MEDWIN PUBLISHERS
Committed to create value for Researchers

Diabetes and Obesity International Journal

Cardiorespiratory Fitness and Insulin Sensitivity Response to high-Intensity Interval Training in Overweight Post-menopausal Women

Nakagaki MS[1,2]*, Michelin E[1], Teixeira O[1] and Burini RC[1]

[1]Departament of Public Health, Center for Nutritional and Exercise Metabolism, Botucatu School of Medicine, Brazil

[2]Departament of Ginecology, Obstetrics and Mastology, Botucatu School of Medicine, Brazil

Research Article

Volume 2 Issue 2

Received Date: February 24, 2017

Published Date: March 13, 2017

***Corresponding author:** Mariana Santoro Nakagaki, Departament of Public Health, Center for Nutritional and Exercise Metabolism, Botucatu School of Medicine, UNESP- Botucatu, SP, Brazil, Email: msantoro16@hotmail.com

Abstract

1.1. Background: It is known that physical exercise is an important non-pharmacological tool in the prevention and treatment of unwanted weight gain and diseases affecting post-menopausal women. High-intensity training is more efficient in improving glycemic control than low-intensity exercise and, interval protocol is better than continuous exercise to increase aerobic capacity. The objective of this study was to analyze the response of insulin resistance in postmenopausal women after 10 weeks of high-intensity interval training (HIIT).

1.2. Methods: 24 postmenopausal women (57 ± 7.8yrs) were submitted to a 10-wk HIIT protocol, performed at 70-90% of maximum heart rate in treadmill. Blood pressure and heart rate were evaluated in every session. Level of physical activity and socio-demographic characterization were measured at baseline by the International Physical Activity Questionnaire (IPAQ-long-form version 8). Physical fitness (flexibility, handgrip, cardio respiratory fitness (VO_{2max})) and, fasting plasma glucose, insulin, triglycerides, total cholesterol were analyzed. Anthropometry of body weight, height and adiposity were taken. The chi-square (c_2), ANOVA for variables with symmetrical distribution and model range for repeated measures with asymmetric distribution were applied for comparison between moments (M0-M1). The significance level adopted was 5%.

1.3. Results: The sample was composed by low-income women, elementary level of schooling, perception of good health and good level of physical activity, showing overweight and dyslipidemia. Baseline insulin resistance was 25%. After 10-week intervention there was a significant increase in aerobic fitness, moderate increase in flexibility and null in handgrip strength. The HIIT protocol reduced 50% of hyperglycemics (and hyperinsulinemics) but only 16.7% of the altered HOMA-IR.

1.4. Conclusions: The present protocol of HIIT was effective in improving cardio respiratory fitness and only moderately effective in improving insulin sensitivity, probably due to the maintenance of overweight and visceral adiposity.

Keywords: Menopause; Blood Glucose; Physical Fitness; Aerobic Exercise

Introduction

The climacteric is a distinctive feature of female aging that establishes the physiological state of progressive hypoestrogenism culminating in the final cessation of menstrual cycles. Menopause or cessation of ovarian function is the most striking stage of menopause, and creates significant physical, psychological and social changes [1].

Women spend around one third of their lives in post-menopause [2] and approximately 70% of Brazilian confirm the presence of symptoms related to menopause [3]. Weight gain in this stage of life is characterized by excessive accumulation of fat especially in the muscles and liver and, therefore, increases the risk of postmenopausal development of insulin resistance, type 2 diabetes and other chronic diseases [4]. Cardiovascular disease is the leading cause of death in postmenopausal women [5].

The identification of diseases and their risk factors affecting women in the aging process allow the introduction of prevention programs aiming to prevent or delay its onset, with consequent decrease in mortality rate and thus increase the quality of life [6-8]. Interventions with aerobic and/or resistance exercises shown to be effective in combating unwanted weight gain and improve cardiovascular and metabolic risk [9] in postmenopausal women [10].

The high intensity training improves fitness level [11], insulin sensitivity, glycemic control [12] and reduces the risk of coronary heart disease when compared to low intensity exercise [13]. However, more intense training programs are associated with poor adherence [14]. In addition, the impact of exercise intensity in type 2 diabetic patients is not yet clears [15]. Therefore, interval protocol is better than continuous exercise to increase aerobic capacity in healthy people [16,17] and in patients with cardiovascular disease [18]. Currently, the interval training is a well-known exercise protocol that merges high-intensity exercise with periods of rest or recovery [19] and helps to strengthen and improve cardiorespiratory fitness [20]. High-intensity interval training protocol showed significant improvement in glycemic control and cardiovascular risk factors in subjects with metabolic syndrome and type 2 diabetes, which [21,22].

We hypothesized that high intensity interval training might reduce insulin resistance in post-menopause women along with physical fitness and body composition improvements. Hence, the aim of this study was to analyze the response of insulin resistance in postmenopausal women after 10 weeks of high-intensity interval training on a treadmill.

Methods

Study Design and Subjects

From the outcomes of reducing plasma glucose and insulin by high-intensity training (23) and taking the test power of 95% reliability and 5% error, the calculated minimum sampling for the present study was 22 patients. Therefore, a convenience sample of 24 post-menopausal women was selected among those enrolled in a Lifestyle Modification Program (Move for Health) conducted by this Institution since 1991. The inclusion criteria was the absence of menstruation for at least 12 months and not referring any type of endocrine-metabolic, gynecological and / or bone-joint diseases that prevented the practice of physical exercise. All included patients were informed about the proposal and procedures to be performed and signed the informed consent form for the Ethics Committee of the Botucatu Medical School – UNESP (SP, Brazil). At the end of the experiment were included only data from those that had achieved the minimum rate of 70% per high-intensity interval training and attended both, the baseline and final assessments.

Measurements

Physical activity level (PAL), socio-demographic characteristics (gender, age, marital status, family income and education) and health status were obtained by applying the International Physical Activity Questionnaire (IPAQ version 8 - long form) [36]. Marital status was classified as married (married and stable union) and unmarried (single, widowed, divorced, and separated). The schooling level was classified as fundamental complete and incomplete, secondary education and higher. Family income ranked from up to five minimum wages (< 5SM) or greater/equal to five times the minimum wage (≥5SM). Health perception was rated as good (excellent, very good or good) or bad (fair and poor).

Body weight and height measurements were taken [24] with subsequent calculation of body mass index (BMI = kg/m^2) classified as normal weight when up to 24.9 kg / m^2, overweight 25 up to 29.9 kg/m^2 and obese with values greater than 30 kg/m^2 [25]. The waist circumference (WC) was measured with millimeter tape inextensible and inelastic on the midpoint between the last intercostal space and iliac crest. The value of 88 cm was adopted as cutoff for abdominal obesity [24].
Body muscle and fat composition was performed in the supine position by bioelectrical impedance (BIA) (Biodinâmics®, model 450, USA) with the calculation of muscle mass by the equation proposed by Janssen et al. [26] calculated as body mass index (IMM) as proposed by Baumgartner et al. [27]. Sarcopenia classification adopted for women was: Normal - IMM> 5.45 kg/m^2, Sarcopenia - IMM ≤ 5.45 kg/m^2 [28]. The percentage of female fat used as normal was 20-35% [29].

The evaluation of the PA was held with the subject seated, following the recommendations of the VI Brazilian Guidelines on Hypertension [30]. Hypertension was defined as blood pressure greater than 130/85 mmHg [31].

The antecubital-vein blood sampling was drawn after an overnight fast (8-12 hours), using standard venipuncture vacuum. Plasma glucose, triglycerides (TG), total cholesterol (TC), HDL cholesterol (HDL-C), LDL cholesterol (LDL-C) and uric acid, were quantified by Dry Chemical method (System Vitros Johnson & Johnson). Insulin and high-sensitivity C-reactive protein (CRP) were measured by chemiluminescent method. The classification of normal values followed the NCEP-ATPIII [32]. All blood samples were measured in the Clinical Research Unit (UPECLIN) Clinical Hospital of the Faculty of Medicine of Botucatu - UNESP.

DM2was defined by blood glucose value ≥ 126 mg/dL [33] or current use of oral hypoglycemic agents or insulin. State of glucose intolerance was defined as blood glucose ≥ 100 mg/dL [34]. Insulin resistance was determined by means of the homeostasis (homeostasis model assessment - insulin resistance) (HOMA-IR), which is the product of fasting insulin (μUI / mL) and fasting plasma glucose (mmol/L) divided by 22.5 [35]. It was adopted 3.5 as the upper limit of normal range.

The trunk flexibility (FLEX) was assessed by using the sit and reach test. Muscle strength of the upper limbs was determined using the handgrip test with hydraulic dynamometer. For both skills have adopted the classifications of "25 percentile" (p25), "percentile 25-75" (p25-75) and 75 percentile (p75) by sex, based on program participants to change in lifestyle (Move for Health).

Cardiorespiratory fitness was determined as maximal oxygen uptake (VO_{2max}), using a treadmill (QMCTM90 model) according to the Balke protocol [37], with constant monitoring of heart rate and blood pressure. The treadmill inclination was used to determine the VO_{2max} through formula. After obtaining the VO_{2max}, cardiorespiratory fitness was classified in "25 percentile" (p25), "percentile 25-75" (p25-75) and 75 percentile (p75) by sex, also based on program participants to sample change in lifestyle (Move for Health). The maximum heart rate (HR max) obtained during the baseline cardiorespiratory test was individually used to prescribe the intensity for the HIIT.

Intervention Protocol

The patients were subjected to 60 minutes of supervised exercise twice weekly for 10 weeks. The exercise-protocol was composed by initial (5 minutes) and final (10 minutes) stretching; the latter was intended as an aid to relaxation for complete heart rate baseline recovering.

High-intensity interval training on treadmill included 10 minutes of warm-up at 70% of maximum heart rate (HR max), followed by 4 series of 4 minutes each on 90% HR max with 3-min intervals between series for active recovery at 70 % of FC max. The protocol ended with 5 minutes backing to calm. The total protocol lasted 43 minutes of treadmill-interval training. During the 10-wk experiment they all received dietary counseling but no specific prescribed diets.

Statistical Analysis

Results were expressed as mean and standard deviation for continuous variables and frequency and percentage for categorical variables. The proportion comparisons were done by chi-square test (χ^2), the ANOVA repeated measure for symmetric quantitative variables and the range model repeated measures for the asymmetric quantitative. SAS for Windows, version 9.1 was used with a significance level of 5% or corresponding p-value.

Results

The sample was composed in majority by under 60 years of age (70.8%), married (62.5%) with complete elementary school (33.3%), family earning income up to five minimum salaries (91.7%) and reporting good general health (79.2%). Anthropometrically, most were obese (54.2%) and overweight (33.3%), with higher than normal waist circumference (79.2%). Clinically mostly were normotensive either as systolic (66.7%) or diastolic (83.3%). Biochemically, the sample was characterized with being dyslipemics, with 54.2% hypercholesterolemia either total (54.2%), LDL-C (83.3%,) or lower HDL-C (41.7%). Normal values were prevalent for triglycerides, uric acid (83.3%) and CRP (83.3%). Abnormal insulin achieved 16.7% whereas altered glucose and HOMA-IR achieved 25% of the women.

At baseline of the study they were within the recommended physical activity (91.7%), with fitness normal handgrip (62.5% between Q1 and Q4), 37.5% showing low flexibility (Q1) and half of them (Q2-Q3) presenting VO_{2max} 30.7+-1.7mlO_2/kg/min.

Thus, overall we selected a sample of low-income women with intermediate schoolarity referring self-perception of good health, although overweight and with good weekly physical activity and grip strength fitness but poor trunk flexibility. Changes in insulin sensitivity were less frequent than those of hyperlipemia.

After 10 weeks of interval training on a treadmill, the average values changed statistically, only for cardiorespiratory fitness markers. The cardiorespiratory test increased 23.8% in time on treadmill, with 21.7% higher inclination of the treadmill ramp leading to a calculated increase of 12.3% in theVO_{2max} (Table 1).

	Mean ± SD	Frequency (%)	p value
Age (years)	57 ± 7.8		
<60 years	53.1 ± 4.2	17 (70.8)	0.009
≥60 years	66.6 ± 5.8	7 (29.2)	
Total Physical Activity (min/week)	841.3 ± 643.6		
<150 min/week	52.5 ± 74.2	2 (8.3)	<0.0001
≥150 min/week	913 ± 623.5	22 (91.7)	
Domestic Physical Activity (min/week)	493.5 ± 454.1		
Occupational Physical Activity (min/week)	125.4 ± 420.2		
Leisure Physical Activity (min/week)	138.2 ± 129.3		
Transportation Physical Activity (min/week)	84.2 ± 110.5		
Flexibility (cm)	23.0 ± 9.3		
Q1	13.9 ± 2	9 (37.5)a	
Q2-Q3	23 ± 3.9	8 (33.3)a	
Q4	35 ± 3	7 (29.2)a	
Handgrip (kg)	29.8 ± 5.3		
Q1	22.0	3 (12.5)a	
Q2-Q3	28.1 ± 2.1	15 (62.5)b	
Q4	36.2 ± 3.5	6 (25)a	
VO^2max (ml/kg/min)	31.6 ± 4.2		
Q1	23.7 ± 1.1	3 (12.5)a	
Q2-Q3	30.9 ± 1.7	16 (66.7)b	
Q4	37.1 ± 0.8	5 (20.8)a	

Q1: 25th percentile; Q2-Q3: 25-75 percentile; Q4: 75th percentile; VO_{2max}: Maximal oxygen uptake; chi-square test (χ^2) trend for proportion of comparison; proportions followed by different letters differ statistically; $p < 0.05$.

Table 1: Demographic characteristics, fitness and physical activity baseline menopausal women participants of interval protocol.

Among the categorical variables the 37.5% flexibility-unfit women (Q1) found at baseline were reassigned either to Q2-Q3 (33.3%) or Q4(11.1%). Regarding the glucose-insulin status the interval protocol resulted in improvement in 50% of the former hyperglycemics and also of the hyperinsulinemics and 16.7% of those with altered HOMA-IR. Nevertheless none of these categorized changes showed statistical significance. Moreover, there was no positive or negative reclassification neither for handgrip strength or body- or abdominal-obesity (Table 2- 6).

Thus, the physical intervention protocol was shown to be effective in improving aerobic fitness and flexibility, in addition to discrete effects on insulin sensitivity. Nevertheless it was ineffective in reducing abdominal adiposity and overweight as well dyslipemia.

	Mean ± SD	Frequency (%)	p value
Body mass (kg)	76.5 ± 12.7		
Height (cm)	157.8 ± 4.6		
BMI (kg/m^2)	30.6 ± 4.3		
Eutrofic	24.2 ± 1.2	3 (12.5)a	
Overweigh	28.1 ± 1.2	8 (33.3)ab	
Obese	33.7 ± 3.2	13 (54.2)b	
Waist circumference (cm)	96.4 ± 10.8		
Normal	81.8 ± 3.9	5 (20.8)	0.0001
Altered	100.2 ± 8.4	19 (79.2)	

Chi-square test (χ^2) trend for proportion of comparison; proportions followed by different letters differ statistically; p <0.05.

Table 2: Baseline characteristics of body composition in postmenopausal women participants of interval protocol.

	Mean ± SD	Frequency (%)	p value
Cardiac Frequency (beat/min)	71.0 ± 7.7		
Systolic blood pressure (mmHg)	123.3 ± 16.1		
Normal	113.7 ± 7.1	16 (66.7)	0.0433
Altered	142.5 ± 10.3	8 (33.3)	
Diastolic blood pressure (mmHg)	75.8 ± 10.6		
Normal	72.5 ± 7.9	20 (83.3)	<0.0001
Altered	92.5 ± 5	4 (16.7)	

Chi-square test (χ^2) trend for proportion of comparison; p <0.05.

Table 3: Baseline hemodynamic characteristics of menopausal women participants of interval protocol.

	Mean ± SD	Frequency (%)	p value
Fasting glucose (mg/dL)	91.8 ± 17.9		
Normal	84.6 ± 8.5	18 (75)	0.0014
Altered	115.8 ± 22.2	6 (25)	
Fasting insulin (mUI/mL)	10.9 ± 8.4		
Normal	8.2 ± 4.8	20 (83.3)	<0.0001
Altered	31.2 ± 1.3	4 (16.7)	
HOMA-IR	2.6 ± 2.5		
Normal	1.6 ± 0.6	18 (75)	0.0014
Altered	8.2 ± 3.1	6 (25)	
Triglycerides (mg/dL)	120.5 ± 43.1		
Normal	103.3 ± 23.2	20 (83.3)	<0.0001
Altered	199.2 ± 26.2	4 (16.7)	
Total cholesterol (mg/dL)	205.0 ± 32.6		
Normal	176.1 ± 14.8	11 (45.8)	0.7728
Altered	230 ± 21	13 (54.2)	
LDL-c (mg/dL)	134.2 ± 30.4		
Normal	89.7 ± 3.8	4 (16.7)	<0.0001
Altered	140.8 ± 26.7	20 (83.3)	

HDL-c (mg/dL)	51.2 ± 12.5		
Normal	60.5 ± 7.3	14 (58.3)	0.3865
Altered	39 ± 6.2	10 (41.7)	
Uric Acid (mg/dL)	5.1 ± 1.4		
Normal	4.7 ± 0.6	20 (83.3)	<0.0001
Altered	7.7 ± 1.8	4 (16.7)	
hsCRP (mg/dL)	0.6 ± 0.3		
Normal	0.5 ± 0.1	20 (83.3)	<0.0001
Altered	1.2 ± 0.3	4 (16.7)	

LDL-C: low density lipoprotein; HDL-C: high density lipoprotein; HOMA-IR: homeostasis model assessment - insulin resistance; hsCRP: C-reactive protein ultrasensitive; chi-square test (χ^2) trend for proportion of comparison; $p<0.05$.
Table 4: Baseline biochemical characteristics of menopausal women participants of interval protocol.

	M0 Mean ± SD	**M1 Mean ± SD**	**p value**
Body mass (kg)	76.3 ± 0.8	76.7 ± 0.8	0.727
Free Fat mass (kg)	46.2 ± 0.7	46.7 ± 0.7	0.644
Body fat (%)	38.6 ± 0.7	38.3 ± 0.8	0.767
Muscle mass (kg)	20.1 ± 0.4	20.8 ± 0.5	0.299
Muscle mass index(kg/m^2)	8.1 ± 0.1	8.3 ± 0.1	0.267
Muscle mass (%)	26.5 ± 0.5	27.2 ± 0.5	0.289
Systolic blood pressure (mmHg)	123.1 ± 3.2	122.7 ± 3.3	0.932
Diastolic blood pressure (mmHg)	75.8 ± 2.0	75.3 ± 2.1	0.861
Cardiac Frequency (beat/min)	71.0 ± 1.7	66.2 ± 1.8	0.073
Maximal Cardiac Frequency (beat/min)	150.1 ± 3.8	150.6 ± 4.0	0.919
Test time (sec)	604.2 ± 27.6	747.7 ± 28.9	**0.002**
Treadmill grade (%)	10.6 ± 0.4	12.9 ± 0.5	**0.002**
VO_{2max} (ml/kg/min)	31.6 ± 4.2	35.5 ± 3.8	**<0.001**
Glucose (mg/dL)	91.9 ± 5.4	99.1 ± 5.5	0.367
Insulin (mUI/mL)	0.1 ± 0.0	0.1 ± 0.0	0.353
HOMA-IR	0.5 ± 0.1	0.4 ± 0.1	0.363
Triglycerides (mg/dL)	120.5 ± 9.5	123.2 ± 9.9	0.843
Total Cholesterol (mg/dL)	205.4 ± 6.8	196.9 ± 7.1	0.400
LDL-c (mg/dL)	133.9 ± 6.1	130.7 ± 6.2	0.707
HDL-c (mg/dL)	51.5 ± 2.0	49.0 ± 2.1	0.415
Uric acid (mg/dL)	5.1 ± 1.4	4.7 ± 1	0.312
hsCRP (mg/dL)	0.6 ± 0.3	0.7 ± 0.5	0.239

VO_{2max}: Maximal oxygen uptake; LDL-C: low density lipoprotein; HDL-C: high density lipoprotein; HOMA-IR: homeostasis model assessment - insulin resistance; hsCRP: C-reactive protein; Model range in repeated measurements for insulin and HOMA IR; ANOVA for repeated measures; $p <0.05$.
Table 5: Effect of interval protocol on biochemical variables. body composition. hemodynamic and physical fitness with adjustment for age. BMI and CA.

	M0	M1	c2	p
Flexibility				
Q4	7 (29.2)	6 (27.3)	0	1.0
Q2-Q3	8 (33.3)	12 (54.5)	13.271	0.2493
Q1	9 (37.5)	4 (18.2)	12.674	0.2603
Handgrip strength				
Q4	7 (29.2)	3 (13.6)	0.8424	0.3587
Q2-Q3	15 (62.5)	16 (72.8)	0.1801	0.6713
Q1	2 (8.3)	3 (13.6)	0.0106	0.9179
Glucose				
Normal	17 (73.9)	17 (77.3)	0	1.0
Altered	6 (26.1)	5 (22.7)		
Insulin				
Normal	22 (91.7)	18 (100.0)	0.2734	0.601
Altered	2 (8.3)	0 (0.0)		
HOMA-IR				
Normal	19 (82.6)	13 (76.5)	0.0064	0.9363
Altered	4 (17.4)	4 (23.5)		

Q1: 25 percentile; Q2-Q3: 25-75 percentile; Q4: 75 percentile; Chi-square test (χ^2) trend for proportion of comparison; $p < 0.05$.
Table 6: Effect of 10 weeks of interval exercise on physical fitness and glycemic profile of postmenopausal women.

Discussion

The outstanding finding in this study was the 12.3% improvement in cardiorespiratory fitness of menopausal women, after 10 weeks of treadmill high-intensity interval training. Usually, the high-intensity interval training shows slight improvement in VO_{2max} compared to continuous training in healthy active adults [38]. However, the same type of training (85-95% of HR max), almost doubles the cardiovascular fitness in chronic disease compared to the continuous training of moderate intensity [39]. In a study with middle-aged and elderly individuals submitted to an interval training (40-70% peak VO_2), four days a week for twelve weeks, the improvement of approximately 10% was observed in the peak VO_2 [40]. The results suggest therefore, that regardless of the sample, the interval exercise can improve cardiorespiratory fitness.

Despite the 12.3% increase in VO_{2max} in this study, SBP, DBP and glucose levels did not change with training which corroborates the results observed by Karstoft *et al.* [23]. Most of our sample had blood pressure levels and normal baseline glucose, which could explain the apparent lack of effect on these parameters. Differently from us, walk training with intervals of 1 hour / session, four days a week for 4 months, led to a decrease of 5%-30% in hypertension, 10-40% in hyperglycemia and 10-30% in high BMI, without significant reduction in blood lipids. These results were attributed to the significant increase in VO_2 peak [41].

Similarly, to other [23] our intervention had not changed the lipid profile of postmenopausal women, following what was found also in obese women undergoing 16 weeks of high intensity training, without changes in HDL-C and triglycerides [42]. Aerobic exercise either moderate or high intensity improves HDL-C, but the same does not occur with the total cholesterol, LDL-C and triglycerides [43]. To achieve beneficial effects on total cholesterol, LDL-C and triglycerides it seems necessary weight loss or change in body composition [44].

Interval training reduces more body weight, fat mass and adiposity abdominal visceral compared to walk [29]. Differently from our data, Irving *et al.* [42] showed greater loss of fat mass after high intensity training. Probably our ten weeks of exercise had been insufficient to observe such changes, while the mentioned studies applied four month-lasting intervention. Furthermore, no prescribed diet was taken for optimizing the weight loss. Moreover, there was no improvement physical fitness of FPM, suggesting either lower volume training and/or the lacking of concurrent resistance training. The high-intensity interval training (2 days/week) combined with training resistance (2 days/week) was effective in healthy adults by reducing total body fat and visceral fat, and improving FPM, flexibility and cardiorespiratory fitness [45].

The presence of impaired fasting glucose was 25%, similar to the 24.5% observed by Mota *et al*. [46] and higher than the 17.8% [47] and 18.7% frequencies, found 10 years latter [48]. Significant changes in glycemic markers such as fasting glucose and HOMA-IR were not detected in this study.

The fasting blood glucose is essentially dependent on endogenous glucose production [49] and is still controversial whether the endogenous glucose production changes or not in response to training [50-52]. Karstoft et al. [29] showed significant reduction in fasting insulin in the interval training group, but found no significant difference in HbA1c, fasting blood glucose and oral glucose tolerance test.

Our previous studies with overweight women, a 2mo.walking exercise did not alter significantly plasma concentrations of glucose and insulin as well their area under the curve in response to overload exogenous carbohydrates [53]. However, by using longer protocol (24wk-walking), the reduction of impaired fasting glucose was 60.5% at 24 weeks and 31.4% at 12 weeks [46]. With the present protocol (HIIT), the found normalization of glycemia was 50% in 10 weeks.

The present study has some limitations as, for example, the sample size. Our sample was a small group in spontaneous demand and not a population sample. It is possible that some variables had reached statistical significance if there were a larger number of subjects studied. We also did not have a control group to determine whether our intervention was efficient in comparison. In addition, the interval protocol occurred only two days a week without diet prescription. Weight loss could have been optimized if accompanied diet and a greater volume of training, possibly result in beneficial results of body composition.

The aerobic interval training maintained the ability to reduce resistance insulin, previously observed in walk, this time with reducing the duration of the 24 protocol for only 10 weeks. Future improvement of this protocol can be done by the associated dietary intervention aimed at reducing adiposity, not obtained these physical protocols.

Conclusion

The high-intensity interval training does not improve the response of insulin resistance in postmenopausal women. However, it is an effective protocol to improve cardiorespiratory fitness and can contribute significantly in tailoring the exercise recommendation for postmenopausal women in individual basis. More studies are needed with people who have more cardiovascular risk factors so as to elucidate the impact of HIIT on body composition and also glycemic control.

References

1. Menditto A, Cassese E, Balbi C (1999) Climacteric and quality of life. Minerva Ginecol 51(3): 83-89.

2. World Health Organization (1996) Research on the menopause in the 1990s. Report of a WHO Scientific Group. World Health Organ Tech Rep Ser 866: 1-107.

3. Pedro AO, Pinto-Nito AM, Costa-Paiva LCM, Duarte Osis MJ, Hardy EE, et al. (2003) Síndrome do climatério: inquérito populacional domiciliar emCampinas,SP. Rev Saúde Pública 37(6): 735-742.

4. Hayes C, Kriska A (2008) Role of physical activity in diabetes management and prevention. J Am Diet Assoc 108(4S1): S19-S23.

5. Mosca L, Edelman D, Mochari H, Christian AH, Paultre F, et al. (2006) Waist circumference predicts cardiometabolic and global Framingham risk among women screened during National Woman's Heart Day. J Womens Health (Larchmt) 15(1): 24-34.

6. Palacios S, Borrego RS, Forteza A (2005) The importance of preventive health care in post-menopausal women. Maturitas 52(S1): S53-S60.

7. Puts MTD, Deeg DJ, Hoeymans N, Nusselder WJ, Schellevis FG (2008) Changes in the prevalence of chronic disease and the association with disability in the older Dutch population between 1987 and 2001. Age Ageing 37(2): 187-193.

8. Alves LCL, Leimann BCQ, Vasconcelos MEL, Carvalho MS, Vasconcelos AGG, et al. (2007) A influência das doenças crônicas na capacidade funcional dos idosos do Município de São Paulo, Brasil. Cad Saúde Pública, Rio de Janeiro 23(8): 1924-1930.

9. Kerksick CM, Wismann-Bunn J, Fogt D, Thomas AR, Taylor L, et al. (2010) Changes in weight loss, body composition and cardiovascular disease risk after altering macronutrient distributions during a regular exercise program in obese women. Nutr J 9: 59.

10. Ciolac EG, Greve JM (2011) Exercise-induced improvements in cardiorespiratory fitness and heart rate response to exercise are impaired in

overweight/obese postmenopausal women. Clinics (Sao Paulo) 66(4): 583-589.

11. Boule NG, Kenny GP, Haddad E, Wells GA, Sigal RJ (2003) Meta-analysis of the effect of structured exercise training on cardiorespiratory fitness in Type 2 diabetes mellitus. Diabetologia 46(8): 1071-1081.
12. Manders RJ, Van Dijk JW, van Loon LJ (2010) Low-intensity exercise reduces the prevalence of hyperglycemia in type 2 diabetes. Med Sci Sports Exerc 42(2): 219-225.
13. Lee IM, Sesso HD, Oguma Y, Paffenbarger RS (2003) Relative intensity of physical activity and risk of coronary heart disease. Circulation 107(8): 1110-1116.
14. Perri MG, Anton SD, Durning PE, Ketterson TU, Sydeman SJ, et al. (2002) Adherence to exercise prescriptions: effects of prescribing moderate versus higher levels of intensity and frequency. Health Psychol 21(5): 452-458.
15. Snowling NJ, Hopkins WG (2006) Effects of different modes of exercise training on glucose control and risk factors for complications in type 2 diabetic patients: a meta-analysis. Diabetes Care 29(11): 2518-2527.
16. Fox EL, Bartels RL, Billings CE, O'Brien R, Bason R, et al. (1975) Frequency and duration of interval training programs and changes in aerobic power. J Appl Physiol 38(3): 481-484.
17. Wenger HA, Macnab RB (1975) Endurance training: the effects of intensity, total work, duration and initial fitness. J Sports Med Phys Fitness 15(3): 199-211.
18. Rognmo ØH, Hetland E, Helgerud J, Hoff J, Slørdahl SA (2004) High intensity aerobic interval exercise is superior to moderate intensity exercise for increasing aerobic capacity in patients with coronary artery disease. Eur J Cardiovasc Prev Rehabil 11(3): 216-222.
19. Suh M, Rofouei M, Nahapetian A, Kaiser WJ, Sarrafzadeh M (2009) Optimizing interval training protocols using data mining decision trees. Wearable and Implantable Body Sensor Networks 318-323.
20. Haddad A, Zhang Y, Su S, Celler B, Nguyen H (2014) Modelling and regulating of cardio-respiratory response for the enhancement of interval training. Biomed Eng Online 13: 9.
21. Tjonna AE, Lee SJ, Rognmo Ø, Stølen TO, Bye A, et al. (2008) Aerobic interval training versus continuous moderate exercise as a treatment for the metabolic syndrome: a pilot study. Circulation 118(4): 346-354.
22. Little JP, Gillen JB, Percival ME, Safdar A, Tarnopolsky MA, et al. (2011) Low-volume high-intensity interval training reduces hyperglycemia and increases muscle mitochondrial capacity in patients with type 2 diabetes. J Appl Physiol (1985) 111(6): 1554-1560.
23. Karstoft K, Winding K, Knudsen SH, Nielsen JS, Thomsen C, et al. (2013) The effects of free-living interval-walking training on glycemic control, body composition, and physical fitness in type 2 diabetic patients: a randomized, controlled trial. Diabetes Care 36(2): 228-236.
24. Heyward VH (2000) Avaliação da composição corporal aplicada (1st Edn.) São Paulo.
25. Geneva (1998) OBESITY Preventing and managing the global epidemic: report of a WHO Consultation on Obesity. Geneva: World Health Organization.
26. Janssen I, Heymsfield SB, Baumgartner RN, Ross R (2000) Estimation of skeletal muscle mass by bioelectrical impedance analysis. J Appl Physiol 89(2): 465-471.
27. Baumgartner RN, Koehler KM, Gallagher D, Romero L, Heymsfield SB, et al. (1998) Epidemiology of sarcopenia among the elderly in New Mexico. Am J Epidemiol 147(8): 755-763.
28. Janssen I, Baumgartner RN, Ross R, Rosenberg IH, Roubenoff R (2004) Skeletal muscle cutpoints associated with elevated physical disability risk in older men and women. Am J Epidemiol 159(4): 413-421.
29. Bray G (1992) An approach to the classification and evaluation of obesity. In: Bjorntorp P, Brodoff BN. Obesity 294-308.
30. Sociedade Brasileira de Cardiologia (2010) VI Diretrizes Brasileiras de Hipertensão. Arq Bras Cardiol 95(1S1): 1-51.
31. (2005) I Diretriz Brasileira de Diagnóstico e Tratamento da Síndrome Metabólica. Arq Bras Cardiol 84(S1): 1-28.
32. de Lemos AS, Wolfe ML, Long CJ, Sivapackianathan R, Rader DJ (2002) Identification of genetic variants in endothelial lipase in persons with elevated high-density lipoprotein cholesterol. Circulation 106(11): 1321-1326.

33. American Diabetes Association (2010) Diagnosis and classification of diabetes mellitus. Diabetes Care 32(S1): S62-S67.

34. International Diabetes Federation (2005). Global guideline for type 2 diabetes.

35. Vasques ACJ, Rosado LE, Alfenas RCG, Geloneze B (2008) Análise crítica do uso dos índices do Homeostasis Model Assessment (HOMA) na avaliação da resistência à insulina e capacidade funcional das células-b pancreáticas. Arq Bras Endocrinol Metabol 52(1): 32-39.

36. Craig CL, Marshall AL, Sjöström M, Bauman AE, Booth ML, et al. (2003) International physical activity questionnaire: 12-country reliability and validity. Med Sci Sports Exerc 35(8): 1381-1395.

37. Balke B, Ware RW (1959) An experimental study of Air Force personel. US Armed Forces Med J 10(6): 675-688.

38. Bacon AP, Carter RE, Ogle EA, Joyner MJ (2013) VO2max trainability and high intensity interval training in humans: a meta-analysis. PLoS One 8(9): e73182.

39. Weston KS, Wisløff U, Coombes JS (2014) High-intensity interval training in patients with lifestyle-induced cardiometabolic disease: a systematic review and meta-analysis. Br J Sports Med 48(16): 1227-1234.

40. Nemoto K, Gen-no H, Masuki S, Okazaki K, Nose H (2007) Effects of high-intensity interval walking training on physical fitness and blood pressure in middle-aged and older people. Mayo Clin Proc 82(7): 803-811.

41. Morikawa M, Okazaki K, Masuki S, Kamijo Y, Yamazaki T (2011) Physical fitness and indices of lifestyle-related diseases before and after interval walking training in middle-aged and older males and females. Br J Sports Med 45(3): 216-224.

42. Irving BA, Davis CK, Brock DW, Weltman JY, Swift D (2008) Effect of exercise training intensity on abdominal visceral fat and body composition. Med Sci Sports Exerc 40(11): 1863-1872.

43. Tambalis K, Panagiotakos DB, Kavouras SA, Sidossis LS (2009) Responses of blood lipids to aerobic, resistance, and combined aerobic with resistance exercise training: a systematic review of current evidence. Angiology 60(5): 614-632.

44. Houston MC, Fazio S, Chilton FH, Wise DE, Jones KB, et al. (2009) Nonpharmacologic treatment of dyslipidemia. Prog Cardiovasc Dis 52(2): 61-94.

45. Giannaki CD, Aphamis G, Sakkis P, Hadjicharalambous M (2015) Eight weeks of a combination of high intensity interval training and conventional training reduce visceral adiposity and improve physical fitness: a group-based intervention. J Sports Med Phys Fitness 56(4): 483-490.

46. Mota JFM, Moreto F, Burini FHP, Medina WL, Rimm EB, et al. (2011) Effect of physical conditioning with lifestyle intervention on community-based hyperglycemic-overweight adults. Journal of US-China Medical Science 8(10): 581-587.

47. Burini RC, Torezan GA, Sloan LA, Corrente JE, McLellan KCP (2014) Dietary Intake Association with IFG and Responses of a Lifestyle Changing Protocol in a Community-B based Adult Cohort. Endocrinol Metab Synd 3(1): 125.

48. Burini FHP (2015) Medicated Non-controlled Wholesomely Ncd Patients-A Field For "Exercise Is Medicine" Effectiveness. ACSM Annual Meeting Medicine and Science in Sports and Exercise.

49. Faerch K, Borch-Johnsen K, Holst JJ, Vaag A (2009) Pathophysiology and aetiology of impaired fasting glycaemia and impaired glucose tolerance: does it matter for prevention and treatment of type 2 diabetes? Diabetologia 52(9): 1714-1723.

50. Kirwan JP, Solomon TP, Wojta DM, Staten MA, Holloszy JO (2009) Effects of 7 days of exercise training on insulin sensitivity and responsiveness in type 2 diabetes mellitus. Am J Physiol Endocrinol Metab 297(1): E151-E156.

51. Winnick JJ, Sherman WM, Habash DL, Stout MB, Failla ML (2008) Short-term aerobic exercise training in obese humans with type 2 diabetes mellitus improves whole-body insulin sensitivity through gains in peripheral, not hepatic insulin sensitivity. J Clin Endocrinol Metab 93(3): 771-778.

52. Healy GN, Dunstan DW, Shaw JE, Zimmet PZ, Owen N (2006) Beneficial associations of physical activity with 2-h but not fasting blood glucose in Australian adults: the AusDiab study. Diabetes Care 29(12): 2598-2604.

53. Burini RC, Torezan GA, McLellan KCP (2013) Behavioral Risk Factors and Effects of Lifestyle Modification on Adults with Diabetes: A Brazilian Community-based Study. Emerging Issues in Medical Diagnosis and Treatment 1(4).