Sport Sciences for Health
https://doi.org/10.1007/s11332-020-00625-7

ORIGINAL ARTICLE

Improvement in insulin sensitivity, but without changes in liver enzymes in obese women after 12 weeks of a walking exercise program with self-selected intensity

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Received: 11 September 2019 / Accepted: 7 February 2020

Abstract

Background Obesity is related to negative changes in insulin resistance and liver enzymes and is associated with the risk factor for the development of type II diabetes mellitus and nonalcoholic fatty liver disease. A number of studies have demonstrated that aerobic exercise shows promise for disease prevention and treatment in this population.

Aim The objective of the present study was to evaluate the effect of a walking exercise program with self-selected intensity on insulin resistance and liver enzymes in obese women.

Methods Forty-eight obese women (47.8 ± 8.4 years; 88.1 ± 12.0 kg; 158.0 ± 0.1 cm) were divided into two groups: control group (CG; $n = 23$) and self-selected walking group (SSWG; $n = 25$). Before and after the exercise program, all subjects underwent anthropometric measurements and blood samples were collected. The intervention consisted of a walking exercise program with self-selected intensity for 12 weeks (3 times/week, totalizing 36 sessions).

Results After the exercise program, fasting glucose, fasting insulin, and HOMA improved only in the SSWG ($p < 0.05$), but there were no differences between groups ($p > 0.05$). In addition, there were no differences in liver enzymes after the intervention in both groups ($p > 0.05$).

Conclusions The results support that a walking exercise program with self-selected intensity improved insulin resistance in obese women. Thus, exercise programs with self-selected intensity seem to be an interesting alternative for improving health and preventing diseases.

Keywords Exercise · Obesity · Health · Self-selected exercise

Introduction

Insulin resistance is a multifactorial process commonly presented in older adults, those with hyperadiposity (i.e., overfat and obesity), and sedentary individuals [1], presenting a risk factor for the development of type II diabetes mellitus and being associated with reduced uptake of glucose [1–3]. Moreover, hyperadiposity is linked to increased serum liver enzymes (e.g., alanine aminotransferase, aspartate aminotransferase) [4]. Additionally, elevated serum liver enzymes are also associated with insulin resistance and nonalcoholic fatty liver disease [4, 5].

Evidence demonstrates that the practice of regular exercise aids in health promotion, as it promotes beneficial effects on cardiorespiratory, neuromuscular, and endocrine systems [6]. Furthermore, exercise protects against

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Published online: 17 February 2020

hyperadiposity-induced insulin resistance [2] and liver conditions [7].

Unfortunately, a large part of the world population is insufficiently active [8]. In addition, it has been demonstrated that an inverse relationship exists between the intensity of exercise and adherence to exercise interventions [9], since health professionals usually prescribe and promote endurance activities for individuals who are overfat, or obese, and endurance activities tend to be applied with a long duration [10]. However, individuals who are overfat present an impaired health status, high rate of fatigability, and low psychological appeasement, resulting in generalized withdrawal from exercise [10]. Therefore, exercise with self-selected intensity is an interesting strategy, as it increases positive affective responses and adherence to exercise programs [11].

It has been verified that the practice of self-selected physical fitness activities in sports promotes positive alterations in anthropometric and biochemical components [12]. Additionally, it has been demonstrated that an acute session of walking with self-selected pace attenuates postprandial triglyceride concentrations in sedentary older women with hypertriglyceridemia, but without alterations in insulin and glucose [13]. As obese individuals present sedentary habits, the prescription of an exercise program with imposed intensities can result in unpleasant sensations, and, consequently, low involvement in the exercise program [14, 15]. Because of this, the self-selected exercise intensity approach seems to promote positive physiological benefits for the subjects' health. Therefore, self-selected intensity could be an interesting tool for prescribing exercise in obese individuals. However, it is not clear whether a walking exercise program with self-selected intensity might cause favorable alterations in variables related to insulin resistance and liver enzymes in women with obesity. Thus, the aim of this study was to evaluate the effect of a walking exercise program with self-selected intensity on insulin resistance and liver enzymes in women with obesity. We hypothesized that the walking exercise program with self-selected intensity would promote positive alterations in insulin resistance, but would not change liver enzymes in women with obesity.

Materials and methods

Subjects

Forty-eight female volunteers with obesity took part in this study. The participants were recruited through printed advertisements and by word of mouth. The inclusion criteria were: (a) a body mass index (BMI) > 30, (b) not participating in a regular exercise program for at least the previous 6 months, and (c) absence of continuous use of medication. Subjects were required to answer a questionnaire clarifying possible questions related to health problems. All participants were aware of the procedures and risks of the experimental protocol, and read and signed an informed consent. All procedures were approved by the University's Institutional Review Board for Human Subjects (Human Research Ethics Committee) and were conducted according to the Declaration of Helsinki. The sample size was calculated based on Kim et al. [16] data and the number of subjects for each group resulted in 16 for all outcome measures to achieve a statistical power > 0.80, with an alpha level of $p \leq 0.05$. Subjects were randomized in a ratio (1:1) by an independent researcher who was not involved in the assessments. A random number generator was used (https://www.random.org) to allocate the participants into the groups. Participants were randomly assigned to two training groups: self-selected walking group (SSWG: $n = 25$; 47.8 ± 6.4 years; 86.4 ± 10.1 kg; 158.0 ± 0.05 cm) and control group (CG: $n = 23$; 47.8 ± 8.4 years; 89.9 ± 14.0 kg; 158.0 ± 0.06 cm). Following recruitment to this study, all subjects underwent anthropometric measurements and blood samples were collected. Following the 12-week intervention, all the same measurements were performed as in pre-intervention. Participants were instructed not to ingest alcohol or caffeinated beverages for 24 h preceding each test. This study was performed in accordance with international ethical standards [17].

Biochemical-metabolic analysis

The blood samples were collected by the same nursing professional in accordance with health standards and in a temperature-controlled room (23 °C). The participants were at rest and in a fasting state for 8–12 h. The collections were always performed at the same time of day (between 8:00 and 9:00 a.m.) by venipuncture, and the samples were placed in plastic tubes (BD Vacutainer®, USA), containing anticoagulant solution EDTA for blood count analysis and without anticoagulant for further analysis. In addition, the participants were advised to consume 250 mL of water before arriving at the laboratory for blood analysis to increase the likelihood they would be in a euhydrated state [18]. The tubes without anticoagulant were centrifuged (3000*g*, 10 min, 4 °C) for serum separation, which were then stored at − 80 °C until analysis. Concentrations of glucose, alanine aminotransferase (ALT), and aspartate aminotransferase (AST) were determined by the colorimetric method using commercial kits (Gold Analisa®, Belo Horizonte, Brazil) in a spectrophotometer (Bioplus® UV-2000, São Paulo, Brazil). Insulin concentration was obtained through the radioimmunoassay technique (LINCO Research®, St Louis, USA). Insulin resistance was estimated using the homeostasis model assessment (HOMA) formula, where resistance is

determined by fasting serum insulin (μU/mL) multiplied by fasting plasma glucose (mmol/L), and divided by 22.5 [19].

Exercise program

Subjects of the SSWG participated in a 12-week supervised walking program. Training sessions were conducted three times per week for 12 weeks (totalizing 36 sessions), considering the basic components of training suggested by the American College of Sports Medicine guidelines [20]. The walking sessions were performed on an athletics track and supervised by an experienced fitness trainer. To avoid any possible effect on the response to exercise, all exercise sessions were conducted individually. All subjects were given the instructions: "You are supposed to choose a walking intensity of your preference. The session is supposed to last 30 min. Intensity must be high enough that you have a good workout, but not so high that when exercising every day or every other day it stops you from continuing to exercise. The intensity must be appropriate for you" [14]. The hours of harmful solar radiation (between 9:30 and 4:00 p.m.) were avoided so as not to influence the performance of the volunteers. In total, 36 sessions of walking were performed with an adherence rate of 85.6 ± 7.5%. During the intervention, the CG participants remained seated in a chair for 30 min, accompanied by one of the researchers. Participants were requested to maintain their daily routine throughout the study.

Statistical analysis

Data are presented as mean ± standard deviation (SD) and 95% confidence intervals. The Gaussian distribution was observed through the Shapiro–Wilk test. Data were analyzed using a two-way ANOVA (group × time) with repeated measures. When significant differences were found, the Tukey post hoc test was applied to discriminate where significant differences occurred. Data were considered statistically significant when $p < 0.05$. Statistical analyses were carried out using SPSS version 20.0 (Chicago, IL, USA). In addition to the comparison analyses, the magnitude of changes was expressed by Cohen's d effect sizes for mean differences, calculated and defined as small (0.20), moderate (0.50), and large (0.80) [21].

Results

There were no differences between groups for blood glucose, blood insulin, and HOMA-IR pre-intervention. The blood glucose [pre = 103.8 ± 10.7 mg/dL (95% CI 99.70, 107.99); post = 92.7 ± 10.1 mg/dL (95% CI 88.74, 96.65); $d = -1.07$ (95% CI −1.58, −0.58)], blood insulin [pre = 86.8 ± 7.7 pmol/L (95% CI 83.78, 89.82); post = 73.2 ± 6.0 pmol/L (95% CI 70.85, 75.55); $d = -1.97$ (95% CI −2.66, −1.28)], and HOMA-IR [pre = 2.2 ± 0.2 (95% CI 2.12, 2.28); post = 1.7 ± 0.2 (95% CI 1.62, 1.78); $d = -2.5$ (95% CI −3.27, −1.75)] values were lower (~ 10, ~ 16 and ~ 25%, respectively) in the SSWG post-intervention ($p < 0.05$). In contrast, there were no differences in the CG post-intervention ($p > 0.05$) blood glucose [pre = 93.6 ± 10.8 mg/dL (95% CI 89.18, 98.01); post = 93.4 ± 11.3 mg/dL (95% CI 88.78, 98.01); $d = -0.01$ (95% CI −0.47, 0.55)], blood insulin [pre = 87.1 ± 5.1 pmol/L (95% CI 85.02, 89.18); post = 86.6 ± 4.8 pmol/L (95% CI 84.64, 88.56); $d = -0.10$ (95% CI −0.67, 0.47)], and HOMA-IR [pre = 2.2 ± 0.2 (95% CI 2.12, 2.28); post = 2.2 ± 0.2 (95% CI 2.12, 2.28); $d = 0.00$ (95% CI −0.57, 0.57)] (Fig. 1). There were no differences between groups post-intervention ($p > 0.05$) (Fig. 1).

There were no differences between groups for the alanine aminotransferase (ALT) or aspartate aminotransferase (AST) ($p > 0.05$). The ALT [CG: pre = 16.4 ± 2.9 RFU/mL (95% CI 16.15, 16.65); post = 16.5 ± 3.9 RFU/mL (95% CI 16.25, 16.75); d = 0.02 (95% CI −0.96, 0.18); SSWG: pre = 17.7 ± 2.9 RFU/mL (95% CI 17.39, 18.01); post = 16.4 ± 3.2 RFU/mL (95% CI 16.13, 16.67); $d = -0.40$ (95% CI −0.53, 0.60)] and AST [CG: pre = 25.0 ± 2.9 RFU/mL (95% CI 24.75, 25.25); post = 26.3 ± 3.0 RFU/mL (95% CI 26.05, 26.55); $d = 0.40$ (95% CI −0.14, 1.01); SSWG: pre = 27.3 ± 3.5 RFU/mL (95% CI 27.03, 27.57); post = 27.8 ± 4.5 RFU/mL (95% CI 27.45, 28.15); $d = 0.13$ (95% CI −0.44, 0.69)] did not change in either group post-intervention ($p > 0.05$) (Fig. 2).

Discussion

The main results of the present study revealed that there were positive changes in glucose, insulin, and HOMA levels post-intervention only in the SSWG. However, the liver enzymes did not change in the SSWG or CG after the intervention.

On the other hand, while the benefits of aerobic exercise on resistance insulin are well established, few studies have compared the effects of aerobic exercise with self-selected intensity [12, 13]. To our knowledge, this is the first study to investigate the effects of a walking exercise program with self-selected intensity on variables related to insulin resistance and liver enzymes.

In the study of Neto et al. [12], after an intervention with self-selected intensity, alterations were observed in biochemical markers, but without changes in glucose, thus, not corroborating the results of the present study. In addition, Kashiwabara et al. [13] demonstrated positive changes in postprandial triglyceride concentrations in an

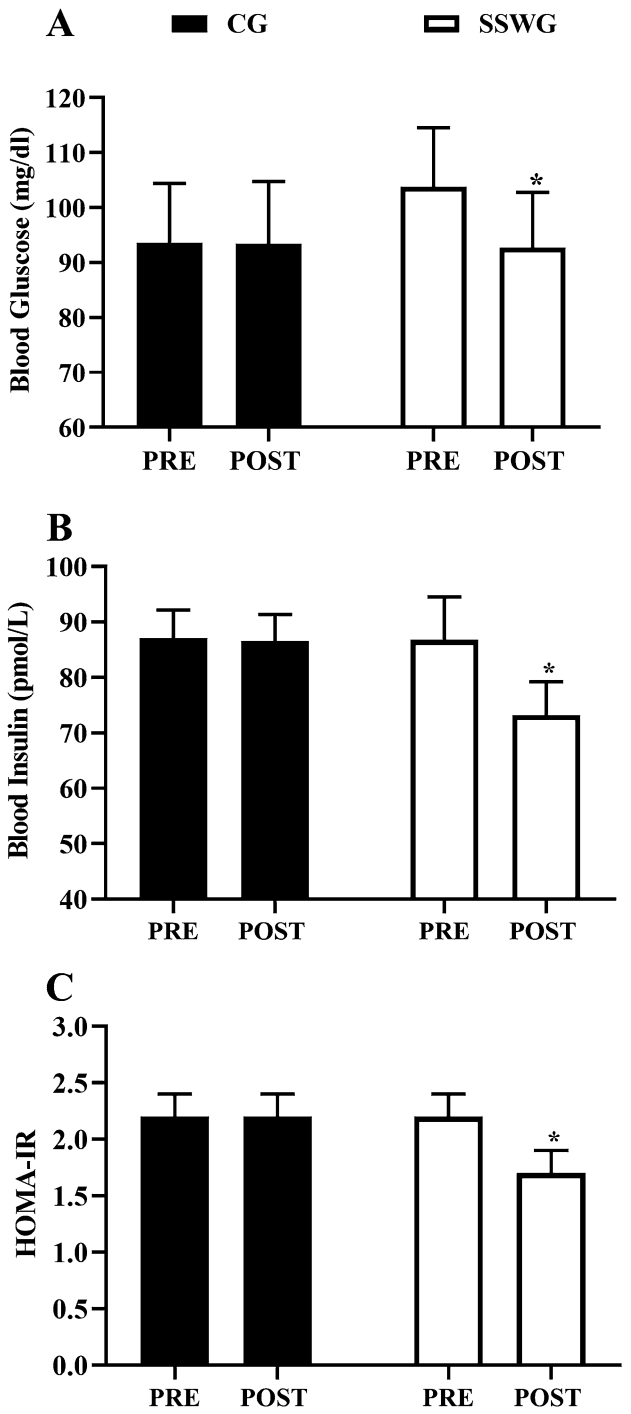

Fig. 1 **a** Blood glucose, **b** blood insulin, and **c** homeostatic model of assessment-insulin resistance following a 12-week walking program in two groups: control group (CG) and self-selected walking group (SSWG). *Statistically different from pre-training ($p < 0.05$).

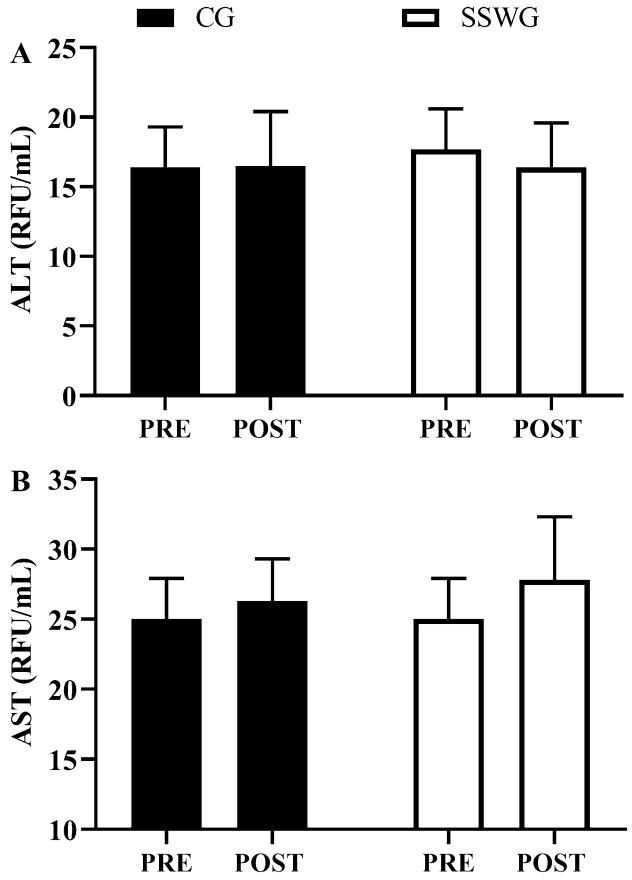

Fig. 2 **a** Alanine aminotransferase (ALT) and **b** aspartate aminotransferase (AST) following a 12-week walking program in two groups: control group (CG) and self-selected walking group (SSWG). *RFU* Reitman–Frankel unit

acute session of walking with self-selected intensity, but without changes in insulin and glucose. The present study corroborates other studies that observed improvement in fasting glucose, fasting insulin, and the HOMA index after aerobic training in overweight and obese adults [22, 23].

The results found in the present study indicate positive adaptations in insulin resistance (HOMA). The mechanisms responsible for these adaptations after aerobic training are not entirely known. Although we did not investigate, it is believed that the mechanisms responsible for these adaptations after exercise program may be related to increased activity of glucokinase relative to glucose-6-phosphatase, where the enzyme's activity is regulated by insulin and due to an improvement after exercise program in the sensitivity of insulin a decrease in fasting glucose is seen to occur [24].

It has been shown that liver enzymes are correlated with and predictive of incident nonalcoholic fatty liver disease and type II diabetes mellitus [25–27]. In the present study, no differences were found in liver enzymes after the intervention. These results do not corroborate with the study of Slentz et al. [22] who found improvements only for the ALT enzyme after aerobic training. However, a recent systematic review and meta-analysis of Smart et al. [4] demonstrated that liver enzymes (ALT, AST, and γ-glutamyl

transpeptidase) were not significantly altered with exercise. Moreover, liver enzymes may not be sensitive enough to be the only measure of liver function [28]. Thus, further studies should be performed to verify the effects of exercise on liver function.

The dual theory assumes that sensation is determined by cognitive factors, thus when the exercises are performed at intensity below the anaerobic threshold there are pleasure sensations for the participants due to low demands of cognitive process and perturbance of organic systems for promoting cellular homeostasis [29]. On the other hand, exercise performed above the anaerobic threshold results in an increase in cognitive demands and perturbance in the organic systems [29]. Therefore, obese individuals with an impaired cognitive precess (health status, high rate of fatigability, and low psychological appeasement) tend to choose lower intensities, because increase positive affective responses [10]. The present study demonstrates that a walking exercise program with self-selected intensity even at low intensity was able to improve insulin resistance in obese individuals maybe due to the increased positive affective responses during the exercise program.

The main limitations of the present study were the lack of a group with imposed intensity, not evaluating other biochemical and metabolic parameters (i.e., A1c), and not measuring the distance covered in each exercise session, which would help us to better understand and explain the adaptations from a walking exercise program with self-selected intensity. Despite these limitations, the current study helped to increase understanding of adaptations to exercise with self-selected intensity.

Conclusions

In summary, it was verified that a 12-week walking exercise program with self-selected intensity promoted changes in insulin sensitivity, but without changes in liver enzymes. Future research is needed to examine the effects of walking exercise programs with self-selected intensity using different samples and times of training and analyzing other variables related to health. Thus, walking exercise programs with self-selected intensity seem to be an interesting alternative for individuals with obesity, providing beneficial effects on health.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures were approved by the University's Institutional Review Board for Human Subjects (Human Research Ethics Committee) (process n. 071112) and were conducted according to the Declaration of Helsinki.

Informed consent All participants were aware of the procedures and risks of the experimental protocol, and read and signed an informed consent.

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