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Effects of Interval Training Versus Continuous Exercise on Anthropometric and Cardiorespiratory Fitness Markers in Obese Women

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Abstract

The purpose of this study was to test the hypothesis that interval training (IT) is as effective as continuous exercise (CE) in reducing markers of obesity in women with abdominal obesity and low cardiorespiratory capacity. Twenty-one women with central obesity (mean ± SD: 47±11 years old; 95.7±9.8 cm of waist circumference; 38.8 ± 4.5% body fat) performed CE (-20% of Ventilatory Threshold - VT) or IT (2 min of stimulus/2 min of recovery +20%/-20% of VT) during a 10 week period, 2 times per week, for 20 to 40 minutes per session. Anthropometric data was recorded and cardiorespiratory fitness was measured before and after intervention. After intervention, both groups exhibited reductions in waist circumference (IT group lost 3.3%, P = 0.022; and CE group 3.9%, P = 0.015), waist/height ratio (IT group lost 3.4%, P = 0.018; and CE group 4.5%, P = 0.019), and Conicity Index (IT group lost 2.4%, P = 0.014; and CE group 3.9%, P = 0.017). Only the IT group reduced their weight (lost 1.4%, P = 0.019) and BMI (lost 3.5%, P = 0.024). After training, the VT increased 6.9% in the IT group (P =0.04), and 7.4% in the CE group (P = 0.04). VO_2 Peak tended to be elevated after 10 weeks of intervention in the IT group (P = 0.08). These data suggest that a practical low-volume IT regimen during a short timeframe was as effective as CE in improving cardiorespiratory fitness and decreasing central obesity markers.

Keywords: Obesity; Exercise; Anthropometry; Cardiorespiratory Fitness; Women's Health

Introduction

Obesity plays a major role in the pathogenesis of several metabolic and cardiovascular diseases, such as type 2 diabetes, hypertension, dyslipidemia, atherosclerosis and coronary artery disease. In addition, the increase of visceral fat deposition appears strongly related to these alterations more than total adiposity [1].

Exercise and an active lifestyle have been proposed as important components of obesity control [2]. Even without concurrent weight loss, they promote visceral fat reductions, increased functional aerobic capacity, improved endothelial functioning, and a reduction of inflammatory potential and disturbances of glucose, lipid metabolism and insulin sensitivity [3-6].

However, it is well known that these results and other adaptations of body systems to exercise loads are dependent on the specificity of the stimulus [7]. In this way, it is necessary to have a better understanding of the dose-response relationship of exercise in promoting the desired effects.

Since the beginning of the last century, several studies have been conducted aiming to investigate and identify the specific effects and mechanisms of exercise on health [8]. In some studies, the effects of different models have already been demonstrated with regard to weekly frequency [9], quantity [10], intensity [11,12] and timing of training [13,14]. However, there is insufficient data available from which to establish confident guidelines to prescribe the most appropriate exercise regimen to treat obesity or to decrease visceral fat.

The latest findings suggest increased benefits of high intensity exercise regimens compared to continuous/aerobic training for many conditions related to obesity [11,15]. Recently, it was observed that high-intensity interval training is a strategy to increase skeletal muscle oxidative capacity and metabolism that is comparable to traditional endurance training in young healthy men and women [16]. Another study showed that low-volume interval training improves the insulin sensitivity and muscle oxidative capacity as endurance training in previously sedentary middle-aged adults [17].

However, the results of these studies are inconclusive and scarcely target women. Thus, the aim of this study was to examine the hypothesis that interval training (IT) is as effective as continuous exercise (CE) to reduce markers of obesity in women with abdominal obesity and low cardiorespiratory capacity.

Methods and Procedures

Participants

Twenty-three women were enrolled in this study. However, two of them dropped out and the study ended with the participation of twenty-one women (mean ± SD: 47±11 years; 78±13 kg; 1.6±0.1 m; 39±4% body fat) with elevated waist circumference (≥ 80 cm), and sedentary at the initiation of the baseline period. The exclusion criteria included: a history of ischemic heart disease, diabetes, pulmonary or musculoskeletal limitations to exercise, inflammation, the use of vasoactive medications, oral hypoglycemics, insulin, glucocorticoids, anti-psychotics and hormone replacement. All volunteers provided written informed consent prior to screening and participation in the study. All participants were asked to refrain from alcohol consumption and vigorous physical activity for 24 hours prior to testing, and to maintain their usual diet during this study. During the first two weeks some participants reported delayed onset muscle soreness, but this complaint did not limit the performance at exercise as recommended.

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Study design

All study procedures were approved by The Human Investigation Committee of the Escola Bahiana de Medicina e Saúde Pública. Eligible participants were assessed (by medical, laboratorial, and cardiorespiratory fitness exams) before and after the intervention. After the first evaluation the participants were randomly assigned to one of two 10-week exercise training regimens.

Medical screening protocol and anthropometric assessment

Participants provided a detailed medical history and underwent a physical examination. Waist circumference (WC- lower measure between the iliac crest and the lowest rib) and hip circumference (maximum measure of the gluteal area) were taken in duplicate to the nearest 0.1 cm using a non-elastic measuring tape. Height of participants was measured with a calibrated vertical stadiometer (stadiometer professional, Sanny, São Paulo, Brazil) and body weight (BW) was measured in a calibrated balance (PL 200, Filizola, São Paulo, Brazil). Body composition was measured using a Bioelectrical Impedance Analyzer (Omron HBF-306©, Omron, Bannockburn, Illinois, USA), and the equation used to predict the body fat percentage (BFP) incorporated gender, age, and physical activity which was included in the equipment measurement template. The participants were instructed to avoid physical activities and alcoholic beverages. They were also advised to drink 2 liters of water 24 hours before the measurements were taken.

Body mass index (BMI), waist/hip ratio (WHR) and waist/height ratio (WHtR) were calculated. The Conicity index (CI) and the Body Adiposity Index (BAI) were also calculated. The CI establishes a relationship between Total Body Mass (TBM), height and waist circumference as shown in Equation 1 [18].

$$CI = \frac{\text{waist circumference(m)}}{0.109 \times \sqrt{\frac{\text{weight(kg)}}{\text{height(m)}}}} \quad (1)$$

Waist circumference was measured in centimeters and referred in meters as were also the height. The weight was measured in kilograms. The BAI was calculated by Equation 2 [19], which establishes a relationship only between height and hip circumference.

$$BAI = \frac{\text{hip circumference(cm)}}{\text{height}^{1.5}\text{(m)}} - 18 \quad (2)$$

Hip circumference was measured in centimeters and height was measured in meters.

Cardio respiratory fitness assessment

Participants completed a continuous VO_2 Peak treadmill protocol. The initial treadmill velocity was 3 $Km.h^{-1}$ and the velocity was increased by 0.5 or 1 $Km.h^{-1}$ every 2 minutes until volitional fatigue. Metabolic data [minute volume (VE), oxygen intake (VO_2) and carbon dioxide production (VCO_2)] were collected during the protocol using standard open-circuit spirometric techniques (VO2000 – Medical Graphics®, St Paul, MN, USA) and heart rate was assessed electrocardiographically (Marquette Max-1 electrocardiograph, Marquette, WI).

The VO_2 Peak was chosen as the highest oxygen intake attained during the test and the Ventilatory Threshold (VT) was identified at the physical effort intensity level at which the VE/VO_2 reached its minimum value before presenting progressive increases without concomitant increases in the VE/VCO_2. When this method could not provide VT, the V-Slope method was used for confirmation. The VT was determined independently by two different evaluators.

Energy expenditure estimate

Energy expenditure per session was estimated using the equation proposed by the American College of Sports Medicine for treadmill use. The energy expenditure of the individual was estimated from oxygen consumption induced by exercise, considering that for each liter of oxygen consumed, approximately 20.9J of energy are spent.

Exercise intervention

Participants were randomly assigned into one of the following two interventions:

1. CE: Participants completed a 10-week supervised continuous exercise intervention, two times per week, with intensity of stimulus at 20% of velocity below their VT;
2. IT: Participants completed a 10-week supervised moderate-high intensity interval training exercise intervention, two times per week, with intensity of stimulus and recovery at 20% of velocity above and below of the VT respectively, with an stimulus/recovery ratio of 2:2 minutes. For the subject that did not reach VT, evaluators used 20% of velocity above and below the maximum velocity developed during the cardiorespiratory fitness assessment.

All exercise sessions were supervised by a member of the investigative team, who monitored the rate of perceived exertion (RPE). During the first and second week the duration of exercise sessions was 20 minutes, and during the following eight weeks the time of exercise sessions was 40 minutes.

Statistical analysis

The sample size was calculated using the PEPI software. It was estimated that there were at least 9 subjects in each group. The parametric distribution data was verified through the Shapiro-Wilk and Kolmogorov-Smirnov tests and visual analysis of normal curve. We performed a Paired Sample *t*-test to identify if the effect of each intervention was significant on obesity markers [WC, BFP, WRR, BMI and CI] and cardiorespiratory parameters (VO_2 peak and VT). The Student T test was performed to compare the absolute delta (final value minus baseline value) on obesity and cardiorespiratory variables between groups. All statistical analyses were performed using SPSS 15.0 software (SPSS, Chicago, IL, USA), and data were presented as means ± SD. The α-Level for main effects was set at $p \leq 0.05$.

Results

Twenty-one middle aged women with elevated waist circumference

Markers	mean±sd	minimum	maximum
Age (year)	47±11	25	60
Body weight (kg)	78.6±14.2	46.3	105.0
Height (m)	1.58±0.06	1.49	1.74
Waist circumference (cm)	95.7±9.8	80.5	115.0
Hip circumference (cm)	111.3±10.9	86.5	134.0
Body fat (%)	38.8±4.5	30.6	47.8
Body Adiposity Index (%)	37.6±6.1	28.6	51.4
Conicity Index	1.25±0.07	1.11	1.38
waist/height ratio	0.60±0.06	0.51	0.74
waist/hip ratio	0.86±0.05	0.73	0.96
VO_2 Peak ($ml.kg^{-1}.min^{-1}$)	18.4±5.03	11.5	32.4
Ventilatory Threshold (km/h)	7.04±0.75	6.0	9.5

Table 1: Baseline characteristics of obese women. N = 21.

completed the entire procedural regimen. The baseline characteristics of subjects are summarized in Table 1.

Following the 10-week intervention, no variable was different between groups. By the tenth week, both groups exhibited lower WC (IT group lost 3.3%, P = 0.022; CE group lost 3.9%, P = 0.015), WHtR (IT group lost 3.4%, P = 0.018; CE group lost 4.5%, P = 0.019), and CI (IT group lost 2.4%, P = 0.014; CE group lost 3.9%, P = 0.017). Only the IT group reduced BW (lost 1.4%, P = 0.010) and BMI (lost 3.5%, P = 0.013).

Both IT and CE groups presented improved cardiorespiratory fitness. There were no between-group differences in VT and VO_2 Peak. Following the exercise regimen, the VT increased 6.9% in the IT group (P =0.04), and 7.4% in the CE group (P = 0.04). The VO_2 Peak tended to be elevated after the tenth week of the intervention in the IT group (P = 0.08) (Table 2).

The absolute delta of the obesity and cardiorespiratory variables were not different between groups (Table 2).

Discussion

Regarding a non-pharmacological approach for the treatment of obesity, it is clear that exercise plays a key role. Considering the reduction of cardiovascular risk factors associated with obesity, some studies [20-22] have documented the advantages of exercise with respect to other interventions. However, the organic adaptations are dependent on the characteristics of exercises [7].

In this study, both exercise regimens decreased WC, WHtR and CI. The reduction of WC, and probably of the other index which is based upon the WC measurement, is highly significant for the health of obese women [23]. It has been previously established that the size of the WC has a greater propensity in predicting liver enzyme concentrations in this population, being positively associated with plasma γ-glutamyltransferase concentration and hepatic lipid content [24].

Only one other study [12] showed that CE and IT can reduce CI. In the same manner, the present study demonstrated that IT and CE reduced CI, and probably visceral fat. This is important to note, since it was established that increased visceral fat was associated with hypertension [25], hiperlipidemia, and insulin resistance [26]. It is also interesting to note that CI was the best anthropometric predictor of high coronary risk in women from our state in Brazil [27,28].

Moreover, the reduction of the CI, WC, BMI and BW related to IT can be justified by factors that involve greater energy expenditure [29] and lipid mobilization [30], and specific stimulation to abdominal fat cells [31]. After high intensity exercise there is a higher removal rate of lactate and hydrogen ions [29] with a consequent increase in energy expenditure, and greater release of catecholamines [30] which leads to increased mobilization of fatty acids. Likewise, more β-adrenergic receptors have been found in abdominal compared to subcutaneous fat [31].

Neither form of exercise promoted a reduction of the percentage of fat or BAI. The BAI was defined with a practice parameter of adiposity, since the percentage of adiposity could be sufficiently estimated without using a mechanical or electronic assessment of body weight [19]. In regards to the BAI, our data are unique, since no other study has analyzed the effect of physical exercise on this parameter to date. Considering that the highest lipolytic activity induced by exercise in women occurs in abdominal rather than in gluteal adipose tissue [32], there was little or no change expected in the BAI.

Although only IT promoted a significant reduction in body weight, both forms of exercise promoted an increase in cardiorespiratory fitness. Epidemiological studies have indicated an inverse association between cardiorespiratory fitness and coronary heart disease or all-cause mortality in healthy men and women [33], and that higher levels of cardiorespiratory fitness protect against Metabolic Syndrome in older individuals [34]. Further, it was previously demonstrated that improving aerobic capacity should be an important clinical target for obese subjects, perhaps as significant as the reduction of body weight [15].

Indeed, another study [3] showed an impressive improvement in the endothelial function profile, induced by exercise or diet independent of weight loss. Likewise, a controlled aerobic exercise program, without weight loss, reduced hepatic and visceral fat accumulation, and decreased insulin resistance in obese subjects [35].

As expected, the IT and CE showed positive effects on cardiorespiratory capacity. The literature contains an accumulation of data regarding the increase in cardiac output and maximum oxygen consumption due to aerobic training [36]. However, it seems that the major effect of IT on cardiorespiratory capacity was probably due to peripheral adaptations translated by mitochondrial biogenesis, and by improvements of the metabolic profile and muscle contractility with a consequent increase in exercise tolerance [15,37].

In this regard, other studies [38,39] showed that IT may promote increased oxidative capacity of glucose and fatty acids and mitochondrial biogenesis by activation of signaling through Phosphorylation of AMP activated (AMPK; subunits 1 and 2) and the p38 mitogen-activated protein kinase (MAPK) to Peroxisome proliferator-activated receptor-γ

Markers	IT (n=12)			AE (n=9)		
	Before	After	Δ	Before	After	Δ
Body weight (kg)	74±15	73±15[a]	-1±1	86±12	86±12	-0.4±0.8
Waist circumference (cm)	92±9	89±10[a]	-3±3	103±8	99±8[a]	-4±3
Waist/hip ratio	0.85±0.1	0.83±0.1	-0.02±0.04	0.87±0.1	0.84±0.1	-0.02±0.02
Waist/height ratio	0.58±0.05	0.56±0.06[a]	-0.02±0.02	0.66±0.07	0.63±0.07[a]	-0.02±0.01
Body fat (%)	38±3	37±3	-0.6±1.5	41±6	40±6	-0.3±0.5
BMI (kg/m^2)	29±4	28±4[a]	-0.4±0.5	35±7	35±7	-0.2±0.4
Conicity index	1.24±0.1	1.21±0.1[a]	-0.04±0.06	1.27±0.1	1.22±0.1[a]	-0.04±0.03
Index of Body Adiposity	35.7±3.9	35.2±3.8	-0.50±0.92	42.7±7	42.2±7	-0.49±0.70
VO_2 Peak ($ml.kg^{-1}.min^{-1}$)	19.7±5.7	22.4±6.4	2.7±4.7	15.6±2	18.3±2	2.7±4.5
Ventilatory Threshold (km/h)	7.2±0.9	7.7±1.2[a]	0.5±0.4	6.8±0.4	7.3±0.5[a]	0.5±0.4

[a]p<0.05 compared with before within group

Table 2: Effect of interval training (IT) versus continuous exercise (CE) on Anthropometric and Cardiorespiratory Fitness markers in obese women. N = 21.

coactivator-1α (PGC-1α). It is important to note that the volume of training was classified as low in this study, and the CE and IT groups were able to demonstrate positive effects on metabolic aspects. Many individuals seem to abandon their exercise programs because they have high expectations of the schemes and believe that a large volume of exercise is required to achieve benefits in relation to the control of body weight or metabolic profile [40].

It is worth noting that this study did not control for the variable of race, and also did not study the effects of exercise on men. A recent study [41] demonstrated that sex and race characteristics need to be considered when predicting effects on adiposity from WC or BMI. Thus, further studies are needed to compare the effects of CE and IT by controlling for variables of sex and race.

Another limitation of this study could be related to the cardiorespiratory performance test. Although the measurement of VO_2 Peak and VT was conducted in accordance with the gold standard, some volunteers reported discomfort in wearing the mask, and this potentially interrupted the evaluation before achieving maximum measurement.

However, this was a study consisting of a sample randomized by intervention groups. Furthermore, the fact that both forms of exercise have been based upon the VT of the subject makes this study more precise in effectively demonstrating the metabolic demand than those prescribed by percentage of the maximal oxygen uptake or heart rate, since these methods may have serious errors [7]. Likewise, it has been shown that both the heart rate and percentage of maximum oxygen consumption are influenced by level of obesity, which has considerable importance on the application of the current guidelines regarding the prescription of exercise intensity in obese individuals [42].

In conclusion, this study demonstrated that a practical low-volume IT exercise regimen during a short timeframe was as effective as CE in improving cardiorespiratory fitness and decreasing central obesity markers.

Considering that many healthcare guidelines and professionals advocate in favor of continuous exercise (CE), future research should explore the effects and mechanisms of intensive training (IT) over longer periods on metabolism and other health outcomes. These types of studies can help to develop a better understanding about the importance of high intensity exercise, and can contribute to a change in clinical scenarios.

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