 25.5	175.0 $\pm$ 26.7	162.3 $\pm$ 23.1	165.8 $\pm$ 21.8
Insulin( $\mu$ U/ml)	14.2 $\pm$ 1.3	12.2 $\pm$ 1.2	13.3 $\pm$ 2.1	10.9 $\pm$ 2.1 <sup>a</sup>	14.5 $\pm$ 3.1	12.1 $\pm$ 2.9 <sup>a</sup>	14.6 $\pm$ 1.2	14.8 $\pm$ 2.0
HbA <sup>1c</sup> (%)	6.5 $\pm$ 0.9	6.2 $\pm$ 0.8	8.0 $\pm$ 0.9	7.0 $\pm$ 1.0 <sup>abd</sup>	9.7 $\pm$ 1.1	9.1 $\pm$ 1.0	7.7 $\pm$ 0.7	8.0 $\pm$ 0.4

a. Significant differences with control group ( $P < 0.05$ )

b. Significant differences with endurance training group ( $P < 0.05$ )

c. Significant differences with resistance training group ( $P < 0.05$ )

d. Significant differences with combined training group ( $P < 0.05$ )

#### 4. Discussion

Exercise is generally recommended for people with type 2 diabetes. Several studies have evaluated the effects of exercise training on glycemic control. However, the beneficial effects of different types of exercise on glycemic control have not been well differentiated. The present study was designed to compare the beneficial effects of endurance, resistance and combined trainings on glycemic control and lipid profile in type 2 diabetic patients.

The results indicated that HbA<sub>1c</sub> decreases only after resistance training. Combined and endurance training had not significant effects on HbA<sub>1c</sub>. Bweir et al. (2009) also indicated that resistance exercise training lowers HbA<sub>1c</sub> more than aerobic training in adults with type 2 diabetes (14). However, de Lade et al. (2016) reported that both aerobic and strength training equally lowers HbA<sub>1c</sub> in the patients with type 2 diabetes (15). The reduction in HbA<sub>1c</sub> levels is associated with a decreased risk of cardiovascular events and microvascular complications, so regular physical exercise over time can assist in effective glycemic control, reducing the risk of vascular complications (16). In absolute numbers, a 1% reduction in HbA<sub>1c</sub> value is associated with a reduction between 15 and 20% of the risk of cardiovascular problems and 37% of the risk of microvascular complications (17).

The results revealed that insulin concentration was decreased after resistance and combined training in compare to the endurance training. Tavakol and Nematolahzadeh Mahani (2019) and Holten et al. (2004) also demonstrated that insulin concentration was decreased in response to resistance training (12,18). Holten et al. (2004) reported that that the mechanisms responsible for the improvements in insulin action included both up-regulation of components in the insulin-signaling cascade, such as protein concentrations of the insulin receptor, protein kinase B, and glycogen synthase, as well as the glucose transporter GLUT4 (18). On the other hand, resistance exercise increases insulin effect in skeletal muscle dramatically. The related mechanism involves inconsistencies such as increasing capillary density, increasing the amount of glucose-carrying proteins, especially GLUT4, and shifting to the types of insulin-sensitive myofibrils and possible changes in the composition of

sarcolemma phospholipids, increasing glycolic and oxidative enzyme activity, and increasing glycogen activity synthesise (19).

HDL level increases after resistance and combined training and TC concentration decreases after combined training however for TG, LDL and FBS no significant changes were observed in response to different types of exercise. There is limited literature that has examined the two modalities combined, although a review by Tambalis et al. (2009) suggested that although some combination protocols have been effective in lowering LDL cholesterol and increasing HDL cholesterol, others have not (20). Hojjati and Shahsavari (2015) reported that TC concentration decreases after aerobic and combined training however the reduction of TC concentration was higher after the combined training (13). Hamasaki et al. (2015) indicated that plasma HbA<sub>1c</sub> levels were decreased and serum HDL was increased after low-intensity resistance training, but these exercise had not significant effects on fasting plasma glucose, serum total cholesterol, TG, or LDL (11). The effects of physical exercises and sport on lipid profile are mostly imposed to the peripheral tissues and the liver and allow the existing mechanisms to increase the effect of Lecithin coulin acil transferase enzyme through sport activities. This enzyme is responsible for transferring cholesterol ester from HDL to other lipoproteins. Occurrence of these changes are associated with other factors including changes of plasma hormones and lipoprotein lipase, (21) and maybe these effective factors might have played a role in obtaining such findings.

## 5. Conclusion

Our findings suggested that resistance and combined training improve insulin concentration and lipid profiles rather than endurance training in type 2 diabetic patients.

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**Conflict of interests:** None of the authors declare competing financial interests.

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