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Maximal oxygen consumption in response to aerobic exercise program and its relation to insulin action in diabetic patients

Eizadi M[*], Dooaly H, Kiani F, Khorshidi F

Department of Physical Education and Sport Science, Saveh Branch, Islamic Azad University, Saveh, Iran

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Abstract

Obesity is related to chronic diseases such as syndrome metabolic and type II diabetic. The aims of present study were 1) to evaluate effect long term aerobic exercise on physical fitness and some marker indicator of type II diabetic in healthy obese men, 2) to determine relation between the change pattern of aerobic capacity and the other mentioned variables in response to this aerobic exercise program. For this purpose, a total thirty adult obese males participated in this study and were randomly divided into experimental or control groups. The experimental group subjects were participated in an aerobic exercise program (3 months / 3 times weekly) and control group did not participate in any exercise session. Aerobic capacity, fasting insulin and glucose were measured in two separate occasions in each 2 groups (before and after aerobic program). Insulin resistance was calculated with fasting glucose and insulin. Statistical analysis was performed using an independent paired t-test. Pearson correlation was used to establish the relationship between the changes pattern between variables in response to exercise program. Aerobic training program resulted in significant increase in aerobic capacity (VO2max) and significant decrease in insulin resistance and fasting glucose in experimental group. The change in VO2max was inversely associated with the change in fasting glucose and directly associated with the change in beta cell function. These data highlight that cardiovascular or physical fitness response to aerobic exercise training is independent of glucose homeostasis and insulin action in obese subjects. Further studies are needed to clarify possible mechanisms between these variables in response to exercise training.

[*] **Corresponding Author:** Eizadi M ✉ izadimojtaba2006@yahoo.com

Introduction

The prevalence of type 2 diabetes and insulin resistance is associated with aging (Chang *et al.,* 2003). On the other hand, risk factors of type 2 diabetes associated with aging including increased adipose tissue and decreased physical activity predispose older people to develop glucose intolerance and increased insulin resistance (Bloem *et al.,* 2008). In addition to genetic and hormonal factors, it is important to make a note here that obesity and sedentary lifestyle also play an important role in the prevalence of diabetes.

Impairment of beta cell sensitivity to glucose and the inability of cells to compensate for insulin resistance in the obese or type 2 diabetic patients have been frequently observed (Chang *et al.,* 2006). A large body of evidence suggests that adults who engage in regular physical activity and/or exhibit high cardiorespiratory fitness have a reduced risk of developing type 2 diabetes (Eliakim *et al.,* 2001; Travers *et al.,* 1998).

There is considerable evidence that cardiovascular fitness level affects insulin levels more than compared the percentage body fat, the importance of exercise to improve insulin function in people prone to the syndrome of insulin resistance or type 2 diabetics is increasing (Dietz, 1998). On the other hand, previous investigations have described Increased VO2max as cardiorespiratory fitness or aerobic capacity follow up long term exercise training program (Eizadi *et al.,* 2011).But, whether there is a relationship between the response of maximal oxygen consumption and determinative of type II diabetic has not drawn much attention. Indeed, most studies have supported benefic effects of exercise training in improving of glucose concentration or insulin resistance as well as aerobic capacity in obese or type II diabetic subjects. But there are limited studies about interaction between glucose or insulin resistance as diabetic determinatives with VO2max as cardiorespiratory fitness in diabetic patients. The objective of this study was to evaluate effect of aerobic exercise training on VO2max, glucose and insulin resistance in type II diabetic patients and to determine relation between these parameters after exercise program in these patients.

Materials and methods

Participants included thirty non-trained healthy men (aged 44 ± 7.4 years, body weight 92 ± 7.59 kg, body fat percentage 28.4 ± 4.66 %) with type II diabetic (fasting glucose, 223 ± 60 mg/dL). This semi-experimental study was conducted with the approval of the Ethics Committee of Islamic Azad University. The present study was conducted to investigate the effects of three months aerobic training on maximal oxygen consumption as VO2max and fasting glucose and insulin resistance in diabetic patients. For this purpose, diabetic subjects were divided into exercise (60 min, 3 days/week for 12 weeks) or control (no training) groups by randomly matched for age, body weight and glucose concentration. All participants gave their informed written consent before participation in accordance with the ethical guidelines set by Islamic Azad University.

Inclusion and Exclusion criteria

Participants were included if they had not been involved in regular physical activity/diet in the previous 6 months. Participants were excluded if they had an orthopedic condition that would limit their ability to perform exercise. Subjects with a history or clinical evidence of recent myocardial infarction, congestive heart failure, active liver or kidney disease, growth hormone deficiency or excess, neuroendocrine tumor, anemia, or who were on medications known to alter insulin sensitivity were excluded. All subjects were non-smokers. In addition, exclusion criteria included inability to exercise and supplementations that alter carbohydrate-fat metabolism.

Anthropometric measurements

We measured height, weight, and waist circumference by using a standardized protocol. Weight was measured by an electronic balance and height by a stadiometer. Height and body mass were measured using a wall- mounted stadiometer and a digital scale, respectively. Body composition monitor (BF508-Omron made in Finland) with a precision error of less than 100 g was used to measure weight and body fat percentage of the subjects. Body mass index (BMI) was calculated as the weight in kilograms divided by the square of the height in meters (kg/m2).

Blood sampling and exercise program

All variables (VO2max, fasting glucose, insulin and insulin resistance, anthropometrical indexes) were measured at baseline and after aerobic training program in two groups. The subjects were advised to avoid any physical activity or exercise 48 hours before the blood sampling. A fasting blood samples were collected in order to measuring fasting glucose and insulin of each subjects. VO2max was calculated by a YMCA standard protocol on cycle ergometer. After baseline measurements, all participants in exercise group completed an aerobic training program lasted 3 months (3 days/wk) 60 to 80 percent of maximum heart rate. Aerobic exercises in each session included walking on a treadmill and stationary cycling. Initially, subjects exercised at low intensity and the intensity of exercise was gradually increased to 80% of peak heart rate in next sessions. The intensity of the activity of any person was controlled using the Polar heart rate tester (made in the US). In this 12-week period, participants in the control group were barred from participating in any exercise training. All measurements were repeated 48 h after last exercise session (post-test). Glucose was determined by the oxidase method (Pars Azmoon kit, Tehran). Serum insulin was determined by ELISA method. Insulin resistance by formula derived from fasting insulin and glucose levels.

Statistical analysis

Data were analyzed by computer using SPSS software version 15.0. Normal distribution of data was analyzed by the Kolmogorov-Smirnov normality test. An Independent sample T-test was used to compare all variables between two groups. Student's paired 't' test was applied to compare the pre and post training values. Pearson correlation method used to determine the relationship between the changes in VO2max with the change of fasting glucose and insulin resistance. A p-value < 0.05 was considered to be statistically significant. All values are represented as mean ± SD.

Results

The clinical characteristics of all study patients who underwent intervention program are presented in Table 1. All values are given as mean and standard deviation. At baseline, there were not significant differences in VO2max and other variables such as glucose, insulin and insulin resistance between two groups. We also did not difference in all anthropometrical parameters between exercise and control groups at baseline.

Discussion

The incidence of type II diabetic is more in societies with sedentary life styles and obesity. Review of research findings show that diabetes type II is evolving into a pandemic which will be one of the health related burdens of the 21st century (Halabchi *et al.,* 2006; Hu *et al.,* 2006). Physical inactivity has been established as an effective stronger predictor incidence of some diseases such as hypertension, hyperlipidemia, diabetes, and obesity for all-cause mortality (Myers *et al.,* 2004). On the other hand, review of research evidence shows that physical training is effective as a treatment in patients with chronic heart diseases, type 2 diabetes and symptoms related to the metabolic syndrome. So that, there is considerable evidence that regular physical activity, independently of BMI, is associated with lower risk of all cause mortality (Hu *et al.,* 2005).

Table 1. Mean and standard deviation of anthropometrical, biochemistry and VO2max before and after intervention in studied groups.

Variables	Control diabetic		Exercise diabetic	
	Pretest	post-test	Pretest	post-test
Age (year)	43.5 ± 6.5	43.5 ± 6.5	44 ± 7.4	44 ± 7.4
Height (cm)	174.2 ± 5.3	174.2 ± 5.3	173.07 ± 4.97	173.07 ± 4.97
Weight (kg)	92.6 ± 6.9	93.1 ± 7.23	91.87 ± 7.59	89.13 ± 8.26
Waist circumference (cm)	106.3 ± 8.23	107.3 ± 6.21	104.9 ± 7.50	101.2 ± 7.28
BMI (kg/m2)	30.52 ± 3.32	30.68 ± 2.63	30.60 ± 2.59	29.87 ± 2.64
Body fat (%)	28.91 ± 3.65	29.3 ± 4.32	28.40 ± 4.66	25.87 ± 4.81
Visceral fat	13.02 ± 2.32	13.22 ± 2.12	12.88 ± 2.03	10.93 ± 1.62
Glucose (mg/dL)	229 ± 53	228 ± 54	223 ± 60	188 ± 42
Insulin (mg/dL)	9.01 ± 1.23	8.79 ± 1.36	8.52 ± 1.82	7.34 ± 2.99
Insulin resistance	5.09 ± 1.36	4.95 ± 1.12	4.62 ± 1.21	3.34 ± 1.33
VO2max (ml.kg.min)	27.14 ± 6.56	28.6 ± 6.2	28.3 ± 7.9	39.3 ± 10.5

Compared to pre-training, the Vo2max levels increased significantly after exercise program in the exercise but not in the control groups. Fasting glucose concentration levels were significantly decreased after exercise training when compared with baseline levels but not in control group. Body weight was reduced in exercise subjects but not significant trend in control subjects. The other anthropometrical markers such as body fat percentage, body mass index, abdominal circumference and visceral fat were also decreased significantly by exercise training in exercise group. With aerobic exercise training, insulin resistance was decreased in subjects (see table 2). There was no correlation between glucose concentrations and VO2max after exercise training in studied patients ($p = 0.311$, $r = 0.21$). We also did not observe significant correlation in VO2max and insulin resistance after aerobic training program ($p = 0.213$, $r = 0.19$).

Table 2. data of Student's paired T test for the pre and post training values in exercise group.

Paired Samples Test

		Paired Differences			t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean			
Pair 3	Weight (pre) - Weight (post)	2.733	2.915	.753	3.632	14	.003
Pair 4	Abdominal (pre) - Abdominal (	3.733	2.576	.665	5.612	14	.000
Pair 5	BMI (pre) - BMI (post)	.733	.884	.228	3.214	14	.006
Pair 6	%fat (pre) - %fat (post)	2.533	1.552	.401	6.321	14	.000
Pair 7	Visceral Fat (pre) - Visceral F	1.933	2.374	.613	3.153	14	.007
Pair 8	Glucose (pre) - Glucose (post	35.333	26.131	6.747	5.237	14	.000
Pair 9	Insulin1 - Insulin3	1.18000	3.34497	.86367	1.366	14	.193
Pair 10	Insulin Resistance (pre) - Insu Resistance (post)	1.27933	1.68007	.43379	2.949	14	.011
Pair 11	VO2max (pre) - VO2max (pos	-11.000	10.191	2.631	-4.180	14	.001

In accordance with these observations, our study clearly showed that aerobic exercise program can be decreased fasting glucose and insulin resistance in type 2 diabetic patients. Our study findings also support benefic effects of exercise training on VO2max as a main predictor of cardiorespiratory fitness in these patients. To support our data, clear evidence has established that the level of daily physical activity is negatively related with the incidence of type 2 diabetes (Hu *et al.,* 1999; Manson *et al.,* 1991).

Although some previous study demonstrated that the effect of exercise on insulin secretion is not permanent, exercise plays an important role in glucose homeostasis (Kaastra *et al.,* 2006; Urano *et al.,* 2004). It has been previously reported that improvement in cardiovascular fitness results in enhanced insulin function while reducing body fat mass (Sinha *et al.,* 2002). On the other hand, several studies have suggested that physical activity improves insulin function or blood glucose levels independently of changes in weight and body composition (Eliakim *et al.,* 2001; Travers *et al.,* 1998). In the another study, the author have reported that aerobic exercise training would result in better control of glycemia and aerobic capacity plus lowered levels of blood fats even in the absence of weight loss (Kadoglou *et al.,* 2007). No significant relationship between the changes in VO2max with glucose or other determinatives of type 2 diabetic was previously reported by other studies (Eizadi *et al.,* 2011).

Overall, data of present study showed that the three months aerobic exercise training is associated with increased VO2max and decreased fasting glucose and insulin resistance in adult males with type II diabetic patients. On the other hand, although, all of these changes occurred in response to aerobic training in exercise group without any changes in control group, but the finding of Pearson analysis showed no significant correlation in VO2max with fasting glucose and insulin resistance after exercise program in studied patients. These results point out that the changes in VO2max in response to aerobic program are independent of the changes in glucose or insulin resistance. This is likely improvement in VO2max by indirect or by influence of other biochemical or hormonal parameters was affect glucose concentration or insulin resistance.

Extensive studies have mentioned that exercise training may increase body's response to intrinsic insulin, by Several interdependent mechanisms including increasing the amount of transporters of glucose into the muscle cells, Increased glucose transporter (GLUT-4), increasing insulin sensitivity and last but not least, increasing the muscle mass, given that more than 75% of the glucose uptake in response to insulin is by the muscular tissue (Dela *et al.,* 2004).

References

Bloem CJ, Chang AM. 2008. Short-Term Exercise Improves B- Cell Function and Insulin Resistance in Older People with Impaired Glucose Tolerance. J Clin Endocrinol Metab **93(2),** 387-92.

Chang AM, Halter JB. 2003. Aging and insulin secretion. Am J Physiol Endocrinol Metab **284,** 7–12.

Chang AM, SmithMJ, Galecki AT. 2006. Impaired B-cell function in human aging: response to nicotinic acid-induced insulin resistance. J Clin Endocrinol Metab **91(9),** 3303–9.

Dela F, von Linstow ME, Mikines KJ, Galbo H. 2004. Physical training may enhance ß-cell function in type 2 diabetes. Am J Physiol Endocrinol Metab **287(5),** 1024-31.

Dietz WH. 1998.Childhood weight affects adult morbidity and mortality. J Nutr **128(2),** 411-14.

Eizadi M, Somayeh B, Payman A, Davood K. 2011. Relationship between the Changes Pattern of Aerobic Capacity and Fasting Glucose in Response to Chronic Exercise Training. Advances in bioresearch **2(2),** 151-155.

Eliakim A, Scheett TP, Newcomb R. 2001. Fitness, training, and the growth hormone insulin-like growth factor I axis in prepubertal girls. J Clin Endocrinol Metab **86(6),** 2797-802.

Halabchi F, Hassabi M, Mazaheri R, Angoorani H. 2006. Exercise and Diseases. TUMS Sports Medicine Research Center **11,** 1-36.

Hu FB, Sigal RJ, Rich-Edwards JW, Colditz GA, Solomon CG, Willett WC, Speizer FE, and Manson JE. 1999. Walking compared with vigorous physical activity and risk of type 2 diabetes in women: a prospective study. JAMA **282,** 1433–1439.

Hu G, Rico-Sanz J, Lakka TA, Tuomilehto J. 2006. Exercise, Genetics and Prevention of Type 2 Diabetes. Essays Biochem **42,** 177-92.

Hu G, Tuomilehto J, Silventoinen K, Barengo NC, Peltonen M, Jousilahti P. 2005. The effects of physical activity and body mass index on cardiovascular, cancer and all-cause mortality among 47 212 middle-aged Finnish men and women. Int J Obes Relat Metab Disord **8**, 894-902.

Kaastra B, Manders RJ, Van Breda E, Kies A, Jeukendrup AE, Keizer HA. 2006. Effects of increasing insulin secretion on acute postexercise blood glucose disposal. Med Sci Sports Exerc **38(2),** 268–75.

Kadoglou NP, Iliadis F, Angelopoulou N. 2007. The anti-inflammatory effects of exercise training in patients with type 2 diabetes mellitus. Eur J Cardiovasc Prev Rehabil **14(6),** 837-43.

Manson JE, Rimm EB, Stampfer MJ, Colditz GA, Willett WC, Krolewski AS, Rosner B, Hennekens CH, and Speizer FE. 1991. Physical activity and incidence of non-insulin-dependent diabetes mellitus in women. Lancet **338,** 774–778.

Myers J, Kaykha A, George S. 2004. Fitness versus physical activity patterns in predicting mortality in men. Am J Med **117,** 912-918.

Travers R, Dufour S, Petersen KF. 2002. Assessment of skeletal muscle triglyceride content by 1h nuclear magnetic resonance spectroscopy in lean and obese adolescents: relationships to insulin sensitivity, total body fat, and central adiposity. Diabetes **51(4),** 1022-7.

Travers SH, Labarta JI, Gargosky SE. 1998. Insulin-like growth factor binding protein-I levels are strongly associated with insulin sensitivity and obesity in early pubertal children. J Clin Endocrinol Metab **83(6),** 1935-9.

Urano Y, Sakurai T, Ueda H. 2004. Desensitization of the inhibitory effect of norepinephrine on insulin secretion from pancreatic islets of exercise-trained rats. Metabolism **53(11),** 1424–32.