

The effect of 8 weeks aerobic exercise training on cardiovascular risk factors in men with type 2 diabetes mellitus

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Abstract

Introduction: Individuals with diabetes are often diagnosed with low high-density lipoprotein cholesterol (HDL-C) concentration, hypertriglyceridemia and development of cardiovascular disease (CVD). The purpose of this study was to determine the impact of aerobic training on blood profile and inflammatory marker (CRP) of type 2 diabetes mellitus (T2DM) people.

Methods: Thirty diabetic males were recruited (age: 50.34 ± 10.28 years) and randomly assigned to 8 weeks aerobic exercise training ($n=15$) and control groups ($n=15$). Before and after training blood pressure, weight, lipid profile (Total cholesterol [TC], triglyceride [TG], low-density lipoprotein cholesterol (LDL-C), HDL-C) and high-sensitivity C-reactive protein (hs-CRP) were measured. Exercise training was in mode of walking and consisted of 5 exercise sessions/week at 50%–70% heart rate maximum and began with 25 minutes of walking. Training increased each week by 5 minutes until 60 minutes of walking was reached. Each exercise session included approximately 10 minutes of warm-up and cool-down periods.

Results: Resting systolic blood pressure decreased following 8 weeks of aerobic training (pre 139 ± 16 vs post 121 ± 11 mm Hg, $P=0.04$). Also, TG significantly decreased (pre 210.19 ± 9.31 vs 191.12 ± 7.25 , $P=0.03$) and HDL-C significantly increased (pre 42.37 ± 3.15 vs 47.56 ± 2.19 , $P=0.01$) after exercise training. However, there was no difference between groups in TC, LDL-C, body mass index (BMI) and weight. In addition, a decrease in fasting blood glucose levels showed a significant difference between groups (pre 142.43 ± 7.96 vs 121.17 ± 8.32 , $P=0.04$).

Conclusion: Regular aerobic exercise training can improve the lipid profile and reduce the cardiovascular risk factors in T2DM patients. Exercise, like walking, is inexpensive and has relatively few negative side effects when performed properly.

Keywords: Aerobic exercise, Cardiovascular risk factors, Type 2 diabetes mellitus

Introduction

The World Health Organization (WHO) estimates that 347 million people worldwide have diabetes and it is predicted to become the seventh leading cause of death in the world by 2030 (1). In Iran about 2.5 million (6% of total population) children and adults are affected by the disease (2). The vast majority of diabetic population (about 90%) has type 2 diabetes mellitus (T2DM) and this population is growing rapidly (3).

T2DM may lead to devastating complications such as renal disease, blindness, heart disease, stroke and impaired peripheral circulation (4). Also, a large percentage of T2DM develop symptoms leading to the progression of atherosclerosis such as high blood pressure, obesity and abnormal lipid profile (5). Individuals with diabetes or pre

diabetes often display more negative lipid profiles than the general population which can lead to an increased incidence of cardiovascular disease (CVD). These negative lipid profiles are elevated triglyceride (TG), low density lipoprotein-cholesterol (LDL-C), TC and low high density lipoprotein-cholesterol (HDL-C) (6). In addition, accumulating evidence shows that inflammation may play a crucial intermediary role in the pathogenesis of T2DM, thus relating diabetes to a number of commonly coexisting conditions thought to originate via inflammatory mechanisms (7). In this regard, more recent data suggest that interleukin-6 (IL-6) and C-reactive protein (CRP) are associated with type 2 diabetes (8). CRP is an acute-phase plasma protein synthesized by the liver and has been shown to be a sensitive, systemic biomarker of inflamma-



tion (9). Currently, there is no cure for T2DM (10), but existing treatment involves modifications of diet, reduction of body fat, exercise prescription, pharmaceutical intervention and insulin therapy in some cases (11). Among all these treatments, exercise training is an intervention that can decrease cardiovascular risk factors without negative side effects (12). Cross-sectional data provide evidence that regular aerobic exercise improves the lipid profiles, thus, reducing the risk factors. (13). Exercise has been shown to help regulate glucose levels by increasing insulin sensitivity, thus slowing the progression and in some cases eliminating the symptoms of disease. However, the effects of exercise on lipid profiles vary in individuals (14).

In order to determine the relationship between the lipid profiles (TG, TC, LDL-C and HDL-C), inflammatory related marker (CRP) and the exercise performed in individuals with diabetes, it is crucial to provide more precise knowledge necessary to educate this specific population and have better exercise prescription. Thus, this study aimed to investigate the effect of 8 weeks aerobic exercise training, in mode of walking, on cardiovascular risk factors in people with T2DM.

Methods

Subjects

Thirty adults with T2DM (aged 50.34 ± 10.28 years) were recruited from Babolsar Diabetes Society and were randomly assigned to one of two groups: the aerobic exercise ($n=15$) and control ($n=15$). The inclusion criteria encompassed those with T2DM, previously sedentary for 6 months and aged 45-60 years. Subjects were excluded from the study if they were taking insulin, had documented coronary artery disease, chronic inflammatory disease, uncontrolled hypertension, cardiac arrhythmia, and musculoskeletal conditions which would make participation in regular exercise difficult or dangerous. All subjects provided their written informed consent to the study and were asked to list their medications before and during study.

Study design

Fasting blood samples were collected after a 12-hour fast 2 days before starting exercise protocol to determine blood lipids, lipoprotein, glucose and CRP concentrations. Height (cm) and body mass (kg) were measured in light clothes and shoes removed. Body mass was measured to the nearest 0.1 kg and height was measured to the nearest 0.1 cm. Body mass index (BMI) was calculated as the weight in kilograms divided by square of the height in meters, using the formula $\text{weight}/(\text{height})^2$. All measurements were done at the time of evaluation and were repeated after 8 weeks.

Aerobic exercise protocol

Subjects of aerobic exercise group participated in a supervised walking program for 8 weeks. The program consisted of 5 exercise sessions/week at 50%–70% heart rate maximum and began with 25 minutes of walking and in-

creased each week by 5 minutes until 60 minutes of walking was reached. Each exercise session included approximately 10 minutes of warm-up and cool-down periods. These periods consisted of stretching and upper-lower body calisthenics. Pulse palpation method was performed to monitor heart rate. Subjects in the control group were instructed not to undertake any formal exercise or change their physical activity level during the study period.

Statistical analysis

All data were analyzed using SPSS for windows (version 16). Paired *t* test was used to examine whether there were significant changes in variables between pre- and post-test in each group. Independent *t* test was used to determine differences between exercise and control groups.

Results

At baseline evaluation, no significant differences were observed between the exercise and control groups for any of the studied variables. As shown in Table 1, the mean of systolic blood pressure in the exercise group decreased from 139 ± 16 to 121 ± 11 after 8 weeks of aerobic training which was statistically significant.

Also, there was a significant difference between the aerobic and control groups for TG (from 210.19 ± 9.31 to 191.12 ± 7.25) and HDL-C (from 42.37 ± 3.15 to 47.56 ± 2.19) (Table 2).

Discussion

This study found that there was a statistically significant improvement in TG, HDL-C and systolic blood pressure following 8 weeks of aerobic exercise in previously sedentary individuals with T2DM.

Dyslipidemia strongly contributes to the development of atherosclerosis, which is a major complication of T2DM (15).

In this study a significant increase in HDL-C and a decrease in TG were observed in T2DM individuals after 8 weeks of exercise training. Some studies are in agreement with the present research (16,17). Lira et al (17) reported that low and moderate intensity exercise training appears to promote clear benefits on lipid profile. A significant increase in HDL-C concentration was also observed by Di Loreto et al (16). However, other data indicated that after exercise training the lipid profile did not change significantly (18,19). Santiago et al (18) indicated that after 40 weeks of walking, there was no change in HDL-C and TG concentration. Kelley and Kelley (19) indicated that only reduction in LDL-C concentration was significant with aerobic training. Triglycerides stored within skeletal muscle cells are considered to be a potentially large energy source. It has been estimated that during exercise, intramuscular TG can provide as much as 20%-25% of energy for muscles to do work. Enhanced epinephrine and glucagon during exercise activate adenylate cycles, resulting in an increase in cyclic adenosine monophosphate (cAMP) (20). Increased cAMP phosphorylates and activates hormone sensitive lipoprotein lipase (LPL). The LPL would hydro-

Table 1. Physiological and anthropometric characteristics of subjects before and after 8 weeks of exercise training in exercise and control groups

Variable	Group	Baseline	8 weeks	P value
Age (years)	AT	48.71±11.25	-	-
	Control	52.09±9.44	-	
Height (cm)	AT	168.53±6.29	-	-
	Control	171.13±4.32	-	
Weight (kg)	AT	73.81±5.22	71.12±6.14	0.26
	Control	74.27±7.72	74.73±8.44	
BMI (kg/m ²)	AT	25.98±2.16	25.04±2.44	0.34
	Control	25.43±3.78	25.59±4.07	
Systolic BP (mm Hg)	AT	139±16	121±11 ^a	0.04 ^b
	Control	143±12	140±14	
Diastolic BP (mm Hg)	AT	85±6	81±5	0.54
	Control	88±7	83±7	

Abbreviations: AT, aerobic training; BP, blood pressure; BMI, body mass index.

Values are means ± SD; ^aSignificant difference compared with baseline $P \leq 0.05$; ^bSignificantly different between groups $P \leq 0.05$.

Table 2. Blood parameters in exercise and control group before and after 8 weeks of exercise training

Variable	Group	Baseline	8 weeks	P value
TC (mg/dl)	AT	204.21±17.38	188.19±14.2*	0.86
	Control	193.64±11.4	198.49±13.63	
TG (mg/dl)	AT	210.19±9.31	191.12±7.25*	0.03**
	Control	202.74±12.63	207.17±10.37	
LDL-C (mg/dl)	AT	123.82±6.41	119.14±11.76	0.88
	Control	116.44±9.72	121.12±7.23	
HDL-C (mg/dl)	AT	42.37±3.15	47.56±2.19*	0.01**
	Control	44.74±4.93	43.11±3.44	
Glucose (mg/dl)	AT	142.43±7.96	121.17±8.32*	0.04**
	Control	147.39±12.64	142.76±9.18	
CRP (mg/L)	AT	2.59±1.02	2.36±1.16	0.63
	Control	2.86±1.24	2.75±1.44	

Abbreviations: AT, aerobic training; TC, total cholesterol; TG, triglyceride; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol; CRP, C-reactive protein.

Values are means ± SD; *Significant difference compared with baseline $P \leq 0.05$; **Significantly different between groups $P \leq 0.05$.

lyze intracellular TG in skeletal muscle and myocardium, as well as adipose tissue during exercise to provide free fatty acids (FFA) as an energy source. After exercise, the endogenous TG that was oxidized needs to be replenished from exogenous TG (21). This may cause rapid uptake of FFA from the circulation, thus, increasing the clearance rate of TG from circulation. Therefore, the increased LPL activity in muscle after exercise may play the most important role in the attenuated TG concentration (22).

Significant changes on HDL-C have been reported after exercise training in most researches like this study. To increase the HDL-C concentration by exercise, many enzymes should be considered. Increased LPL activity hydrolyzes triglycerides from LDL with transfer of the excess surface cholesterol to the HDL particles. This process helps the formation of HDL-C, therefore, increasing the plasma HDL-C concentration (23).

We found no significant change in TC and LDL-C following 8 weeks exercise. The effects of exercise training on TC and LDL-C have usually been relatively small when compared with TG and HDL-C. Generally, the changes on TC and LDL-C are in the range of 5%-10% and are

highly variable (24). Decreased TC and LDL-C have been found after training in overweight and obese populations if accompanied with substantial weight loss (25). Some investigators suggest that individuals with an initially higher LDL-C concentration have the greatest reduction in LDL-C concentration (26). Weight and LDL-C level in the current study, however, were within normal limits at baseline and lack of changes can be the result of low exercise volume.

The results of the present study showed that 8 weeks of aerobic exercise training significantly decrease systolic but did not have an impact on diastolic blood pressure. Exercise training is considered as a fundamental way in the prevention and management of hypertension (27). Epidemiological studies indicate that greater physical activity is associated with a lower blood pressure and interventional studies have shown that chronic dynamic aerobic endurance training is able to reduce blood pressure (27). Studies in this regard indicate that exercise has an antihypertensive effect on humans (28). Regular exercise training can reduce heart rate and improve the sensitivity of aortic baroreceptors which contributes to a more efficient

regulation of blood pressure (29). The beneficial effects of exercise on blood pressure lowering due decreased activity of both sympathetic nervous system and the rennin-angiotensin system were also documented. Other mechanisms responsible for the antihypertensive effect of training include the decrease in peripheral arterial resistance caused by vasodilatation (30).

This study showed no significant changes in C-reactive protein in T2DM subjects. Previous studies regarding the effects of exercise training on CRP are different in their results. Some protocols have elicited a reduction in CRP (31,32) while others have not (33,34). Although an abundance of cross-sectional evidence supports a relationship between physical activity and CRP concentrations but only a limited number of longitudinal studies have shown a significant decrease in CRP concentrations with exercise training (35). Hewitt et al (35) found significant improvement in CRP concentration over the first 8 weeks of a progressive aerobic exercise training program in healthy and sedentary population. Subjects of current study were T2DM people and CRP levels of them were within normal limits. However, several other longitudinal training studies have found little or no effect of aerobic exercise training on CRP concentrations (36). The findings of current study are consistent with the results of the study conducted by Marcell et al (37) in which no significant change was reported for CRP concentration.

Physical activity may modify inflammation through the IL-6 pathway. IL-6 is released during a bout of exercise from various tissues including adipose tissue, skeletal muscle, mononuclear cells, and brain (38). Acutely, the rise in IL-6 increases CRP levels approximately 8-12 hours after the exercise bout (38). Despite the increase in IL-6 and CRP after an acute bout of exercise, IL-6 also acts to stimulate the release of anti-inflammatory agents (39). An increase in IL-6 levels during the acute phase initiates a cascade response involving the secretion of anti-inflammatory markers such as IL-10 and IL-1ra which down regulate the release of tumor necrosis factor alpha (TNF- α) (38). The decrease in TNF- α may also inhibit the release of IL-6, and ultimately, the release of CRP from the liver. This negative feedback loop suggests that although the acute effect increases CRP, the chronic influence of exercise may decrease CRP. It is hypothesized that the mechanism behind the decrease inflammation with chronic activity is due to or more of the following reasons: 1) reduced adiposity, 2) reduced macrophage accumulation in adipose tissue, 3) increase in parasympathetic system due to training, and 4) improved acute stress sensitivity from repeated exercise bouts and increased anti-oxidant activity (40).

Conclusion

Physical exercise training is an efficient tool for the prevention and treatment of T2DM and should, therefore, be part of any therapeutic strategies for such patients. We conclude that regular aerobic exercise can improve some cardiovascular risk factors in T2DM patients and the protocol used for the participant in the present study might

be suitable for having an effect on lipid profile.

Ethical issues

The study was approved by the ethical committees of the Shiraz University, and all participants signed a written informed consent regarding participation in the research project.

Authors' contributions

Both authors equally contributed to the writing and revision of this paper.

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