Available online at **www.ijmrhs.com**

ISSN No: 2319-5886

International Journal of Medical Research & Health Sciences, 2016, 5, 6:27-33

Effects of aerobic training on FBS, HbA1C, Fructosamine and plasma lipid profile in male with type 2 diabetes

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ABSTRACT

Regular exercise represents an effective strategy to prevent and treat type 2 Diabetes.The present study examined the effects of aerobic exercise on glycemic control and serum lipid profile in men with type 2 diabetes.20 men with type 2 diabetes (age:45.05 ± 3.8) were randomly divided into aerobic exercise group (n=10) and control group(n=10). Exercise Group participated in aerobic training program at 50 -70 % HRR for 8 weeks and 3 sessions per week. Fasting blood sugar (FBS),Fructosamine, HbA1C, Triglyceride (TG), cholesterol (TC), high density lipoproteins (HDL), low density lipoproteins (LDL) and very low density lipoprotein(VLDL) were measured before and after 8 weeks. Paired and independent t tests were used for data analysis (P<0.05).At the end of period, significant decreases have been found in FBS (p=0.017),HbA1c(p=0.045),Fructosamine(p=0.012) and LDL (p=0.048) levels and a significant increase has been observed in HDL(p=0.012) of exercise group, while there were no significant changes for the investigated factors in control group (P>0.05).Also there was a significant difference in FBS (p=0.03) and HDL levels (p=0.04) between 2 groups.Aerobic trainings effectively improve lipid profile and lead to better glycemic control in men with type 2 diabetes.

Key words: Type 2 diabetes, Aerobic training, Fasting blood sugar, Glycated hemoglobin, Fructosamine and Lipid profile.

INTRODUCTION

Modern life has caused people to spend most of their leisure time without any physical activity. Reports show that people who exercise and have proper nutrition are less prone to diseases such as cardiovascular diseases and type 2-diabetes [1]. Type 2 diabetes is the most common endocrine abnormality [2].Insulin resistance and inadequate secretion of insulin involve in the development of type 2 diabetes [3]. Diabetes mellitus represents a group of diseases of heterogeneous etiology, characterized by chronic hyperglycemia and other metabolic abnormalities, which are due to the deficiency of insulin effect. After a long duration of metabolic derangement, specific complications of diabetes [retinopathy, nephropathy, and neuropathy] may occur [4]. Metabolic disorders resulted from diabetes mellitus cause cardiovascular complications in patients and would cause problems for the community health system [3].Although the risk of microvascular complications such as retinopathy and nephropathy increase in type 2 diabetes, these patients often die because of macrovascular complications including coronary artery disease and stroke. The risk of these complications is 200-400% [5]. Regular exercise represents an effective strategy to prevent and treat type 2 Diabetes [6]. For several years, exercise is considered one of the three therapeutic methods

for diabetes along with diet and medical therapy [4].Experts believe that not only diet and medical therapy are not effective in the treatment and glycemic control for the patients but also physical activity and exercise should be added to the diabetics daily schedule [7].Studies have shown that repeated muscle contractions,in patients with type 2 diabetes who have insulin sensitivity problem, facilitate glucose entrance to muscle cells in the absence of insulin. Furthermore exercise activities increase glucose transport protein [GLUT4] levels and decrease insulin resistance [8].Endurance or aerobic exerciseimprove glycemic control [by decreasing HBA1C level], increase insulin sensitivity and decrease cardiovascular risk factors [9-12]. In a meta-analysis of randomized controlled trials, Hayashino et al investigated the studies done on the effects of controlled exercise [aerobic, strength and combined training] on cardiovascular risk factors [lipid profile] and blood pressure control in patients with type 2 diabetes. The results of these studies showed that exercise help to improve blood pressure control and low density lipoprotein and high – density lipoprotein in patients with type 2 Diabetes[9].The control of glycemic and lipid profile is very important to prevent complications of diabetes in patients with type 2 Diabetes. Therefor it is necessary that such studies with regard to training methods and their effects, examine the influence of physical activity on some blood factors in the population.So the purpose of this study is to investigate the effects of 8 weeks of aerobic exercise on glycemic control and lipid profile in men with type 2 diabetes.

MATERIALS AND METHODS

In this semi experimental study, 20 men with type 2 diabetes were selected from diabetes clinic of Golestan hospital in Ahvaz,Iran**.** The participants were randomly divided into exercise(n=10) and control groups(n=10).The subjects were men aged 30-50 years with type 2 diabetes and fasting blood sugar level less than 200 mg/dl, Vo2max level less than 40 ml.kg.min, no smoking, no insulin injection, no history of cardiovascular and respiratory diseases, no muscular and skeletal problems, no regular participation in physical activity within 6 months prior to the study, no history of repeated hypoglycemia or hypoglycemia during exercise. The subjects were excluded from the study if they had more than two absences from training sessions and regular participation in exercise sessions besides this study in control and experimental group. First the subjects were become familiar with the objective of this study and received necessary instructions. Then each subject signed the informed consent form after that. Volunteers were examined by an endocrinology and metabolism physician. Demographic information, physical fitness status, characteristics of the disease and physical activity were collected by a questionnaire. After baseline measurements, the supervised exercise intervention was conducted for 8 weeks and at the end the variables were measured again. The study was approved by Student Research Committee, ShahidChamran University, Ahvaz, Iran

In this study the subjects' height were measured by Seca height gauge, weight, BMI and body fat percent (PBF) by body composition machine, Olympic Model 3/3, made in Korea (table2). Rakport test was used to evaluate aerobic capacity of patients (13).Before and after the intervention period, morning blood sample after 10 to 12 hours of fasting was taken from left Antecubital vein for measuring serum concentration of glucose and lipid profile. HbA1C and Fructosamine were measured using Nico Card kit and Dyazime kit respectively. Fasting blood glucose, triglyceride, total cholesterol and high- density lipoprotein concentration were measured by photometric method using Parsazmoon kits made in Iran. Low density lipoprotein was estimated using Friedewald formula(14).

The Exercise program in experimental group included supervised aerobic training that was conducted safety. Warm up consisted of fast walking, jogging and static stretching for 10 minutes after that, running (Main training program) was started at 50% of Heart Rates Reserve (HRR) for 10 minutes at the beginning week and increased to 70% of Heart Rates Reserve (HRR) for 30 minutes at the last week (table1). The Heart Rate Reserve (HRR) was determined by the Karvonen Formula. At the end of every training session walking fast and stretching movements was conducted for 5 minutes (cool down). To avoid potential hazards a nurse was present in all training sessions. The patients was advised that to have sweet snack if they had hypoglycemia. The subjects' blood glucose and blood pressure were measured using digital glucometer and blood pressure machine before starting the training and if they had high glucose level or high blood pressure they were not allowed to participate in training.

Table 1. Duration and intensity of aerobic training program during 8 weeks

Weeks	Duration (minutes)	Intensity(%HRR)
1	10	50-60%
2	15	50-60%
3	15	50-60%
4	20	50-60%
5	20	60-70%
6	25	60-70%
7	25	60-70%
8	30	60-70%

Statistics:

SPSS 19 software was used for analyzing data .The normality of the distribution and homogeneity of variances tested with Kolmogorov–Smirnov and Levene's tests respectively. Independent samples t test was used to compare variables between the exercise and control groups. To compare pretest and posttest of each group paired sample t test was used. Significant levels in all tests were $P \leq 0.05$.

RESULTS

The purpose of this study was to examine the effects of aerobic training on fasting blood glucose and plasma lipid profile in men with type 2 diabetes. Table 2 shows anthropometric characteristics of the subjects before the intervention.

Table2. Comparison of characteristics of the exercise and control groups

Variables	Exercise group	Control group	P
Age (y)	44.5 ± 3.8	45.6 ± 3.9	0.526
Height (cm)	173.1 ± 6.0	170.6± 5.3	0.344
Weight (kg)	78.0± 11.0	76.0 ± 10.5	0.680
BMI (kg/m^2)	25.9±2.2	26.1± 3.0	0.915
PBF	26.3±3.6	26.7±1.6	0.778
VO2max ($ml.kg^{-1}.mim^{-1}$)	36.6±1.9	36.0±1.6	0.391

Eight weeks of aerobic training resulted in a significant decrease in fasting blood glucose (P=0.017), HbA1C (P=0.045),Fructosamine (P= 0.012) and LDL(P=0.048) and a significant increase in HDL(P=0.012) of exercise group .There were no significantly changes in all variables of control group(P>0.05) (table 3).

Table 3.Preintervention and Postintervention Values for FBS, HbA1C, Fructosamine,TG, TC, LDL, HDL and VLDL (Means ± SD)

Variables	Exercise group			Control group		
	Pre-test	Post-test	P	Pre-test	Post-test	P
FBS(mg/dl)	129.9±28.1	118.5±24.2	0.017*	151.2±28.8	152.5±21.0	0.761
HbA1C%	6.3±0.6	6.1±0.7	0.045*	6.42±0.68	6.40±0.66	0.764
Fructosamine(µmol/l)	316.8±51.4	280.6±52.7	0.012*	345.0±77.8	339.8±63.1	0.690
TG(mg/dl)	178.5±77.5	162.4±42.4	0.267	175.2± 61.2	196.9±65.0	0.248
TC(mg/dl)	170.2± 26.1	150.3± 18.5	0.071	183.1± 32.7	181.9± 28.3	0.840
LDL(mg/dl)	95.6 ±22.4	75.0± 20.5	0.048*	104.6± 28.0	98.7± 25.5	0.285
HDL(mg/dl)	38.9± 5.0	42.8± 4.5	0.012*	43.5 ±7.7	43.8± 7.6	0.792
VLDL(mg/dl)	35.7 ± 15.5	32.5±8.5	0.267	35.0± 12.2	39.4±13.0	0.248

Note: FBS= Fasting blood glucose,HbA1C= Glycated hemoglobin ,TG=Triglyceride, TC =Total cholesterol, HDL =High-density lipoprotein cholesterol, LDL =Low-density lipoprotein cholesterol, VLDL=Very low-density cholesterol

**Significantly difference between pre and post intervention at P < 0.05*

Independent t test's results indicated a significant difference in fasting blood glucose (P=0.03) and HDL (p=0.04) between exercise and control groups (table4).

Table 4. Comparison of Mean differences of investigated variables between exercise and control groups (Means ± SD)

Variables	Exercise group	Control group	P
FBS(mg/dl)	-11.4±12.4	+1.3±13.1	0.039*
HbA1C%	-0.18±0.24	-0.2±0.20	0.129
Fructosamine(µmol/l)	-36.2±36.3	-5.2±39.9	0.086
TG(mg/dl)	-16.1±43.0	+21.7±55.6	0.106
TC(mg/dl)	-19.9±30.8	-1.2±18.3	0.116
LDL(mg/dl)	-20.6±28.4	-5.8±16.2	0.172
HDL(mg/dl)	+3.9±3.9	+0.3±3.5	0.043*
VLDL(mg/dl)	-3.2±8.6	+4.3±11.1	0.106

***** *Significantly difference between exercise and control groups at P < 0.05*

DISCUSSION

One of the common recommendations is to do exercise to control blood sugar and decrease diabetes complications such as cardiovascular diseases. In general, the findings of this study showed aerobic exercise effects on glycemic control and lipid profile positively.

A significant decrease was observed in fasting blood glucose, glycosylated hemoglobin and Fructosamine after eight weeks in exercise group [table3]. These results are consistent with the findings of Bacchi et al [15],Tamura et al [16], Misra et al [17] and Castaneda et al [18] who reported significant decrease in fasting blood glucose. Also Bacchi et al [15] and Shenoy et al [19] indicated significant reduction in glycosylated hemoglobin. Lucotti et al [20] reported a significant reduction in FructosamineThe positive changes in blood glucose levels are mostly due to the cumulative effects of blood glucose reduction after several times of exercise [21].Evidence show muscle contractions have an insulin-like effect and increase glucose transport into the skeletal muscle cells to use as energy [22, 23].Muscle contraction probably increases membrane permeability to glucose by increasing glucose transporter[Glut4] in plasma membrane. Exercise increases Glut4 levels in trained muscles, also improves insulin function on glucose metabolism and can decrease FBS and HbA1C [24]. Accumulation of free fatty acids in muscle cells disrupts Glut4 transportation to the cells surface. Exercise may increase fatty acids oxidation and prevent their accumulation in muscle cells [25]. Increased capillary density and insulin sensitivity, change in composition of sarcolemma phospholipid, increased oxidative enzymes activity and increased glycogen synthase enzyme are some factors to decrease blood glucose [19].Another positive regulatory mechanism of glucose metabolism is increasing of insulin action and insulin signals [26]. Some other possible reasons of positive changes in glycemic control can be proposed, for example, protein content of insulin receptors and protein kinase B activity[has an important role in insulin signals transportation] increase after aerobic exercise. These changes also lead to decrease blood glucose29.In addition, It is possible that exercise or exercise-induced weight loss improves beta cells function or insulin sensitivity that is associated with decreased blood glucose levels in diabetic patients, indirectly and by its effects on other biochemical mediators or peptide hormones [27-29]. Several mechanisms have been proposed about the effect of aerobic exercise on reducing blood glucose, HbA1C and Fructosamine. The main mechanisms include biochemical adaptations, skeletal muscles structural adaptations and systemic effects on physical activity. Biochemical adaptations include regulating mitochondrial proteins involving respiratory system [Nitrate production], increasing glucose production and Glut4 protein. Also structural adaptations of these training include increasing contractile proteins [hypertrophy] and more absorbing net glucose [30].

The results of the present study showed significant changes of HDL and LDL levels; also there was a marked but not significant decrease in plasma total cholesterol [TC] in exercise group [table3]. Aerobic exercise increases HDL in this study, this result is consistent with some studies[31] and is inconsistent with other studies[16]. Difference in the characteristics of the subjects and the period of training are probably reasons for this difference. For example, this result is inconsistent with the finding of De Feyter, et al [6] who reported no significant increase in HDL, some possible reasons of this difference are older subjects [age mean 59 years] with lower physical fitness and disability to perform the training in De Feyter's study. It was observed that a significant decrease in plasma LDL levels in exercise group that is inconsistent with the findings of Walker et al [32] study. This results indicated no significant difference between two groups in lipid profile [TC,TG,LDL,VLDL] after 8 weeks [table4], it is probably due to nutrition effects of patients on results that was one of the limitations of the study. Another reason is probably the short period of training and the low cost of energy in our study.

In addition to glycemic control and insulin sensitivity increasing, exercise can improve cardiovascular risk factors and lipid profile [10, 33]. Some of the effective adaptations induced by aerobic exercise include increasing mitochondria and subsequently lipolysis enzymes activity that resulted in the increasing of lipids catabolism during exercise [34].HDL level increases by aerobic exercise. One of the possible reasons of increased HDL level after exercise may be the increasing of lipoprotein lipase enzyme activity induces by exercise [LPL]. LPL has a role to convert VLDL to HDL. So, increased LPL activity results in increased HDL level. Also Lecithin-cholesterol acyltransferase [LCAT] convert LDL and cholesterol to HDL. Increased LCAT may be responsible for the exercise induced increase in HDL [35]. It has been shown that LCAT has increased significantly in some exercise trainings, probably, other mechanisms, such as decrease in insulin sensitivity that can change blood lipids and lipoprotein levels, may be effective [35, 36].Changing of LPL activity results in more entrance of VLDL to the circulation from the liver then it will be cleared from the circulation. Other possible mechanisms such as increased cholesterol transport may also be important. Some indirect influences of exercise on lipids may be related to a decrease in abdominal fats, subsequently, the free fatty acids movement from abdominal fat to the liver decreases and results in reduction in VLDL production in the liver [37]. Also regular physical activity for a long time can reduce hepatic lipase [38].It has been shown that people with type 2 Diabetes have lower fat oxidation capacity in muscles that may be related to lower mitochondrial function. On the other hand, an increase in insulin resistance [decrease in insulin sensitivity] increases fatty acid accumulation in the musculoskeletal system[39].

CONCLUSION

The result of this study has shown that aerobic exercise effects on blood glucose control positively and improve lipid profile in patients with type 2 diabetes. Diabetics should consult their doctor and perform these trainings under the supervision of an expert in exercise in order to control the blood glucose and improve lipid profile. If these trainings are done regularly for a long time, it would increase health level.

Acknowledgement
We sincerely thank all of those who helped us in this research. And finally we thank doctorAnooshehAshoori for all her endless efforts in analyzing the data.

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