ARTIGO ORIGINAL

Fitness level of overweight/obese women after 8 weeks of aerobic exercise or mixed metabolism

Nível de condicionamento de mulheres sobrepeso/obesas depois de 8 semanas de exercícios aeróbios ou de metabolismo misto

Carlos Alexandre Fett [1]
Waléria Christiane Rezende Fett [2]
Julio Sérgio Marchini [3]

Resumo – Exercícios aeróbios ou de metabolismo misto são utilizados para o tratamento da obesidade, mas não está claro qual deles tem melhor impacto para este fim. Para investigar este assunto, foram formados dois grupos de mulheres sobrepeso ou obesas: o treinamento com pesos em circuito (TPC, n=14), ou a caminhada (CA, n=12), treinando 1 hora x 3 dias/semana no primeiro mês e 1 hora x 4 dias/semana no segundo, ajustados pela freqüência cardíaca e escala de Borg, mais dieta hipocalórica para ambos os grupos. Elas foram avaliadas quanto à antropometria, gasto energético de repouso (GER), balanço nitrogenado (BN) e testes físicos. Foram reduzidos o peso, o percentual da gordura corporal e aumentada a massa magra (MM) em ambos os grupos ($p < 0,05$). A circunferência muscular do braço aumentou significativamente somente no TPC e a circunferência muscular da coxa em nenhum grupo. O TPC melhorou nos seis testes físicos e o CA em três ($p < 0,05$). A relação kcal/kg foi mantida, a kcal/MM diminuiu, a kcal/gordura corporal aumentou e o BN foi mantido em ambos os grupos. Ambos os grupos tiveram resultados semelhantes relativos às variáveis da composição corporal e metabolismo. Mas, o TPC mostrou melhor resultado relativo ao desempenho físico, o que é considerado redução dos fatores de risco para saúde.
Palavras-chave: Massa muscular; 1-RM; Atividade física.

Abstract – *Aerobic exercise or mixed metabolism is used for the treatment of obesity, but it is unclear which approach has a greater impact. Thus, two groups of overweight or obese women were submitted to either a circuit weight training (CWT, n=14) or jogging program (JOG, n=12), performed 1 hour x 3 days/week in the first month and 1 hour x 4 days/week in the second months. The exercises were adjusted based on heart rate and the Borg scale, and both groups consumed a low-calorie diet. The participants were evaluated regarding anthropometric data, resting energy expenditure, nitrogen balance, and performance in different physical tests. Weight and percent body fat were reduced and lean body mass (LBM) was increased in the two groups ($p < 0.05$). Arm muscle circumference was significantly increased only in the CWT group and leg muscle circumference remained unchanged in either group. The CWT group showed improved results in six physical tests and the JOG group in three ($p < 0.05$). In both groups, the kcal/kg ratio was unchanged, kcal/LBM was decreased, kcal/fat mass was significantly increased, and the nitrogen balance continued to be positive. Similar body composition and metabolism variables were observed in the two groups. However, the CWT group showed a better physical performance, indicating a reduction of health risk factors.*
Key words: *Muscle mass; 1-RM; Physical activity.*

1 Universidade Federal de Mato Grosso. Laboratório de Aptidão Física e Metabolismo. Cuiabá. MG, Brasil.

2 Universidade de Cuiabá. Curso de Educação Física. Cuiabá. MG, Brasil.

3 Universidade de São Paulo. Laboratório de Espectrometria, Faculdade de Medicina de Ribeirão Preto. Ribeirão Preto, SP. Brasil.

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INTRODUCTION

Evidence indicates that weight loss is qualitatively more effective when obtained by physical activity rather than by diet only[1,2,3]. Any type of exercise that improves lean body mass (LBM) should elicit a reduction in body weight since this body composition component is positively associated with resting energy expenditure (REE)[4]. On the other hand, aerobic exercise might be used to directly oxidize fat[1,2]. In this respect, circuit weight training (CWT), a type of resistive exercise characterized by working different muscle groups on each using a mixed metabolism, and low-intensity aerobic exercise such as jogging (JOG) are two types of exercise that can be used as coadjuvants for the treatment of obesity. CWT[5] and JOG[6] have been associated with weight loss, maintenance of REE and an increase in VO_2max, and CWT is also related to strength gain. Regardless of the type of exercise, the dose-response (intensity x volume and improvement) change in fitness across levels of exercise training[7].

Furthermore, an increase in physical fitness has been demonstrated to improve health and body composition status and to reduce all-cause mortality in obese subjects[1]. Obese women present low physical fitness and exercise tolerance, are more susceptibility to pain, and show a greater difficulty in sustaining intense physical activity[8]. A high body mass index (BMI, kg/m^2) and body fat were found to be inversely correlated with muscle strength in elderly women[9]. However, improvement of strength and physical fitness has been demonstrated in obese women submitted to a very low calorie diet and weight lifting[10], suggesting this combination to be a good approach for this group of patients.

Thus, the main objective of the present study was to establish which physical activity, CWT or JOG, has a greater impact on the improvement of body composition, fitness, nitrogen balance (NB) and the ratio of REE to body composition components in overweight and obese women.

METHODS

Sample

Sedentary women (fewer than two weekly sessions of physical activity in the last 6 months) were studied. The subjects were submitted to physical examination performed by a physician of the Nutrology team at the Department of Internal Medicine, Faculty of Medicine of Ribeirão Preto, University of São Paulo (FMRP-USP). Women with a history of metabolic diseases (e.g., diabetes) in addition to obesity, smokers, alcoholics (> 15 g ethanol equivalents/day), subjects taking medications such as beta blockers (e.g., Propranolol) and/or sympathomimetic drugs (e.g., Amphepramone), and subjects with orthopedic impairments were excluded from the study. The study was approved by the Research Ethics Committee of FMRP-USP, and all participants signed a free informed consent form.

After an initial interview, the subjects were randomly divided into two groups: CWT group (n=14; BMI: 32±8 (mean±SD), age: 34±10 years) submitted to circuit weight training, and JOG group (n=12, BMI: 30±3, age: 38±11 years) submitted to a jogging program. The groups were similar in terms of baseline BMI, which was an inclusion criterion.

Anthropometry

Body weight (kg) and height (m) were measured with a Filizola® ID1500 electronic scale (São Paulo, SP, Brazil) with 0.1 kg and 0.5 cm precision, respectively. Skinfold thickness was measured with a Lange® skinfold caliper (Beta Technology, Inc., Santa Cruz, CA, USA) at a constant pressure of 10 g/mm^2 on the contact surface and 1 mm precision using a scale ranging from 0-65 mm. Next, the body composition components (percent body fat, %BF, LBM and fat body mass, FBM) were calculated[11].

Waist circumference (cm) was measured with the subject standing just above the navel and the tape parallel to the ground. Arm and leg circumferences (cm) were determined in the respective limb midpoint and then calculated by subtracting the respective skinfolds in cm multiplied by π. A flexible non-extensible plastic tape with 0.1 cm precision was used for these measurements[11].

Physical fitness test protocols

The subjects were submitted to six physical tests in order to determine their general physical fitness:

Tests 1 to 3: One-repetition maximum (1-RM) is the maximum load one can lift once in a given exercise and was assessed according to a previously described protocol[12]. *Test 1:* 1-RM bench press (triceps, shoulders and chest). *Test 2:* 1-RM leg press (thighs and glutei). *Test 3:* 1-RM seated low row (biceps, shoulders and back).

Test 4: Maximum oxygen consumption (VO_2max) was assessed on an electrical treadmill (model E17A®, Del Mar Reynolds Medical, Inc., Irvine, CA, USA) using the Micromed Ergo PC13® and

ECG digital programs (Micromed Biotecnologia Ltda, Guará II, Brasilia, DF, Brazil) according to the protocol of Bruce[11]. The tests were supervised by the Cardiology service of FMRP-USP.

Test 5: The abdominal resistance test was performed with the subjects lying on their back on a floor mat, with the knee flexed and the feet in contact with the floor at 30.5 cm from the buttocks and a shoulder width apart. The subjects were then asked to lift their back from the floor and touch their knees with their hands and to repeat this movement.

Test 6: The push-up resistance test was performed with the subjects lying in ventral decubitus and the hands resting on the floor at a width slightly greater (± 5 cm) than the shoulder width. The subjects were instructed to place the knees at an angle of more than 90°, thus avoiding ante- or retroversion of the hip and increasing lordosis, and consequently keeping the spine aligned. The breast had to touch the ground during each movement and the arms were supposed to be fully extended. In both resistance tests, the subject had to perform the largest number of repetitions possible over a period of one minute or until the occurrence of muscle fatigue[11].

Nitrogen balance

For 24-hour urine collection, the first morning urine was discarded and all subsequent urine samples were collected until the first urine of the next morning. Urinary nitrogen was measured by the Kjeldahl method as described by Munro & Fleck[13]. NB was estimated by subtracting excreted nitrogen from total ingested nitrogen. To calculate ingested dietary nitrogen, each gram of nitrogen is assumed to correspond to 6.25 g of ingested protein. The latter is calculated by computing the food record. Additional nitrogen loss in the stool was estimated by the addition of 2 g/day[13].

Resting energy expenditure and fractions

A mobile Vmax 29® Sensor Medics instrument (Yorba Linda, CA, USA) was used to determine REE (kcal/day). REE was measured after a 12-hour fast and after the subjects had rested in the sitting position for 30 minutes and in the supine position for an additional 30 minutes. While still lying down, indirect calorimetry was performed for an additional 30 minutes during absolute rest. Daily REE was calculated by the equation of Weir[14]. Next, REE was divided by body weight (kcal/kg), FBM in kg (kcal/FBM) and LBM in kg (kcal/LBM). In the two groups, dietary calorie supply corresponded to the respective REE.

Physical activity

The groups were trained for 60 minutes x 3 days/week in the first month and for 60 minutes *x* 4 days/week in the second month. The exercise intensity was adjusted in the two groups based on the heart rate palpated at the wrist and by the modified Borg scale ranging from 3-5 (moderate to hard)[11]. CWT consisted of 15 stations of resistive exercise each lasting 30 seconds, intercalated with 30 seconds of walking/jogging until completing a period of 40-45 minutes. In the JOG group, the subjects walked/jogged continuously for 45 minutes. The remaining 15-20 minutes were used for warm-up and for cool down in both groups.

Statistical analysis

The groups were compared between the beginning (T1) and the end of the exercise program (T2) by the paired *t*-test. The groups were compared on the basis of the variation in each group (Δ=T2-T1) using the unpaired *t*-test, with P set at 5% and a 95% confidence interval in all analyses. The power of the test was higher than 90% for comparison between groups and intragroup comparison, calculated using two scores of difference to BMI.

RESULTS

A significant reduction in weight, %BF, FBM and waist circumference and an increase in LBM were observed in the two groups (Figures 1 and 2), whereas arm muscle circumference was significantly increased only in the CWT group and leg muscle circumference remained unchanged in either group (Figure 2).

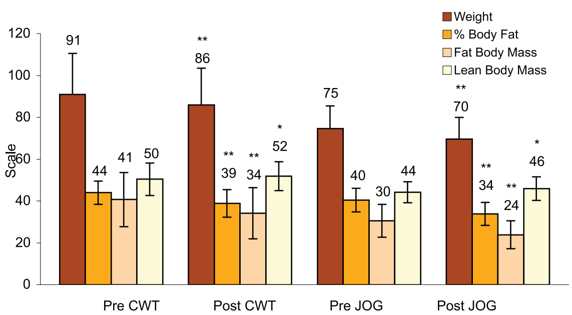

Figure 1. Mean and SD of anthropometric variables obtained for overweight/obese women before (Pre) and after (Post) 8 weeks of circuit weight training (CWT, n=14) or jogging (JOG, n=12). Both groups received a diet corresponding to resting energy expenditure. Statistical analysis: Pre CWT x Post CWT; Pre JOG x Post JOG: *P<0.05, **P<0.01. Weight, fat body mass and lean body mass are expressed as kg. Percent body fat is also shown.

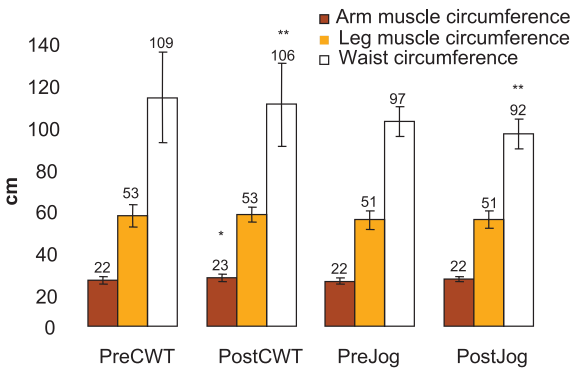

Figure 2. Mean and SD of anthropometric variables obtained for overweight/obese women before (Pre) and after (Post) 8 weeks of circuit weight training (CWT, n=14) or jogging (JOG, n=12). Both groups received a diet corresponding to resting energy expenditure. Statistical analysis: Pre CWT x Post CWT; Pre JOG x Post JOG: *P<0.05, **P<0.005.

The CWT group presented significant improvement in all six physical tests, whereas the JOG group only improved in the bench press, VO_2max and abdominal resistance tests (Table 1).

The groups did not differ in terms of kcal/kg. However, kcal/LBM was decreased and kcal/FBM was increased (P<0.05) (Figure 3).

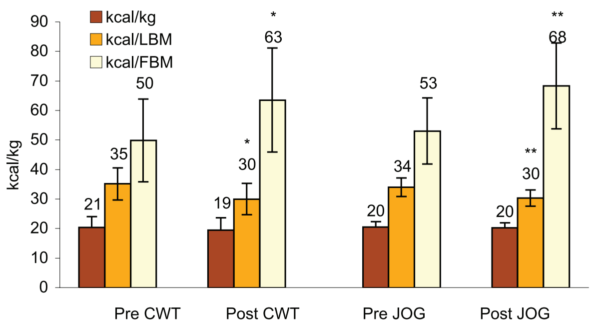

Figure 3. Mean and SD of anthropometric variables obtained for overweight/obese women before (Pre) and after (Post) 8 weeks of circuit weight training (CWT, n=14) or jogging (JOG, n=12). Both groups received a diet corresponding to resting energy expenditure. Statistical analysis: Pre CWT x Post CWT; Pre JOG x Post JOG: *P<0.05, **P<0.005.

A significant reduction in NB was observed in the CWT group (Pre: 7±6 g N/day, and Post: 3±5 g N/day, P<0.031), whereas NB was increased in the JOG group (Pre: 1±4 g N/day, and Post: 2±3 g N/day, P=0.25). Only ΔNB differed between groups (P<0.05).

DISCUSSION

Improvement in body composition and physical conditioning, maintenance of kcal/kg, a positive NB and a reduction in waist circumference were observed in the two groups within a relatively short period of 2 months. Similar results have been reported for longer, supervised or unsupervised programs (18 months)[15]. However, the results of the present study are limited by some baseline differences between groups.

Weight loss due to calorie restriction has a negative effect on LBM and REE, which can be reversed by jogging exercise[2]. However, a training overload is necessary for the occurrence of muscle hypertrophy, an event more common in resistive activities[8] such as those included in the present CWT protocol. This may explain, at least in part, the increase of arm muscle circumference observed only in this group. The increase of LBM observed in the JOG group might be explained by the fact that sedentary women were studied and forced jogging had an overload effect during the initial period of adaptation[12], an assumption supported by the fact that leg muscle circumference was unchanged in the two groups.

In addition, untrained obese women have been shown to be more susceptible to pain, a fact impairing their adherence to training[16], with consequent lower physical performance and synthesis of contractile tissue. The feeling of discomfort during physical activity perceived by obese subjects is not only due to

Table 1. Results of the physical tests before (Pre) and after (Post) 8 weeks of intervention obtained for each group (intragroup) and differences (PΔ) between the two groups (intergroup).

Variable	Circuit weight training (n=14)			Jogging (n=12)			$P\Delta_{groups}$
	Pre	Post	P	Pre	Post	P	
Bench press[a]	36±5	43±4	0.001	34±6	40±5	0.007	0.190
Leg press[a]	90±2	100±2	0.005	71±2	76±2	0.218	0.352
Low rowing[a]	49±1	53±1	0.009	38±1	44±1	0.072	0.165
VO_2max[b]	34±9†	39±1‡	0.039	34±7†	41±6**	0.003	0.475
Abdominal[c]	22±6*	25±6†	0.027	20±6*	23±5*	0.012	0.356
Push up[c]	14±8*	22±1†	0.013	16±1*	17±1*	0.385	0.065

Mean±SD; P value obtained by the paired (Pre x Post, in each group) and unpaired ($P\Delta_{groups}$) *t*-test. [a]One-repetition maximum test (1-RM) in kg; [b]maximum oxygen consumption (ml.kg $^{-1*}$min^{-1}); [c]maximum number of repetitions in 1 minute or until exhaustion in both tests. Classification of fitness result: *regular; †good; ‡excellent; **superior.[11] To 1-RM do not have a classification.

overweight, but also to pain[16]. However, the protocols proposed seem, at least in part, to have reversed these effects, especially the CWT protocol.

Another favorable finding was the observation of a positive NB throughout the study, maintaining or increasing LBM in both groups. A positive NB is related to protein synthesis, which depends on the muscle training stimulus, and prevents excessive losses even in situations of low-calorie intake[17]. However, an adequate calorie and protein supply is necessary to prevent a negative NB[18], impairing weight loss and the concomitant increase in LBM, as observed here, indicate these were adequate in present study.

The CWT group showed a better performance in the physical tests than the JOG group. This result was mainly due to the intensity of muscle contraction and mixed metabolism in the CWT group. Exercise volume and intensity interfere positively with changes in fitness[4]. In this respect, Lafortuna et al.[19] compared a low-volume and moderate-intensity exercise protocol with a protocol consisting of high-volume and low-intensity exercise, and observed that the former protocol was better in terms of muscle performance and physical fitness than the latter. Physical fitness *per se* is inversely correlated with morbidity and mortality in obese subjects and is a predictor of mortality similar to diabetes and hypertension[20]. Additionally, high BFM and high BMI were found to be associated with a higher probability of functional limitation in a population of elderly women at the high end of the functional spectrum[8]. A study conducted on nurses showed that poor health and fitness profiles and a high incidence of back pain were correlated with increased %BF[21]. In this respect, CWT was found to improve these problems in obese subjects. At baseline, there were some differences between groups, but in general these results could be probably expected because obesity has been shown to impair physical fitness results[8] and the CWT group presented a higher BMI.

None of the volunteers in either group received a diet with less than 1100 kcal/day. Moderate calorie restriction was chosen since a very low calorie diet reduces or excludes the thermal effect of food in obese women, regardless of the concentration of macronutrients administered[22]. In addition, moderate diets have been demonstrated to be more efficient than very low calorie diets in inducing a greater loss of stored FBM per kilocalorie deficit[23]. In this respect, the present results suggest that a diet with moderate calorie restriction plus regular physical exercise had a favorable impact on body composition, REE and NB.

In contrast to the present study, Henson et al.[24] observed that, when expressed per unit LBM, REE continued to be suppressed throughout the period of calorie restriction. However, the largest decrease in FBM (3.7 ± 0.4 kg) was observed during exercise, resulting in a small apparent increase in REE when expressed per kilogram total body weight. The authors concluded that exercise of sufficient intensity to substantially increase VO_2max does not reverse the diet-induced depression of REE. In this respect, the present study showed an increase in VO_2max in the two groups ($P<0.05$). The two groups were first classified into the good category and the CWT group then progressed to the excellent category, superior to JOG[11], a fact that may have contributed to the maintenance of kcal/kg. The increase in kcal/LBM and the decrease in kcal/FBM might be explained, at least in part, by a change in the proportion of these variables, with an increase of LBM, a decrease of FBM and maintenance of REE. The maintenance of a positive NB in the two groups may have induced protein synthesis, which may have contributed to the fact that REE was not depressed.

In practice, REE needs to be related to a measure of LBM. This is because LBM is the major determinant of REE[4], and when it is decreased in the presence of a diet it is associated with a fall in REE[25]. However, Geliebter et al.[26] observed that weight lift training in combination with a diet prevented the loss of LBM but not the decline in REE, in contrast to what was observed in the present study. Other factors such as a marked increase in FBM may have also been correlated with REE. Differences in the populations and environments studied may partially explain these controversial results.

CONCLUSION

The combination of a moderate low-calorie diet and regular physical activity seems to be beneficial for the treatment of overweight/obese women. The present results show that CWT and JOG had a similar effect on the improvement of body composition and on the maintenance of NB and kcal/kg. In addition, our data suggest that CWT was more effective in improving fitness level which, in turn, contributes to the prevention of morbidity and mortality in obese subjects[20,21]. However, regarding some difference between groups in the basal, these differences could not be attributed just to exercise type. Further studies involving larger and more homogenous samples may help elucidate this controversy.

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Endereço para correspondência
Carlos Alexandre Fett
Av. Fernando Correa da Costa,
Faculdade de Educação Física, Ginásio de Esportes, Secretaria,
Universidade Federal de Mato Grosso,
78060-900 -Cuiabá, MT. Brazil.
E-mail: cafett@hotmail.com