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Effects of aerobic exercise on lipids profile and insulin resistance in patients with type 2 diabetes

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Abstract

Aim: Lipid abnormalities significantly contribute to the increased risk of cardiovascular disease and other morbidity in diabetics. The aim of present study was to examine the effect of 8 weeks aerobic training on lipid profile and insulin resistance in patients with type 2 diabetes.

Material & Methods: Twenty four middle-aged men (age, 40 - 50 years, 44.0 ± 2.3 mean ± SD) with type 2 diabetes participated as the subject. The subjects were randomly assign to control group (n=12) or the training group (n=12). The subjects in the training group performed 35 to 50 min aerobic training on bicycle ergometer with 40-55% of their heart rate reserve (HRR), 3 days a week for 8 weeks. The subjects in the control group were instructed to maintain their normal physical activity throughout the study.

Results: The results indicated blood lipid profile improved in the training group. The results also revealed that fasting blood sugar, fasting insulin and insulin resistance index decrease in the training group compare to the control group ($P<0.05$).

Conclusion: In summary, it seems that aerobic training utilized in this study improves blood lipid profile and insulin resistance in patients with type 2 diabetes.

Keywords: Dyslipidemia, Type 2 diabetes, Aerobic training, Insulin resistance, Cardiovascular disease

1. Introduction

Diabetes mellitus is a worldwide health problem predisposing to markedly increased cardiovascular mortality and morbidity (1). Lipid abnormalities significantly contribute to the increased risk of cardiovascular disease and other morbidity in diabetics (2). There is a growing body of evidence showing that hyperglycaemia and dyslipidaemia are linked to increased cardiovascular risk (3). It has been demonstrated that high levels of serum total cholesterol (TC), triglycerides (TG), LDL, VLDL, glycated haemoglobin (HbA_{1c}), microalbuminuria, hypertension, low concentration of HDL and increased body mass index (BMI) are significantly associated with coronary heart disease (4).

Exercise is a major therapeutic modality in the treatment of diabetes mellitus (5-7). Regular physical exercise has been reported to be effective in the prevention and delay of onset of type 2 diabetes, increases insulin sensitivity, and ameliorates glucose metabolism (8). Some benefits of exercise are could be useful for cardiovascular disease by favorable changes in blood lipid profile, improved blood pressure, increased insulin sensitivity, weight loss, maintaining optimal weight, glycemic control and improved quality of life (9-11). The mechanism of acute effects of exercise on blood lipid profile are not well known and there are few studies that have investigated different types of exercises in the same

population (12), while the long-term effects of exercise training on lipid profile are well known (13,14).

The effects of exercise training on the lipid profile of persons with type 2 diabetes are not well known. For example, 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 (15). However, Hayashino et al (2012) indicated that HDL, LDL, and TC levels were improved in repose to aerobic exercise (16). According to conflicting results of some studies about the effect of acute exercise on serum lipids; the present study was done to determine the effect of 8 weeks aerobic training on lipid profile and insulin resistance in patients with type 2 diabetes.

2. Materials and methods

Subjects

Twenty four middle-aged men (age, 44.0 ± 2.3 mean ± SD years of old) with Type 2 diabetes participated in the present study as the subject. All subjects were non-smokers and had not participated in regular exercise/diet programs for the preceding 6 months. The exclusion criteria were as follows: Patients with known history of acute or chronic respiratory infections, neuromuscular disease, and cardiopulmonary disease. In addition, exclusion criteria included inability to exercise and supplementations that alter carbohydrate and fat metabolism. The subjects were given both verbal and written instructions outlining the experimental procedure, and written informed consent was obtained. The study was approved by the Islamic Azad University, Gachsaran branch Ethics Committee. The subjects were divided into training group (n=12) or control group (n=12) based on their insulin resistance index.

Table 1. Demographic characteristics (mean ± SD) of the subjects in each group

	Training group (n=12) (mean±SD)	Control group (n=12) (mean±SD)
Age (year)	44.0±2.7	44.0±1.9
Height (cm)	172.5±3.4	171.0±3.6
Body mass (kg)	77.7±3.9	76.7±1.4
BMI (kg/m^2)	26.1±1.4	26.2±0.9
WHR	0.81±0.07	0.74±0.1

Exercise training

The subjects in the training group performed 35 to 50 min aerobic training on the bicycle ergomete with 40-55% of their heart rate reserve (HRR), 3 days a week for 8 weeks. Each participant was equipped with a heart rate monitor (Polar, FS3c, Finland) to ensure accuracy of the exercise level. The subjects in the control group were instructed to maintain their normal physical activity throughout the study.

Blood samples and laboratory analysis

Fasting blood samples were collected at rest (before training) and 48h after last session of training. All the subjects fasted at least for 12 hours and a fasting blood sample was obtained by venipuncture. Blood samples were kept in the temperature of –20˚c. Glucose was determined by the oxidase method. Insulin was also determined by ELISA kit (Mercodia, Sweden). The intra and inter-assay coefficients of variation for glucose were <1.3% and a sensitivity of 1 mg/dl. Insulin resistance determined by HOMA-IR model (17). Serum TC and TG levels were measured by enzymatic kits (Mann Chemical Company) using an auto analyzer. LDL and HDL were measured by an Auto analyzer using commercial kits (Pars Azema Company, Teheran, Iran).

Statistical analysis

Results were expressed as the mean ± SD and distributions of all variables were assessed for normality. Data were analyzed using independent and paired sample t-test. The level of significance in all statistical analyses was set at $P<0.05$. Data analysis was performed using SPSS software for windows (version 24, SPSS, Inc., Chicago, IL).

3. Results

Biochemical parameters of the subjects are presented in Table 2. The results indicated that fasting glucose (49.4%), fasting insulin (21.6%), insulin resistance determined by HOMA-IR (25.7%), TC (33.2%), TG (55.9%) and LDL (30.0%) were decreased and HDL (38.5%) was increased after 8 weeks aerobic training ($P<0.05$).

Table 2. Changes of the biochemical parameters of the subjects before and after training

	Control (mean±SD)		Training (mean±SD)	
	Pretraining	Posttraining	Pretraining	Posttraining
TC (mg/dl)	240.3±27.3	242.5±29.8	235.8±31.9	157.5±32.4*†
TG (mg/dl)	264.2±51.8	278.8±65.3	247.9±61.9	109.3±11.9*†
LDL (mg/dl)	130.3±16.9	131.5±17.5	131.9±20.2	92.2±12.5*†
HDL (mg/dl)	33.6±4.1	38.0±8.2	35.2±2.8	57.3±12.8*†
Fasting glucose (mg/dl)	146.9±58.0	190.2±34.2	233.7±34.9	118.2±18.9*†
Fasting insulin (IU/ml)	18.1±1.5	18.3±1.4	18.0±2.4	14.1±1.8*†
HOMA-IR	3.8±0.4	3.9±0.1	3.5±0.6	2.6±0.2*†

*: $P<0.05$ for between-group differences.

†: $P<0.05$, pretraining *vs.* posttraining values.

4. Discussion

Diabetic patients are at increased risk of developing dyslipidemia (18). One mechanism underlying this connection is increased free fatty-acid release present in insulin-resistant fat cells. High levels of free-fatty acids promote TG production, which in turn stimulates the secretion of apolipoprotein B (ApoB) and very LDL (vLDL) cholesterol. High levels of ApoB and vLDL have both been tied to increased risk of cardiovascular disease (19,20). In addition to high ApoB and vLDL, hyperinsulinemia is associated with low HDL cholesterol levels (21). Hyperglycemia may also negatively impact lipoproteins (particularly LDL and VLDL) through increased glycosylation and oxidation, decreasing vascular compliance and facilitating the development of aggressive atherosclerosis (22). High circulating FFA's and triglycerides, increased stimulation of ApoB and vLDL, decreased HDL levels and lipoprotein modification have all been appreciated in patients with diabetes mellitus and likely contributes to the high prevalence of cardiovascular disease in diabetic patients. The aim of present study was to examine the effect of 8 weeks aerobic training on lipid profile and insulin resistance in patients with type 2 diabetes. Our results indicated that fasting glucose and insulin and insulin resistance determined by HOMA-IR were decreased after 8 weeks aerobic exercise in compare to the control group. Since muscle contraction increases glucose uptake in

skeletal muscles, physical activity has been suggested in type 2 diabetes (23). It seems that physical activity has a meaningful relationship with the insulin effectiveness increase in the skeletal muscles (23,24). This effect is related to the promotion of glucose uptake in the skeletal muscles, loss of body fat in the body central part (23,24), the lipid products reduction and lipid oxidative capacity increase in the muscle cells (25), the insulin function increase in the organs cells involved in the exercise, the positive regulation of signaling pathway stimulation by insulin (23) glycogen reserve decrease in liver and muscles (26), the inflammatory markers change (26), the prevention of muscle atrophy, new muscle tissue being built and capillary network congestion increase in muscles (23,26). Insulin resistance is marked by a decreased responsiveness to metabolic actions of insulin such as insulin-stimulated glucose disposal and inhibition of hepatic glucose output (27). The exercise-induced increase in insulin sensitivity is believed to reflect adaptations in muscle insulin signaling (28,29), glucose transporter type 4 (GLUT4) protein expression, content and action (30,31) and associated improvement in insulin-stimulated glucose disposal and glycogen synthesis (28,29). This is accompanied and influenced by enhanced intramyocellular oxidative enzyme capacity and possibly changes in muscle architecture from fast-type to slow-type fibers (32,33).

Exercise increases insulin-mediated GLUT4 translocation to the sarcolemma and subsequent glucose uptake, which may reflect a transient elevation as a consequence of the "last bout" (30). The underlying increase in GLUT4 transcription and expression of GLUT4 mRNA has been shown to persist for 3 to 24 hours after exercise (31,34). In this way, regular exercise translates into a steady-state increase of GLUT4 protein expression, and subsequent improvement in glucose control over time (31). Similarly, enhanced whole-body insulin sensitivity has been shown to occur in the hours immediately following exercise, and evidence from a limited number of studies using hyperinsulinaemic-euglycaemic clamp and oral glucose tolerance test (OGTT) suggests that this may persist for up to 24 to 72 hours after the last bout (35-37).

The results of present study revealed that TC, TG and LDL were decreased and HDL was increased after 8 weeks aerobic training.

Individuals physically active present higher levels of HDL and lower levels of TG, LDL and vLDL, if compared to inactive individuals (38). Intervention studies demonstrate the unfavorable lipids and lipoprotein profiles improve with physical training (25). These improvements are not dependent on gender, body weight and diet; however, there is a possibility of being dependent on the glucose tolerance degree (38,39). The physical activity has demonstrated to be effective in decreasing the level of vLDL in individuals with type 2 diabetes; however, except for a few, most studies have not demonstrated significant improve on levels of HDL and LDL in this population maybe due to the low intensity of the exercise employed (40). Although studies on the effect of physical exercises on the lipids and lipoprotein profiles in individuals with MS are scarce, considering the evidences above and the fact that physical exercises increase the ability of the muscular tissue in spending fatty acids and the activity of the enzyme lipoprotein lipase in the muscle (41), it is likely that the physical exercise be effective in improving the lipid and lipoprotein profiles in individuals with MS. Physical activity improve lipid metabolism and increases the conversion of vLDL to HDL that result activation of lipolysis of fat tissue and decreases insulin and increases glucagon which lead concentration of free fatty acids in plasma. This process effects cholesterol buildup and reduce it (42). The factors influencing HDL levels are: Increase utilizing lipids by skeletal muscle as fuel and decrease consumption glycogen (43). Also it is possible physical activity decreases homocysteine which increasing HDL. On the other hand, although the mechanism of exercise-induced lipid changes is unclear, exercise itself may increase blood lipid consumption hence to decrease lipids levels (44). Mechanisms may involve the increased activity of lipoprotein lipase (LPL) - lipoprotein lipase responsible for chylomicrons and VLDL TAG hydrolysis in granules (45).

5. Conclusion

The findings of the study demonstrate the efficacy of aerobic exercise on fasting blood glucose, insulin resistance and lipid profile in patients with type 2 diabetes.

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Conflict of interests: The authors declare that they have no conflict of interests.

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