

# Effects of circuit-based exercise programs on the body composition of elderly obese women

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**Aim:** The aim of this study was to investigate the impact of circuit-based exercise on the body composition in obese older women by focusing on physical exercise and body weight (BW) gain control in older people.

**Methods:** Seventy older women (>60 years old) voluntarily took part in the study. Participants were randomized into six different groups according to body mass index (BMI): appropriate weight (AW) control (AWC) and trained (AWT) groups, overweight (OW) control (OWC) and trained (OWT) groups, and obesity (O) control (OC) and trained (OT) groups. The exercise program consisted of 50 minutes of exercise three times per week for 12 weeks. The exercises were alternated between upper and lower body using rest between sets for 40 seconds with intensity controlled by heart rate (70% of work). The contraction time established was 5 seconds to eccentric and concentric muscular action phase. The following anthropometric parameters were evaluated: height (m), body weight (BW, kg), body fat (BF, %), fat mass (FM, kg), lean mass (LM, kg), and BMI (kg/m<sup>2</sup>).

**Results:** The values (mean ± standard deviation [SD]) of relative changes to BW (−8.0% ± 0.8%), BF (−21.4% ± 2.1%), LM (3.0% ± 0.3%), and FM (−31.2% ± 3.0%) to the OT group were higher ( $P < 0.05$ ) than in the AWT (BW: −2.0% ± 1.1%; BF: −4.6% ± 1.8%; FM: −7.0% ± 2.8%; LM: 0.2% ± 1.1%) and OWT (BW: −4.5% ± 1.0%; BF: −11.0% ± 2.2%; FM: −16.1% ± 3.2%; LM: −0.2% ± 1.0%) groups; additionally, no differences were found for C groups. While reduction ( $P < 0.03$ ) in BMI according to absolute values was observed for all trained groups (AWT: 22 ± 1 versus 21 ± 1; OWT: 27 ± 1 versus 25 ± 1, OT: 34 ± 1 versus 30 ± 1) after training, no differences were found for C groups.

**Conclusion:** In summary, circuit-based exercise is an effective method for promoting reduction in anthropometrics parameters in obese older women.

**Keywords:** anthropometric parameters, body fat, obesity, older women, physical exercise

## Introduction

In older adults, age-related changes contribute to alterations in body composition such as increases in fat mass (FM) and decreases in lean mass (LM) and loss of height caused by compression of vertebral bodies and kyphosis.<sup>1</sup> Additionally, the prevalence of obesity (O) has increased among older adults and will likely continue to increase.<sup>2</sup>

Therefore, weight gain worsens age-related impairment of physical function and often leads to frailty and is frequently associated to sarcopenia. These changes in body composition, low muscle mass, and/or low muscle strength may coexist in the same person, a condition defined as sarcopenic O. This condition may induce a decrease in the level of physical activity, reducing the most important trophic effect on muscle mass

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as well as predisposing adults to positive energy balance and FM gain. Moreover, excess adiposity is a strong contributing factor for cardiovascular disease risk.<sup>3</sup>

Exercise training (ET) has been shown to be an effective non-pharmacological method to reduce body weight (BW) and physical disability in obese older people; moreover, ET has been considered a primary strategy for reducing cardiovascular disease risk and inducing weight loss through reduced daily energy intake and moderate endurance exercise.<sup>4</sup>

It is well-established that ET improves the physical capacity of obese people,<sup>5,6</sup> and therefore, physical activity should be increased among this group. Obese people are a challenging group for physical activity promotion as they have more comorbidities and physical impairments and they report an increased number of diseases compared to their non-obese age peers, such as diabetes, cardiovascular diseases, and osteoarthritis, smaller muscle strength relative to body mass, pain, and tiredness.<sup>7</sup> Basic exercise guidelines recommended by the American College of Sports Medicine for healthy adults and elderly people emphasize that training programs should consist of resistance, strength, aerobic, and flexibility exercises.

However, the shortage or interruption in body composition changes in exercise programs may be determinants of withdrawal, so in order to structure weight loss programs more effectively it is important to develop methods of physical training that effectively awaken changes in body composition. Among the most varied methods, resistance training has been applied in the form of circuit training (CT). Using this exercise protocol to change the body composition in overweight (OW) adults, Fett et al<sup>8</sup> demonstrated that training caused decreases in BW and FM; however, no effects were demonstrated by Dias et al<sup>9</sup> on anthropometric parameters after CT.

There is no information available to describe the effect of CT in obese older women. Therefore, the aim of this study is to investigate the impacts of circuit-based exercise on body composition in obese older women.

## Materials and methods

### Subjects

After receiving approval from the Healthy Institute (015-2010) ethics committee, 90 healthy older women were recruited from the regional community adult day care facilities focusing around the School of Arts, Sciences, and Humanities of the University of São Paulo, São Paulo, Brazil. All participants voluntarily took part in the study, received medical examinations, and filled in questionnaires regarding

their medical history. All procedures in this study conformed to the 196/96 resolution of the Brazilian Ministry of Health and the Helsinki Human Rights Declaration (<http://www.wma.net/en/30publications/10policies/b3/>). Only those who gave written informed consent were included in the research.

Inclusion criteria to this study were being  $\geq 60$  years of age, healthy, and physically independent. Exclusion criteria were as follows: participation in current or previous regular exercise training in the last 6 months, recent hospitalization, symptomatic cardiorespiratory disease, severe hypertension, metabolic syndrome, and renal or hepatic disease, cognitive impairment or progressive and debilitating conditions, marked O with inability to exercise, recent bone fractures, or any other medical contraindications to training.

The classification of O was established according to the body mass index (BMI) by the World Health Organization<sup>10</sup> and is of use in the Brazilian population.<sup>11</sup> Thus three levels were determined: appropriate weight (AW; 18.5–24.9 kg/m<sup>2</sup>); overweight (OW; 25.0–29.9 kg/m<sup>2</sup>), and obese (O;  $>30.0$  kg/m<sup>2</sup>).

According to the exclusion criteria, 12 women were excluded and 78 women were randomized into six groups, including AW control (AWC, n: 9) and trained (AWT, n: 20) groups, OW control (OWC, n: 10) and OW trained (OWT, n: 14) groups, and O control (OC, n: 9) and trained (OT, n: 16) groups. Subjects that could not frequent the training sessions on the program days were considered as the control group. Participation in  $<90\%$  of the stipulated exercise program was also considered as an exclusion criteria. All groups maintained their usual daily activities. All subjects were instructed to keep their previously controlled normal dietary intake, to inform the study directors of any new prescribed medication, and to not take part in any other type of physical exercise.

### Body composition

Height was measured to the nearest 0.1 cm using a Cardiomed stadiometer (WCS model, Cardiomed, Curitiba, Brazil). Body mass was measured to the nearest 0.1 kg using a Filizola scale (Personal Line 150 model, Filizola, São Paulo, Brazil). BMI (kg/m<sup>2</sup>) was calculated as follows:  $BMI = \text{weight} / \text{height}^2$ . Body composition was determined using anthropometric measures.<sup>11</sup> Each skinfold was measured three times to the nearest 0.1 cm using a Lange skinfold caliper (Sanny Scientific Skinfold Caliper, São Paulo, Brazil) and the mean value was used for calculations. Body fat (BF) percentage was derived with skinfolds as was done previously by our

group.<sup>12</sup> The following parameters were evaluated: BW, BF, LM, FM, and BMI.

## Circuit-based exercise program

The exercise program consisted of 50-minute exercise sessions three times per week on nonconsecutive days for 12 weeks. After 5 minutes of aerobic warm-up performed on a treadmill, the following isotonic exercises were performed in a circuit: knee flexion, arm raise, shoulder abduction, shoulder adduction, shoulder rotation, squat, biceps curl, triceps extensions, calves raise, push-up, abdominal crunch, and hip extension. All participants were encouraged to accomplish the exercise movement within 45 seconds. Weight resistance was performed using elastic bands and free weights; contraction time was 5 seconds for eccentric and concentric phases followed by rest for 40 seconds. In order to allow a proper familiarization with the exercises with the correct and safe technique of execution and breathing, training intensity was lower during the first three sessions. After this period, the exercise intensity (70%) was controlled based on the individual preprogrammed target heart rate previously calculated using the Karvonen equation: % of work  $\times$  (maximal heart rate – baseline heart rate) + baseline heart rate, corrected for resting heart rate on the day of the exercise and monitored in all participants during training sessions by Polar-HR monitors (S150; São Paulo, Brazil). To minimize fatigue, the exercise was alternated between upper and lower body exercises. Rest was used between sets of 40 seconds, but there were no pauses between repetitions. Each session was guided by trained fitness instructors and supervised by the researchers.

## Statistics

All statistical analyses were performed using SPSS for Windows software (version 12.0, SPSS Inc, Chicago, IL,

USA). All data are expressed as mean  $\pm$  standard deviation. The D'Agostino–Pearson test was applied for Gaussian distribution analysis. Analysis of comparisons between groups along the time periods were performed using two-way analysis of variance with repeated measures, followed by Kruskal–Wallis or Bonferroni's post hoc tests when appropriated. Comparisons between groups concerning relative changes in variables after training were performed by one-way analysis of variance followed by Kruskal–Wallis or Bonferroni's post hoc tests when appropriate. Statistical significance was established at  $P < 0.05$ .

## Results

During the research period, no one left the study; however, two and seven women in the AWT and OT groups, respectively, participated in  $<90\%$  of the physical activity program. Therefore, our data are based on 69 subjects: (AWC,  $n = 9$ ) and (AWT,  $n = 18$ ) groups, (OWC,  $n = 10$ ) and (OWT,  $n = 14$ ) groups and (OC,  $n = 9$ ) and (OT,  $n = 9$ ) groups.

During and after training, no participants suffered injuries as a result of the training programs. Table 1 shows the anthropometrics parameters of all groups. At baseline, the values of BW, BF, FM, LM, and BMI of the O groups did not differ; however, the values were higher than in the AW and OW groups. Additionally, no differences were found between the respective control to AWT and OWT groups.

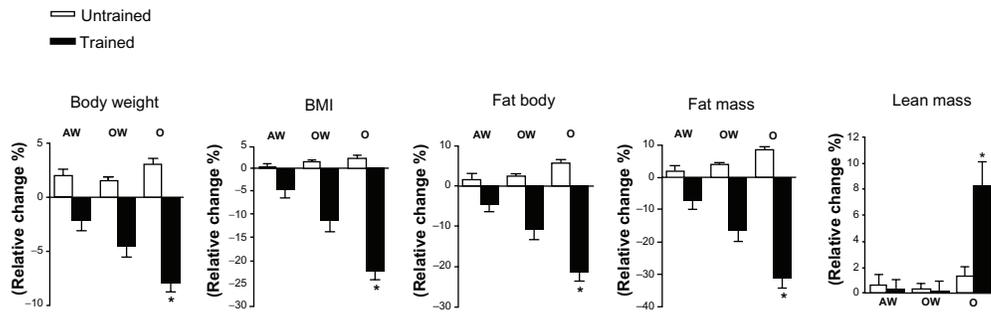
For all analyzed parameters in the AWT group, there was no significant difference in the values before versus after training and AWC; however, in the OWT and OT groups, the values of BW, BF, FM, and BMI were lower than the baseline values and respective controls. However, only the OT group showed an increase in LM after training (Table 1).

The relative changes are showed in Figure 1. Changes of values in BW ( $-8.0\% \pm 0.8\%$ ), BF ( $-21.4\% \pm 2.1\%$ ), LM ( $8.0\% \pm 2\%$ ), and FM ( $-31.2\% \pm 3.0\%$ ) in the OT group were

**Table 1** Anthropometrics measures

	Appropriate weight				Overweight				Obesity			
	Control		Trained		Control		Trained		Control		Trained	
	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before
Age (years)	67 $\pm$ 9	–	66 $\pm$ 4	–	63 $\pm$ 2	–	64 $\pm$ 4	–	62 $\pm$ 1	–	62 $\pm$ 2	–
Height (meters)	1.66 $\pm$ 0.1	–	1.66 $\pm$ 0.1	–	1.59 $\pm$ 0.1	–	1.61 $\pm$ 0.1	–	1.58 $\pm$ 0.1	–	1.55 $\pm$ 0.1	–
Body weight (kg)	63 $\pm$ 6	63 $\pm$ 7	61 $\pm$ 7	60 $\pm$ 7	68 $\pm$ 5	69 $\pm$ 5	69 $\pm$ 6	66 $\pm$ 5*	81 $\pm$ 4	84 $\pm$ 5	81 $\pm$ 4 <sup>‡</sup>	75 $\pm$ 5* <sup>†‡#</sup>
Body fat (%)	28 $\pm$ 5	28 $\pm$ 4	26 $\pm$ 5	25 $\pm$ 4	33 $\pm$ 4	34 $\pm$ 4	33 $\pm$ 2	30 $\pm$ 4*	35 $\pm$ 4	37 $\pm$ 4	35 $\pm$ 3 <sup>‡</sup>	29 $\pm$ 2* <sup>†‡#</sup>
Fat mass (kg)	17 $\pm$ 6	18 $\pm$ 4	16 $\pm$ 4	15 $\pm$ 3	22 $\pm$ 3	23 $\pm$ 3	23 $\pm$ 4	20 $\pm$ 3*	29 $\pm$ 3	31 $\pm$ 3	29 $\pm$ 3 <sup>‡</sup>	19 $\pm$ 2* <sup>†‡#</sup>
Lean mass (kg)	44 $\pm$ 4	45 $\pm$ 4	44 $\pm$ 4	45 $\pm$ 5	45 $\pm$ 5	45 $\pm$ 5	46 $\pm$ 5	46 $\pm$ 4	53 $\pm$ 5	54 $\pm$ 6	53 $\pm$ 5	58 $\pm$ 7* <sup>†#</sup>

**Notes:** Values are presented as mean  $\pm$  error deviation of appropriate weight, overweight, and obesity groups. Two-way analysis of variance with repeated measures was used, followed by Bonferroni's post hoc tests; \* $P < 0.05$  before versus after; <sup>†</sup> $P < 0.05$  versus respective control; <sup>‡</sup> $P < 0.05$  appropriate and overweight versus obesity trained group; <sup>#</sup> $P < 0.05$  indicated interaction.



**Figure 1** Repercussion (means  $\pm$  standard error) of appropriate weight (AW), overweight (OW), and obesity (O) groups from baseline in body weight, body fat, lean mass, fat mass, and body mass index (BMI).

**Notes:** Positive or negative values result from 12 weeks of circuit-based exercise program. \* $P < 0.05$  versus all groups.

higher ( $P < 0.05$ ) than in the AWC (BW:  $2.0\% \pm 0.4\%$ ; BF:  $1.6\% \pm 1.5\%$ ; LM:  $0.6\% \pm 0.6\%$ ; FM:  $2.0\% \pm 1.5\%$ ), AWT (BW:  $-2.0\% \pm 1.1\%$ ; BF:  $-4.6\% \pm 1.8\%$ ; LM:  $0.2\% \pm 1.1\%$ ; FM:  $-7.0\% \pm 2.8\%$ ), OWC (BW:  $1.5\% \pm 0.3\%$ ; BF:  $2.5\% \pm 0.3\%$ ; LM:  $0.3\% \pm 0.4\%$ ; FM:  $4.0\% \pm 0.4\%$ ), OWT (BW:  $-4.5\% \pm 1.0\%$ ; BF:  $-11.0\% \pm 2.2\%$ ; LM:  $-0.2\% \pm 1.0\%$ ; FM:  $-16.1\% \pm 3.2\%$ ), and OC (BW:  $3.0\% \pm 0.5\%$ ; BF:  $6.0\% \pm 1.0\%$ ; LM:  $1.3\% \pm 0.7\%$ ; FM:  $9.0\% \pm 0.8\%$ ) groups. No differences were found among other groups.

Although a significant ( $P < 0.03$ ) reduction in BMI (Figure 2) was found in all trained groups (AWT:  $22 \pm 1$  versus  $21 \pm 1$ ,  $\text{kg}/\text{m}^2$ ; OWT:  $27 \pm 1$  versus  $25 \pm 1$ ,  $\text{kg}/\text{m}^2$ ; OT:  $34 \pm 1$  versus  $30 \pm 1$ ,  $\text{kg}/\text{m}^2$ ) after training (Figure 2), no differences were found in control groups (AWC:  $23 \pm 5$  versus  $23 \pm 4$ ,  $\text{kg}/\text{m}^2$ ; OWC:  $26 \pm 1$  versus  $27 \pm 1$ ,  $\text{kg}/\text{m}^2$ ; OC:  $33 \pm 1$  versus  $33 \pm 1$ ,  $\text{kg}/\text{m}^2$ ). Additionally, the relative

change in BMI (Figure 1) in trained groups (AWT:  $-5\% \pm 2\%$ ; OWT:  $-1\% \pm 3\%$ ; OT:  $-22\% \pm 2\%$ ) was higher than in control groups (AWC:  $1\% \pm 1\%$ ; OWC:  $2\% \pm 1\%$ ; OC:  $2\% \pm 1\%$ ). Furthermore, the decrease in values of the OT group was statistically ( $P < 0.05$ ) stronger than other groups.

## Discussion

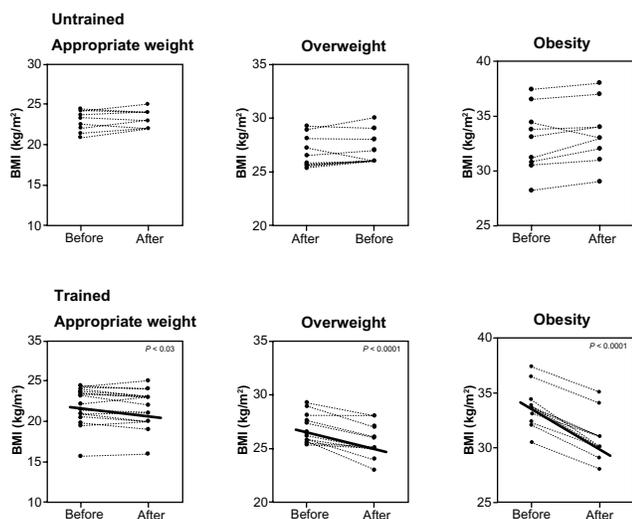
This is the first study to assess the effects of 12 weeks of circuit-based exercise on obese older women. According to our results, circuit-based exercise is effective for promoting reductions in anthropometrics parameters, particularly the increase in LM.

The prevalence of OW people is a serious public health concern, and is a risk factor for developing cardiovascular and metabolic disorders.<sup>13,14</sup> Thus, there is a need to identify effective therapeutic practices for regulating BW and improving quality of life.

An appropriate level of physical activity has direct effects on the maintenance of lean body mass in adults.<sup>14</sup> Therefore, treatment strategies for O, which maximize the BF loss and increase LM, carry significant benefits to obese people.<sup>15-17</sup>

The ET plays an important role in weight control and is often associated with other types of interventions such as diet. However, several studies<sup>18-22</sup> showed similar results presented in this paper without dietary control to modify body composition, particularly free FM. In addition, the weight loss achieved with moderate physical activity can be easily reversed by a small compensatory increase in food intake.<sup>23</sup>

Additionally, aging often leads to a loss of functional fitness in older people, reducing their ability to perform daily tasks.<sup>19-21,24</sup> Moreover, fall-related injuries are serious problems in old age, as they often lead to prolonged, or even permanent, disability. Therefore, maintenance of LM is frequently considered an important strategy for



**Figure 2** Repercussion (means  $\pm$  standard error) of body mass index (BMI) before and after 12 weeks of circuit-based exercise program in appropriate weight, overweight and obesity groups.

improving functional fitness, preventing BW gain, reducing disability,<sup>25</sup> improving the quality of life, and reducing the costs of health care. Moreover, a review of randomized controlled trials has demonstrated that exercise reduces the risk of falls in elderly people, and reduction in the incidence of fall-related injuries is related to lower health care costs.<sup>26</sup> The preservation of functional capacity, muscle strength and BW, prevention of injuries that reduce disability, improvement of quality of life, and reduction of costs of health care should be the most relevant features of exercise programs. The contribution of ET in general for the weight loss process is due to the increase in daily caloric expenditure promoted by the fat-free mass, as found in our study. Additionally, the ET energy expenditure may also stimulate elevation of basal metabolic rate due to increased muscle mass. It is believed that the tendencies of people to gain weight with age are due largely to a reduced basal metabolic rate by progressive LM loss.<sup>27</sup>

Not surprisingly, strength exercises can substantially modify the body composition and capacity of power generation in different populations.<sup>28</sup> In relationship to CT, the effectiveness is unclear, with studies showing positive<sup>8,29</sup> and discordant results<sup>9,30</sup> in adults and old people. However, clinically, our results are important for future research, specifically for sarcopenic subjects. The loss of muscle mass reduces targets available to insulin-responses, promoting insulin resistance, in turn promoting metabolic syndrome and O.<sup>31–35</sup> Moreover, increasing FM promotes production of tumor necrosis factor- $\alpha$ , interleukin-6, and other adipokines that further promote insulin resistance as well as potentially having a direct catabolic effect on muscle reducing the muscle strength. Villareal et al<sup>36</sup> suggest that sarcopenic O is a major public health problem; in this perspective, circuit-based exercise is considered cheaper and a reliable method for preventing sarcopenic status.

Additionally, it is known that one factor contributing to the failure of the treatment of O is maintaining a low-calorie diet intake for long periods, causing demotivation.<sup>37</sup> An important feature of ET is that it allows the possibility of a large number of people taking part in exercise sessions. This fact corresponds to the wide variety of exercise as well as the increased possibility of intrapersonal relationships with exercise practice, leading to higher level of motivation during training.

There were some limitations to this study. This was a relatively small sample study, and it was not designed to examine possible biochemical mechanisms of bone adaptation to exercise programs.

In conclusion, we demonstrated the positive effects of circuit strength training on body composition parameters, and relevant importance should be given to improve LM in obese older women. For future therapeutic considerations, the present work may support the safety and utility of this exercise modality for larger trials, as well as for education and physical training in this population.

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## Disclosure

The authors report no conflicts of interest in this work.

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