Hrvat. Športskomed. Vjesn. 2013; 28: 33-38

THE EFFECTS OF AQUA AEROBIC ON PATIENTS WITH TYPE II DIABETES MELLITUS

UČINCI AEROBIKE U VODI KOD PACIJENATA SA ŠEĆERNOM BOLESTI TIPA 2

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SUMMARY

The purpose of this study was to analyze the effects of 6 months of aqua aerobic exercise in obese patients with Type II Diabetes Mellitus. A total of 24 adults (mean age 56.12±6.27 years; 12 men mean age 55.83±3.37 years and women mean age 56.41±8.41 years) with diet controlled or oral hypoglycemic medications controlled type 2 diabetes, were recruited. Exercise sessions were supervised by a certified exercise trainer three times per week for a period of six months. Testing was done three times: initial testing, testing after 3 months (transitive testing) and final testing after 6 months. Statistically significant differences were determined between the first and the second trial in HbA1c (HbA1c decreased 4.28%, $p<0.05$), the first and third trial in HbA1c (HbA1c decreased 7.03%, $p<0.05$), while between the second and third trial the decrease in HbA1c was the lowest (2.87%, $p<0.05$). Statistically significant differences between trials were also determined for the values of total cholesterol and HDL and LDL cholesterol and body weight. Statistically significant and linear decrease was found for the values of blood glucose between before training values of glucose and the values of glucose after training. In conclusion, this study showed that aqua aerobic training has a positive effect on glycemic control, body weight and lipid profile among patients with type II diabetes mellitus.

Key words: exercise, aqua aerobic, non-insulin-dependent diabetes mellitus

SAŽETAK

Cilj ovog istraživanja je bio analizirati učinke šestomjesečnog vježbanja aerobike u vodi kod pacijenata sa šećernom bolesti tipa 2.

U istraživanju su sudjelovala 24 odrasla ispitanika (prosječni broj godina 56.12±6.27; 12 muškaraca prosjeka godina 55.83±3.37 i 12 žena prosjeka godina 56.41±8.41) koji su imali prehranom ili oralnim hipoglikemicima kontroliranu šećernu bolest tipa 2. Ovlašteni kineziolog je nadzirao provođenje vježbanja aerobike u vodi tri puta tjedno kroz period od 6 mjeseci. Testiranje je bilo provedeno tri puta: početno testiranje, testiranje nakon 3 mjeseca (prijelazno testiranje) te završno testiranje nakon 6 mjeseci vježbanja.

Statistički značajne razlike su utvrđene u vrijednostima HbA1c između prvog i i drugog testiranja (HbA1c se smanjio 4.28%, $p<0.05$), prvog i trećeg testiranja (HbA1c se smanjio 7.03% $p<0.05$,) dok je pad u vrijednosti HbA1c između drugog i trećeg testiranja bio manji (2.87%, $p<0.05$). Također, statistički značajne razlike su zabilježene u vrijednostima tjelesne mase, ukupnog kolesterola kao i HDL i LDL kolesterola između pojedinih testiranja. Linearan, statistički značajan pad u vrijednostima glukoze u krvi je uočen između vrijednosti glukoze prije vježbanja i vrijednosti glukoze nakon vježbanja.

U zaključku, ovo istraživanje je pokazalo da vodeni aerobik ima pozitivan učinak na kontrolu glikemije, tjelesne mase te lipidnog profila osoba sa šećernom bolesti tipa 2.

Ključne riječi: tjelesna aktivnost, aquaerobika, diabetes mellitus tipa 2

Primljeno 09.05. 2013., prihvaćeno 01.07. 2013.

INTRODUCTION

The patients with type 2 (non–insulin-dependent) diabetes mellitus constitute about 80 to 90% of all patients with diabetes. When discussing treatment of type 2 diabetes mellitus, one of the most important aspects is consideration of all of the metabolic abnormalities associated with the disease (e.g. obesity, dyslipidaemia and hypertension), and not solely hyperglycaemia. Much research now supports the beneficial role of physical activity in the prevention and management of diabetes (3,5,8,11,31). Exercise is recommended in the treatment of glycemic profiles in individuals with type 2 diabetes, principally because of its beneficial effect on blood glucose profiles (1). It has been established that a single period of exercise can improve glycemic control in individuals with type 2 diabetes (18). Aerobic endurance exercise has been advocated as the exercise mode most suitable for the treatment of non-insulin-dependent diabetes mellitus (NIDDM) (13). One of the main goals in the treatment of NIDDM is the achievement of good glyceamic control in order to avoid micro and macro vascular complications. In participants with Type 2 diabetes the main problems are old age, overweight, orthopedic problems and co-existing cardiovascular diseases which may hinder even moderate physical activity. The metabolic syndrome is loosely defined as a cluster of cardiovascular risk factors, including disturbed insulin and glucose metabolism, hypertension, overweight and abdominal obesity, and dyslipidemia (elevated triglycerides and decreased HDL cholesterol levels). Furthermore, this syndrome predicts the development of type 2 diabetes, cardiovascular diseases, and also general mortality in nondiabetic subjects (22,23). Previous cross-sectional (6,16,28) and prospective (24,25) studies suggest that aerobic fitness and physical activity protect against the development of the metabolic syndrome. Previous cross-sectional studies have shown that older adults who engage in regular aerobic exercise training have lower arterial stiffness than sedentary older adults (32). Prospective examinations of a moderate aerobic exercise program in middle-aged subjects with type 2 diabetes (38) and normal older adults (32) have demonstrated a decrease in arterial stiffness. Many studies have found the positive effect of physical activity on glucose tolerance, insulin sensitivity and lipid profile (29,34,36.) in type 2 diabetic patients. These studies are based mainly on training programmes focusing on young and middle aged diabetic patients (27). The purpose of this study was to determine the effects of aqua aerobic on glucose level, and lipid profile among non-insulin-dependent diabetes mellitus (NIDDM) patients.

MATERIALS AND METHODS

Subjects

At the beginning of the study thirtyfive adults (16 men and 19 women, mean age 56.12±6.27 years, age ranging from 39 to 73 years) were recruited initially from the local community in north of Croatia through advertisement in local publications. All subjects had to be aged 50 years and older and were excluded if they had any history of angina, myocardial infarction, stroke, chronic pulmonary disease, were current smokers, or had exercise limiting orthopedic impairment. All subjects were required to have type 2 diabetes for at least 5 years. Subjects were excluded if they took β-blockers, calcium channel blockers, or any other agent that influenced autonomic function. Subjects had to be sedentary at the start of the study (as defined as no training and 30 min brisk walking/moderate exercise per week and no vigorous exercise in the preceding 6 months). Eleven subjects were excluded (4 male and 7 female) on the basis of this screening, leaving a total of 24 subjects participating in the study. This study was approved by the Human Subjects Committee of the Faculty of Kinesiology, University of Zagreb, and all subjects had given written informed consent.

Training program

One of the reasons we used aqua aerobic exercise is because of the special characteristics of the population studied –patients with type two diabetes mellitus. For this population even their daily routine is physically demanding. Aqua aerobic exercise has many benefits: exercising in water requires you to support only 50% of your body weight; the risk of injury is comparatively lower on account of its low-impact nature; stress and compression on the joints is less and the resistance offered by water leads to better muscular endurance and tone; the heart rate is maintained at a lower rate than in activities such as cycling and running. It was previously reported that there was no differences in the effects of aerobic activities in the water versus weight-bearing aerobic exercise on land (17). The endurance training (aqua aerobic) intervention was designed to improve aerobic fitness according to current guidelines (7) and consisted of moderate to vigorous intensity exercise in the swimming pool (1,5 meters deep), average temperature of water ranged from 26 to 28 °C. Training sessions were conducted three times per week, and subjects had to attend 90% of all training sessions to remain enrolled in the study. The aqua aerobic training sessions were 60 min in duration and consisted of a 10-min warm-up, 40 min of aerobic training, and 10 min of cool down/stretching. Moderate to moderate/vigorous intensity of the exercise was attained via self monitoring of heart rates during the class. Based on the resting heart rate and maximal heart rate, the training heart rate was set to 60–75% of heart rate reserve based on the Tanaka et al. equation (1). Intensity progression was planned in the way that first two months intensity was 60% of HR_{max}, third and fourth month 65% of HR_{max}, fifth 70% of HR_{max} and last (sixth) month intensity was set to 70% of HR_{max} but there were exceptions and problems with target intensities as aquaerobic is a group class and it is hard to adjust intensity individually. The trainer also contacted each subject weekly to ensure that he or she was not undertaking any additional exercise. Blood glucose measurements were taken before, during, and after exercise.

Data Collection

The conditions were standardized according to established guidelines: all measurements were performed after 30 min of supine rest, the environment was quiet and temperature controlled (25±1°C), all subjects were fasting, and all subjects were instructed to refrain from consumption of alcohol or caffeine for the preceding 24 h. The total cholesterol (mmol/l), LDL cholesterol (mmol/l), HDL cholesterol (mmol/l), body weight (kg) fasting blood glucose (mmol/l) and HbA1c were measured.

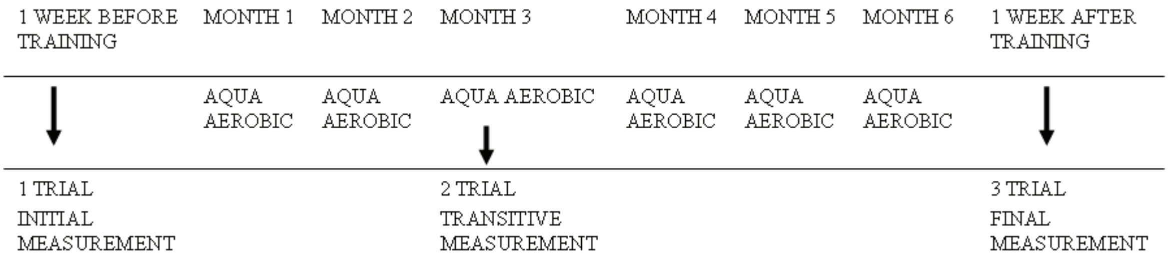

Figure 1. Study design and protocols
Slika 1. Dizajn istraživanja

Statistical Analysis

The statistical Packages for Social Studies PASW STATISTICS (ver. 18.0., PASW) and G Power (14) was used for statistical analysis. Descriptive statistics were reported as Mean ± SD for all measures. Moreover, all data were examined by the test of normal distribution (Kolmogorov-Smirnov) before any further analysis. Statistical power and effect size was calculated using G-power software (ver. 3.1). Differences between trials were determined using Pair Sampled t-test. Analysis of variance (ANOVA) was used to determine the differences between the male and female participants. A value of *p* < 0.0023 was considered significant, because of a Bonferroni correction for multiple comparisons (9).

RESULTS

All the analyzed variables in this study had normally distributed data according to Kolmogorov-Smirnov test. Analysis of variance ANOVA showed no statistically significant differences between male and female participants in all measured variables regardless the trial measured (p> 0.05).

Body weight:

Significant but low decrease in body weight was determined between the first and second measurement (84.48±21.12 vs. 83.42±20.95; t(23)=5.16, p<.05) with decrease in body weight by 1.24%, then the first and the third trial (84.48±21.12 vs. M=82.24±SD=20.59; t(23)=5.58, p <.05, decrease in body weight by 2.64%, but no statistically significant differences were determined between the second and third trial (p <.05).

HbA1c:

Statistically significant differences were determined between the first and the second trial (7.58±1.77 vs. 7.25±1.52; t(23)=3.68, p<.05) in Hba1c, and the improvement was measured for 4.28%, then the first and third trial (7.58±1.77 vs. 7.05±1.45; t (23)= 5.52, p <.05, improvement of 7.03%,) while between the second and third trial improvement was the lowest but significant (p <.05).

Total cholesterol:

Statistically significant differences between the first and second measurement (5.77±=1.43 vs. 5.54±1.35, t (23) = 6.65, p <.05 and the decrease in total cholesterol was 4.08%. Also the difference was significant between the first and the third measurement (5.77±1.43 vs. 5.45±=1.30; t (23) = 7.49, p <.05 and the decrease in total cholesterol was 5.66% .

HDL cholesterol:

The statistically significant improvement was found in HDL values between the first and the second measurement (1,18±0,18 vs. 1.24±0.16; t (23) = 3.85, p <.05) and the increase in HDL was 4.77% but not between the second and the third (1,25±0,15).

LDL cholesterol:

Statistically significant decrease was found for the values of LDL between the second and the third measurement in comparison with the first trial (first 4.63±1.47 vs. second 4.29±1.25 vs. third 4.20±1.21; p <.05) and the decreases in were 7.26%. and 9.21% and 2.10%.

Triglycerids:

Only one statistically significant difference in triglycerides values was determined between the first and third measurement (2.04±0.70 vs. 1.91±0.58; t(23)= 3.94, p <.05) and the decrease in triglycerides was 6.12%.

Glucose:

The largest improvement among measured variables was determined between all trials in measured glucose level before and after aqua aerobic exercise. Statistically significant decrease was found for the values of blood glucose in the first trial between before training values of glucose and the values of glucose after the training (9.58±3.20 vs 7.69±2.50; t(23)=4 .67, p <.05) and the decrease in blood glucose was 19.73%. Statistically significant decrease was also found for the values of blood glucose in the second trial between before training values of glucose and the values of glucose after the training (9.19±2.40 vs. 6.10±1.88; t (23) =6.12, p <.05) and the decrease in blood glucose was 33.57%. The decrease in

Table 1. Characteristic of the sample
Tablica 1. Opis uzorka

	Total	Men	Female
Weight (kg)	84.48±21.12	82.66±25.93	86.30±15.91
Height (cm)	167.75± 8.88	172.60± 8.80	162.91± 6.03
Years of DM	7.45± 1.76	7.75± .86	7.16± 2.32
Age (y)	56.12± 6.27	55.83± 3.37	56.41± 8.41
BMI	33.55± 9.60	29.90± 5.13	34.76±10.66

Table 2. Differences in mean values between three trials (Note: significant differences between the pairs of trials are reported in text!)
Tablica 2. Vrijednosti pojedinih parametara tijekom tri mjerenja

	Trial 1	Trial 2	Trial 3
Weight (kg)	84.48±21.12	83.42±20.95	82.24±20.59
Hba1c (%)	7.58± 1.77	7.25± 1.51	7.05± 1.45
Cholesterol (mmol/l)	5.77± 1.43	5.54± 1.35	5.45± 1.30
HDL-C(mmol/l)	1.18± .17	1.24± .16	1.25± .15
LDL-C(mmol/l)	4.63± 1.47	4.29± 1,25	4.20± 1.21
Triglycerides(mmol/l)	2.04± .70	1.96± .64	1.91± .58
Glucose pre(mmol/l)	9.58± 3.20	9.19± 2.40	8.15± 2.64
G1ucose post(mmol/l)	7.69± 2.50	6.10± 1.88	5.73± 1.54

glucose in the third trial was also found between before training values of glucose and the values of glucose after the training (8.15±2.64 vs. 5.73±1.54; $t(23) = 4.62$, $p < .05$) and the decrease in blood glucose was 29.65%.

DISCUSSION

We studied the effect of aqua aerobic on treatment of patient's with type II diabetes mellitus and found improvements in glucose tolerance, lipid profile and weight lost during the six month period. One of the interesting findings of this study was that statistically significant differences were not found between male and female participants, regardless of the variable measured and regardless of the trial measured. We can conclude that men and female patient's with type II diabetes mellitus participants react similar to aqua aerobic program used in this study. In our study we have determined the decrease in body weight. This decrease was linear and statistically significant for the first to second trial and from the second to third trial. Our results are similar to the results from the previous study, which have also detected the decrease in body weight under the influence of aerobic training (2,10,12,30). Concerning the effect of physical training on glycaemic control we observed small but significant differences in Hba1c levels between trials. These results were expected because exercise interventions were generally found to reduce glycosylated hemoglobin HbA1c (10,36) even though more recently the effects on other parameters, such as carnitine, had been investigated (3,15).

We can conclude that regular aqua aerobic exercise have a statistically and clinically significant effect HbA1c and that this kind of intervention improves glycemic control in the six month period of aqua aerobic training.

The effects of aerobic exercise on HbA1c are well established. However, the most interesting question to be addressed, it is not the effect of aerobic exercise itself but the effects of exercise intensity, specifically, vigorous exercise versus moderate physical activity. Aqua aerobic training had a positive influence on lipid profile (Table 2). We have determined the decrease in total cholesterol (2,19,36), LDL-C (2,36) and triglycerides (4,26), this decrease was linear and statistically significant and in accordance with previous studies. Improvement was determined in HDL-C levels. This was similar to the improvements found in the studies of Vanninen et al. (36) and Lehmann et al. (26) under the effects of aerobic training. The improvement in HDL-C was expected, because HDL-C is related to changes in blood glucose (26) but in our study we have detected decrease in blood glucose before and after aqua aerobic training. One of the reasons why elevation in HDL-C levels did occur was because weight reduction induces an elevation of HDL-c in type II diabetes (35). The most important impact of exercise in Type 2 diabetes is the beneficial effect on cardiovascular risk factors (20). The studies have showed that exercise training resulted in a significantly higher increase in HDL-C (37).

In summary, we demonstrated that aqua aerobic exercise reduces to some extent the multifactorial glycemic control, body weight and lipid profile with a relatively short intervention. Aquaaerobic exercise might be a good additional therapy for treatment of patients with type II diabetes mellitus.

Limitations of the study

The major limitation of the study was the lack of control group as only the results of aqua aerobic group were followed. Though, as the aim of the study was to investigate the influence of this type of exercise on diabetic patients and as this was the only intervention measure, in our opinion we might contribute the obtained effects to the aqua aerobic exercise. We also do not know if the observed improvements in glycemic control, body weight and lipid profile among studied patients with type II diabetes mellitus with aqua aerobic exercise persist over longer periods of time, because our subjects were only examined during the 6-month training period. The limitation of the study was also the problem of intensity monitoring as that was a group program so it was hard to adjust the intensities for each individual.

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