Ovidius University Annals, Series Physical Education and Sport / SCIENCE, MOVEMENT AND HEALTH
Vol. XVIII, ISSUE 1, 2018 Romania
The journal is indexed in: Ebsco, SPORTDiscus, INDEX COPERNICUS JOURNAL MASTER LIST,
DOAJ DIRECTORY OF OPEN ACCES JOURNALS, Caby, Gale Cengage Learning, Cabell's Directories

Science, Movement and Health, Vol. XVIII, ISSUE 1, 2018
January 2018, 18 (1): 31-35
Original article

EFFECTS OF METABOLIC TRAINING IN TYPE 2 DIABETES PATIENTS

BIANCALANA Vincenzo[1], LUCCHETTI Cristiana[1]

Abstract

Aim: Give a type of physical exercise that increases the sensitivity to insulin and improves the following parameters: Glycated Hemoglobin (HbA1c), Body Mass Index (BMI), Maximum Ozygen Consumption (VO2max) and Body weight.

Methods: A group of type 2 diabetes patients (6 males and 5 females) in care at *INRCA-IRCCS Hospital of Ancona - U.O.C. Diabetes and Metabolic Disease*s sono stati sottoposti ad un combination of aerobic and resistance training for a period of 12 weeks.

Results: It was pointed out a reduction, no statistically significant ($p>0.05$), of the HbA1c (-2.8%), BMI (-0.9%), Body weight (-1.9%) values. It has been recorded a statistically significant increase ($p<0.05$) of VO_2max values (5.5%).

Conclusion. The combination of aerobic and resistance training on patients with type 2 diabetes, improves insulin sensitivity and oxygen consumption, reduces body weight and BMI, the main predictors of metabolic improvement induced by exercise

Keywords: physical exercise, Type 2 Diabetes, insulin sensibility.

Introduction

The prevalence of diabetes mellitus is rapidly increasing worldwide; the number of people with diabetes, aged between 20 and 79 years, will increase over the next 20 years from 415 million in 2015 to 642 million in 2040. (International Diebetes Federation, 2015)

This growth is attributable to several factors such as worsening eating habits, obesity, sedentary lifestyle and growing well-being in emerging countries. In addition to reducing the life expectancy of 5-10 years, diabetes is responsible for serious complications.

Cardiovascular diseases (macroangiopathies, retinal, kidney, heart, and peripheral and autonomic nervous system microangiopathies) justify 70-80% of total mortality, with an overall cardiovascular risk 3 time higher in the diabetic population than in no diabetic one. (Seo et al., 2012)

The most serious complications (heart attack, stroke, heart failure and sudden death) represent the main cause of high mortality and a significant impairment of quality of life. (Haskell et al., 2007)

Physical exercise is recommended as a preventive intervention that improves metabolic control and reduces the risk factors of many cardiovascular diseases, including type 2 diabetes.

Physical exercise causes a positive alteration of energy metabolism: it increases the consumption of body oxygen up to 20 times, improves cardiorespiratory fitness (VO_2 max), increases plasma and blood volume, ensuring better ventilation in response to a greater demand of oxygen from the tissues. (Myres et al., 2002). Furthermore, physical exercise decreases adiposity and improves weight control, reduces triglycerides, increases the levels of high-density lipoprotein (HDL) and decreases levels of low-density lipoprotein (LDL); increases insulin sensitivity and improves glycaemic control, reduces blood pressure, decreases systemic inflammation and promotes endothelial function. (Bassi et al., 2016)

The aim of this research was to verify on a sample of type 2 diabetes patients, the hypothesis that an intervention on lifestyle, based on combined physical exercise (aerobic and resistance) in addition to the conventional treatment, improves the following parameters: Glycated Haemoglobin (HbA1c) Maximal Oxygen Consumption (VO_2 max), Body Mass Index (BMI), Body weight.

Methods

Study design and participants

The study has been conducted *INRCA-IRCCS Hospital of Ancona - U.O.C. Diabetes and Metabolic* Diseases has been conducted from …….. to …….. ; the participants were recruited directly from health staff of Diabetes Clinics of the same hospital. The inclusion criteria were the diagnosis of type 2 diabetes and a physical exercise practiced level lower than that recommended by American Diabetes Association (150 minutes/week of aerobic physical activity with moderate intensity) (*). In addition to this, patients with a base HbA1c value >10%, a severe cardiovascular disease or dysfunctions of the

[1] Department of Biomolecular Sciences, School of Health and Sport Sciences; University Of Urbino "Carlo Bo" ITALY
E-mail address: vincenzo.biancalana@uniurb.it
Received 29.10.2017 / Accepted 24.11.2017

central nervous system, with diabetes-related complications as the retinopathy or the plantar ulcers and disorders of the musculoskeletal system, were excluded.

In the study, 11 patients were considered (6 males and 5 females).

.

All participants signed on informed consent form before starting treatment.

All participants were obliged to keep the same eating and exercise habits for the entire duration of the training program and not to change their drug therapy

Table 1 Physical characteristics of the subjects

	M ± SD	
Variables	**Males (n = 6)**	**Females (n = 5)**
Age (years)	59.5 ± 11.7	59.2 ± 6.0
Body weight (Kg)	98.8 ± 22.0	79.8 ± 10.4
BMI (Kg/m^2)	32.7 ± 5.7	31.8 ± 2.9
VO_2 max (ml/Kg/min)	18.8 ± 2.1	17.1 ± 1.7
HbA1c (%)	8.1 ± 0.5	7.1 ± 1.2

BMI, body mass index; VO_2 max, maximal oxygen consumption; HbA1c, glycated hemoglobin; M, mean; SD, standard deviation; n, number of subjects.

Experimental

A combination of Aerobic and Resistance Training was submitted to all participants, according to the Guidelines of the American Diabetes Association; it was divided into three not consecutive weekly sessions, for a period of 12 weeks.

The Aerobic Training with a duration of 30 minutes was performed on the treadmill and the cycle ergometer with an intensity of 30-40% HRR during the first month, 40-50% HRR during the second month and with an intensity of 50-60% HRR during the third month, as estimated by the Karvonen equation (**). Heart rate monitors were used to standardize exercise intensity (Polar S810i).

The Resistance Training was composed of exercises on weight machines and free weights for the involvement of the main muscle groups (pectoral and dorsal muscles, quadriceps femoris, buttocks and abdominals) each performed with 3 series of 12 repetitions and 30"/1' rest between the series.

To determine protocol loads, the 1-RM test was applied by gradually increasing resistance until the volunteer succeeded in performing no more than one repetition [13]. The 1-RM test was performed for all exercises. The intensity of the training was gradually incremented: the 60% of 1RM during the first month, 65% of 1RM during the second and 70% of 1RM during the third month. In the meanwhile, the exercises changed every month in order to remedy the boredom of training without changing the musculature involved: upper body exercises (bench press, shoulder press, seated row, push up and pull down), leg exercises (squat, leg press, extension, and flexion) and abdominal crunch.

The description of the Combination Training protocol is shown in the **Table 2**.

Table 2: Description of the training protocol

Weeks	Sessions/wks	Combination Training				
		Aerobic Training		Resistance Training		
		Intensity/ % HRR	Time (min)	Intensity/ % 1RM	Sets/ Repetitions	Rest (s)
1-2	3	30-40	30	60	3 x 12	30"/ 60''
3-4	3	30-40	30	60	3 x 12	30"/ 60''
5-6	3	40-50	30	65	3 x 12	30"/ 60''
7-8	3	40-50	30	65	3 x 12	30"/ 60''
9-10	3	50-60	30	70	3 x 12	30"/ 60''
11-12	3	50-60	30	70	3 x 12	30"/ 60''

Outcome measures

The socio-demographic variables (age, sex, marital status), the years of diagnosis and drug related to the type 2 diabetes, have been detected through a standardized medical history interview and recorded in a special Personal Card.

The weight and the height were measured for the calculation of the Body Mass Index (BMI, kg/m2).

For the evaluation of VO_2max, it was used the modified Balke Test run on the treadmill. The test involved 18 step with the duration of 1 minute each, a speed of 4,3 km/h and with a gradient increase of 1% for each step. The test ended when the subject had reached the 80% of HR max and subsequently the evaluation of VO_2max through the ACSM equation. (Marsh, 2012))

The HbA1c (%) was detected by ematoclinic analysis made at *C.A.D. of INRCA - Ancona*.

Data were collected at the beginning of treatment (T_0) and after 12 weeks at the end of treatment (T_1).

Statistical analysis

The statistical analysis was conducted using the GraphPad Prism 7.0 software (GraphPad Software, La Jolla California USA). The significance level was set at $p<0.05$. Involved variables were analysed performing the statistical test Paired Sample t-test, with the aim to assess the effect over time of the used training protocol (Combination Training) on the sample. Data are represented using the arithmetic mean (M) and standard deviation (SD).

Results

HbA1c

Data analysis of the training protocol effects did not show a statistically significant reduction ($p> 0.05$) of HbA1c at T1. However there is an improvement of insulin sensibility from T_1, with a reduction of the -2.8% HbA1c values (**Fig.1**).

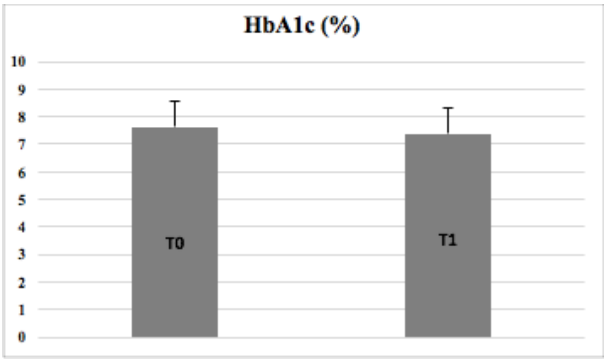

Fig. 1. Effects of the 12-wk intervention on HbA1c. The upper graph shows HbA1c (%) with baseline values of 7.6±1.0 and post intervention values of 7.4±0.9. * denotes statistically significant differences from T_0.

Body weight

Data analysis of the training protocol effects did not show a statistically significant reduction ($p> 0.05$) of body weight from T_1. However there is an improvement of body weight at T_1, with a reduction of the -1.9% body weight values (**Fig.2**).

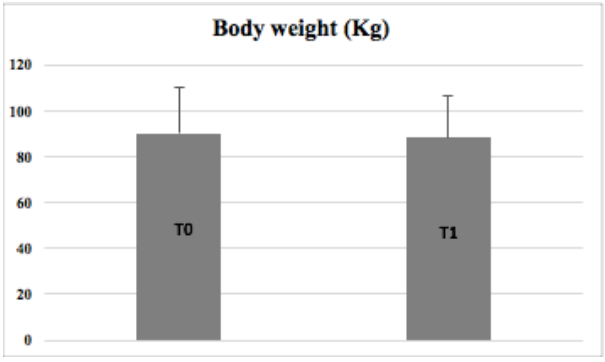

Fig. 2. Effects of the 12-wk intervention on body weight. The upper graph shows body weight (Kg) with baseline values of 90.2±19.6 and post intervention values of 88.3±18.5. * denotes statistically significant differences from T_0

BMI

Data analysis of the training protocol effects did not show a statistically significant reduction ($p> 0.05$) of BMI at T_1. However there is an improvement of BMI at T_1, with a reduction of the -0.9% BMI values (**Fig.3**).

Ovidius University Annals, Series Physical Education and Sport / SCIENCE, MOVEMENT AND HEALTH
Vol. XVIII, ISSUE 1, 2018 Romania
The journal is indexed in: Ebsco, SPORTDiscus, INDEX COPERNICUS JOURNAL MASTER LIST,
DOAJ DIRECTORY OF OPEN ACCES JOURNALS, Caby, Gale Cengage Learning, Cabell's Directories

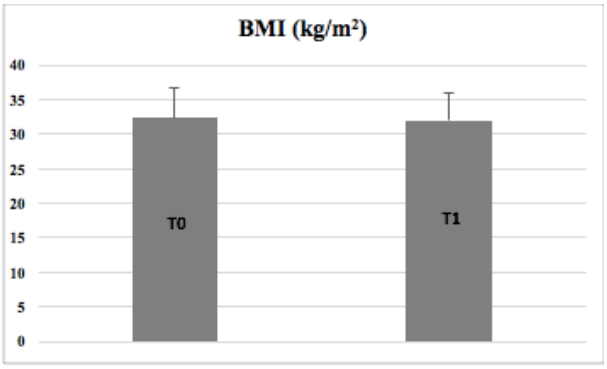

Fig. 3. Effects of the 12-wk intervention on BMI. The upper graph shows BMI (Kg/m2) with baseline values of 32.3±4.5 and post intervention values of 32.0±4.0. * denotes statistically significant differences from T_0

VO_2 max

Data analysis of the training protocol effects did not show an improvement in aerobic capacity at T_1, with a statistically significant increase ($p < 0.05$) of VO_2 max values of +5.5%. (**Fig.4**)

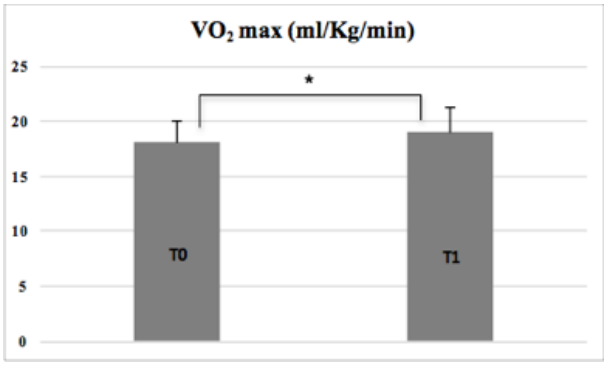

Fig. 4. Effects of the 12-wk intervention on VO_2 max. The upper graph shows VO_2 max (ml/Kg/min) with baseline values of 18.0±2.1 and post intervention values of 19.0±2.3. * denotes statistically significant differences from T_0.

Discussion

Although, it is generally accepted that regular exercise provides substantial health benefits to individuals with type 2 diabetes, the exact exercise prescription in terms of type (aerobic or resistance or both) is still unclear (Haskell et al., 2007; Marwick et al., 2009).

The aim of this study is to evaluate the effects of a combination of aerobic and resistance training, cardiovascular fitness and weight loss on insulin sensitivity of persons with type 2 diabetes.

The results have confirmed the effectiveness of the type of training used; data analysis, indeed, has revealed a reduction – even if not statistically relevant – of HbA1c, BMI and body weight and a statistically relevant increase of VO_2max.

It has been shown that increased VO_2max is associated with decreased cardiovascular and all-cause mortality (Myres et al., 2002). From a clinical perspective, our data indicate that combination training can be an effective strategy in reducing cardiovascular risk factors with potential beneficial effects on VO_2max in patients with T2D. Our findings show that a significant increase in VO_2max was also correlated to the decrease in HbA1c and consequently to a significant improvement in aerobic capacity with an insulin action improvement (Bassi et al., 2016).

Our results, although somewhat narrow sample size, support the American Diabetic Association Guidelines (American Diabetes Association, 2016) which indicate the combination of aerobic and resistance activities as a viable alternative to individual activities, confirming that mixed programs of aerobic and resistance exercise confer an additional benefit on glycaemic control and some risk factors in type 2 diabetics.

Conclusions

The combination of aerobic and resistance training on patients with type 2 diabetes, improves insulin sensitivity and oxygen consumption, reduces body weight and BMI, the main predictors of metabolic improvement induced by exercise (Conn et al., 2007; Church et al., 2010).

Aknowledgements

Thank you for all of subjects who participated in my study.

References

American Diabetes Association. Standards of Medical Care in Diabetes, 2016. Diabetes Care. 2016; 39(1).

Balducci S, Leonetti F, Di Mario U, Fallucca F, 2004, Is a long term aerobic plus resistance training program feasible for and effective on metabolic profiles in type 2 diabetic patients? Diabetes Care. 27:841-842.

Bassi D, Mendes RG, Arakelian VM, Caruso FC, Cabiddu R, Júnior JC, Arena R, Borghi-Silva A, 2016, Potential Effects on Cardiorespiratory and Metabolic Status After a Concurrent Strength and Endurance Training Program in Diabetes Patients - a Randomized Controlled Trial**.** Sports Med Open. 2:31.

Church TS, Blair SN, Cocreham S, Johannsen N, Johnson W, Kramer K, Mikus CR, Myers V, Nauta M, Rodarte RQ, Sparks L, Thompson A, Earnest CP, 2010, Effects of aerobic and resistance training on haemoglobin A1c levels in patients with type 2 diabetes: a randomized controlled trial. JAMA. 304(20):2253-62

Conn VS, Hafdahl AR, Mehr DR, LeMaster JW, Brown SA, Nielsen PJ, 2007, Metabolic effects of interventions to increase exercise in adults with type 2 diabetes. Diabetologia. 50:913-921.

Cuff DJ, Meneilly GS, Martin A, Ignaszewski A, Tildesley HD, Frohlich JJ, 2003, Effective exercise modality to reduce insulin resistance in women with type 2 diabetes. Diabetes Care. 26:2977-2982.

Emerging Risk Factors Collaboration, Sarwar N, Gao P, Seshasai SR, Gobin R, Kaptoge S, Di Angelantonio E, Ingelsson E, Lawlor DA, Selvin E, Stampfer M, Stehouwer CD, Lewington S, Pennells L, Thompson A, Sattar N, White IR, Ray KK, Danesh J, 2010, Diabetes mellitus, fasting blood glucose concentration, and risk of vascular disease: a collaborative meta-analysis of 102 prospective studies. Lancet. 375(9733):2215-22.

Haskell WL, Lee IM, Pate RR, Powell KE, Blair SN, Franklin BA, Macera CA, Heath GW, Thompson PD, Bauman A, 2007, Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. Med Sci Sports Exerc. 39(8):1423-1434.

International Diebetes Federation (IDF), 2015, Diabetes Atlas, Seventh Edition.

Karvonen MJ, Kentala E, Mustala O, 1957, The effects of training on heart rate; a longitudinal study. Ann Med Exp Biol Fenn. 35:307-315.

Marsh CE, 2012, Evaluation of the American College of Sports Medicine submaximal treadmill running test for predicting VO2max. J Strength Cond Res. 26(2):548-54.

Marwick TH, Hordern MD, Miller T, Chyun DA, Bertoni AG, Blumenthal RS, Philippides G, Rocchini A, 2009, Council on Clinical Cardiology, American Heart Association Exercise, Cardiac Rehabilitation, and Prevention Committee; Council on Cardiovascular Disease in the Young; Council on Cardiovascular Nursing; Council on Nutrition, Physical Activity, and Metabolism; Interdisciplinary Council on Quality of Care and Outcomes Research. Exercise training for type 2 diabetes mellitus: impact on cardiovascular risk: a scientific statement from the American Heart Association. Circulation. 119(25):3244-62.

Myers J, Prakash M, Froelicher V, Do D, Partington S, Atwood JE, 2002, Exercise capacity and mortality among men referred for exercise testing. N. Engl. J. Med. 346: 793-801.

Seo DI, Kim E, Fahs CA, Rossow L, Young K, Ferguson SL, Thiebaud R, Sherk VD, Loenneke JP, Kim D, Lee MK, Choi KH, Bemben DA, Bemben MG, So WY, 2012, Reliability of the ne-repetition maximum test based on muscle group and gender. J Sports Sci Med. 11(2):221-5.

Tokmakidis SP, Zois CE, Volaklis KA, Kotsa K, Touvra AM, 2004, The effects of a combined strength and aerobic exercise program on glucose control and insulin action in women with type 2 diabetes. Eur J Appl Physiol. 92:437-442.

Warburton DE, Haykowsky MJ, Quinney HA, Blackmore D, Teo KK, Taylor DA, McGavock J., Humen DP, 2004, Blood volume expansion and cardiorespiratory function: effects of training modality. Med Sci Sports Exerc. 36(6):991-1000.

Warburton DE, Nicol CW, Bredin SS, 2006, Health benefits of physical activity: the evidence CMAJ. 174(6):801-809.

World Health Organization (OMS), 2016, Global Report on Diabetes.