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ORIGINAL ARTICLE

The beneficial effects of aerobic and concurrent training on metabolic profile and body composition after detraining: a 1-year follow-up in postmenopausal women

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BACKGROUND/OBJECTIVES: Aerobic and concurrent training (CT, aerobic and strength training) improves body composition and metabolic profile; however, it is not known whether these positive outcomes acquired after aerobic or CT are maintained long term (⩾6 months) after program interruption in postmenopausal women. This study investigated the changes in total and appendicular body composition, bone mineral density and metabolic profile following 16 weeks of aerobic or CT, and through 6 months and 1 year of detraining in postmenopausal women.

SUBJECTS/METHODS: In total, 60 postmenopausal women were divided into the following groups: aerobic (AT), aerobic plus strength training (CT) and control group (CG), and 31 participants were assessed for the 1 year follow-up. Body composition and bone mineral density were evaluated by dual-energy X-ray absorptiometry (DXA), and total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, triacylglycerol, glucose, insulin, leptin, adiponectin and plasminogen activator inhibitor-1 (PAI-1) were assessed.

RESULTS: There were main effects of time for arm fat mass, arm lean mass and trunk lean mass ($P < 0.05$). There was a statistical difference between AT and CG for leg fat mass and percentage of fat ($P < 0.05$). After 6 months of detraining, leg lean mass decreased in relation to post-intervention, and there was a statistically significant interaction for total and appendicular lean mass ($P < 0.05$). There were differences between CT and CG in glucose and between AT and CG in glucose and triacylglycerol ($P < 0.05$).

CONCLUSIONS: A duration of 16 weeks of aerobic or CT improved total and appendicular body composition and metabolic profile but after 6 months of detraining, leg lean mass returned to the values obtained pre-training in CT.

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INTRODUCTION

The menopausal period results not only in lower estrogen hormone concentrations but also contributes to significant changes in body composition, increasing fat mass and central adiposity,[1] which is linked to the development of morbidities such as hypertension, type 2 diabetes mellitus, dyslipidemia and metabolic syndrome.[2] These morbidities increase the risk of cardiovascular diseases, such as atherosclerosis, which is the leading cause of death worldwide.[3] Furthermore, physical inactivity can lead to decreased lean mass (LM), bone mass and muscular strength, which can result in the development of musculoskeletal diseases such as sarcopenia and osteoporosis, impaired locomotion, balance, increasing fragility, incidence of falls and consequently decrease the quality of life during daily activities.[4]

Several studies have assessed exercise interventions in an attempt to minimize the deleterious effects of the postmenopausal period. Aerobic exercise has demonstrated anti-inflammatory effects,[5] improved cardiovascular fitness, oxidation of lipids in skeletal muscle and liver,[6] and has been shown to induce significant improvements in the reduction/control of whole and central adiposity,[7] lipids and lipoproteins.[8] On the other hand, strength training has anti-catabolic effects, increases the oxidation of carbohydrates in skeletal muscle and increases muscle anabolism.[9] Therefore, the combination of aerobic plus strength training (concurrent training (CT)) is a promising option for increasing LM, decreasing total fat mass and trunk fat,[10,11] and regulating the metabolic profile in postmenopausal women.[12]

Physical activity (PA) and exercise training improves body composition and metabolic profile in various populations, but to prevent lifestyle-related diseases, it is important not only to encourage people to start a training program but also to maintain adherence[13] as adaptations that occur during training are reversible and often lost following detraining.[14] Therefore, more research is needed to study training methods that induce longer lasting adaptations following the cessation of exercise training.

Mora-Rodriguez *et al.*[15] investigated the time-course effects of 4 months of aerobic training (AT) and short-term detraining (1 month) in patients with metabolic syndrome and reported that high-density lipoprotein cholesterol (HDL-c) and VO2peak decreased to the values obtained after 1–2 months of training, whereas HOMA index and maximal fat oxidation returned to

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pre-training values. Lo *et al.*[16] compared body composition, body size and muscle strength after 24 weeks of strength or AT and 24 weeks of detraining in young men and concluded that resistance training maintained the gains in strength and LM for more prolonged periods compared with AT.

Therefore, it is not known whether these positive outcomes acquired after aerobic or CT are maintained for longer periods (⩾6 months) after program interruption in postmenopausal women, or whether there are differences between AT and CT with regard to adaptation maintainability during detraining. We hypothesized that CT would be more efficient than AT in improving LM, fat mass, bone mass and metabolic profile by emphasizing both aerobic and strength training, and that the benefits would be maintained for a longer time (6 months to 1 year). Thus, the objectives of the present study were to investigate the changes in total and appendicular body composition and metabolic profile after 6 months and 1-year follow-up in relation to the corresponding values before and after aerobic or CT in postmenopausal women.

METHODS

Participants and study design

This controlled clinical trial study was carried out at the Science and Technology Department of the University Estadual Paulista (FCT/UNESP), Presidente Prudente campus – São Paulo, Brazil. This study was performed according to the guidelines of the Declaration of Helsinki. The project was approved by the Ethics Research Group of the University (Protocol 64/2011) and Brazilian registry of clinical trial (RBR-9CBP8S).

Evaluations were performed at baseline, post training and after 6 months and 1 year of detraining (follow-up) in all the groups and involved the following: screening for inclusion in the study (only baseline), metabolic profile measurements, body composition, three nonconsecutive 24-h dietary questionnaires and free-living PA assessment.

Participants were invited through television and newspaper advertising to participate in the study. The participants contacted the researchers by phone and an appointment was made in order to carry out a more detailed interview. All measurements were taken at the university laboratory. The inclusion criteria were as follows: (1) being in menopause (having had no menstrual cycle for one or more years) and FSH ⩾ 26.72 mUI/ml; (2) not taking medication for diabetes and/or dyslipidaemia; (3) not consuming tobacco or alcohol; (4) not having participated in any systematic physical exercise for at least 6 months before the study; (5) not receiving hormone replacement therapy treatments; (6) not presenting any physical limitations or health problems that could prevent the completion of the assessments and exercise interventions; and (7) signing the consent form.

We performed a power analysis of this study based on the observation from a previous study that verified a reduction in trunk fat of 0.9 kg and s.d. of 0.6 after 16 weeks of AT and detraining in patients with metabolic syndrome.[15] Our primary hypothesis was that this difference would be statistically significant as compared with the control group (CG) assessed at the similar time period, with a power (1-type II error) of 0.80 and a type I error of 0.05. Using PS software (ver 3.1.2, Dupont and Plummer, http://biostat.mc.vanderbilt.edu/wiki/Main/PowerSampleSize), it was estimated that we would need eight participants per group. Considering a dropout rate of 25–40%, we over-recruited the number of participants.

Out of a total of 113 women who participated in the first screening, only 60 women met all the inclusion criteria and agreed to participate in the study protocol. Participants were randomized into the following three study groups for 16 weeks of training: CT ($n = 20$), AT ($n = 20$) and a CG ($n = 20$) which maintained 16 weeks without participating in any regular PA. Simple randomization techniques were used for allocation, which ensures that trial participants have an equal chance of being allocated to a treatment group;[17] furthermore, the investigator was blinded to the group allocation during the experiment and/or when assessing the outcome. During the 16 weeks of training, five women from each group dropped out of the study (a dropout rate of 25%) and were excluded from the final analysis. The reasons for dropouts included personal/family problems, unspecified reasons or the participants did not comply with over 80% of frequency during the training program. After the intervention participants were encouraged to maintain their habits, and the researchers contacted the participants by phone after 6 months and then 1 year after the end of training. After 6 months and 1 year follow-up, the participants were evaluated again: CT ($n = 15$), AT ($n = 8$) and CG ($n = 8$). The reasons for dropouts at this measurement time point included personal/family problems, unspecified reasons or the participants refused to come back for assessing (Figure 1).

PROCEDURES

Body composition, dietary intake and free-living physical activity assessment

Body weight was measured using an electronic scale (Filizola PL 50, Filizzola Ltda., São Paulo, Brazil), with a precision of 0.1 kg.

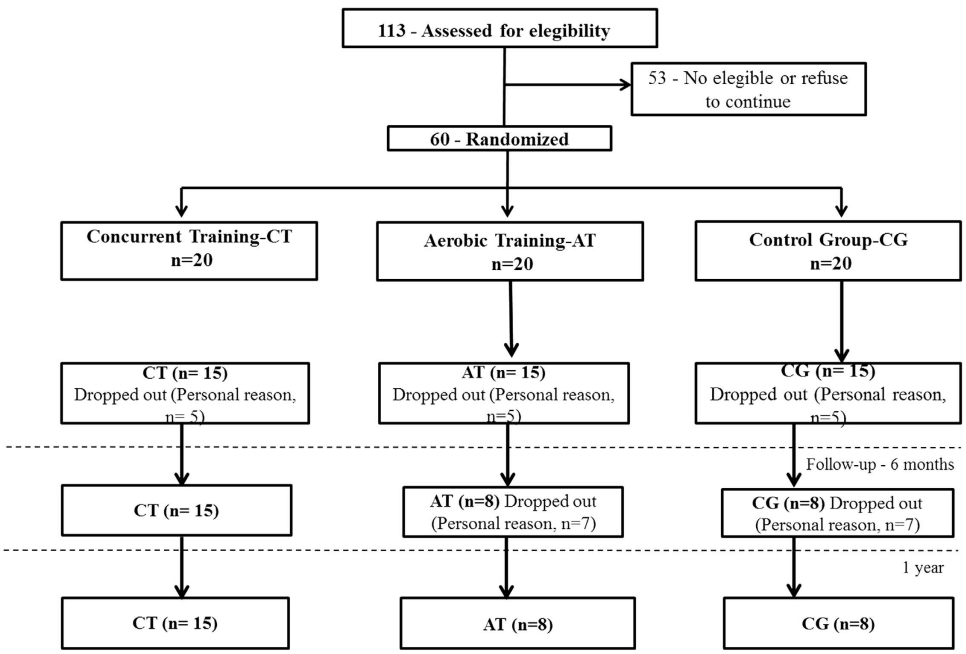

Figure 1. The trial profile of this study.

Height was measured on a fixed stadiometer of the Sanny brand, (Sanny brand, São Paulo, Brazil) with an accuracy of 0.1 cm and a length of 2.20 m. The participants remained barefoot, wearing light clothing and standing at the base of the stadiometer, positioning themselves with their backs to the machine, touching their shoulder blades, buttocks and heels to the equipment's vertical support. Total fat mass, total LM, trunk fat, trunk LM, leg LM (LLM), arm LM, total bone mineral content in kilograms, percentage of fat mass and bone mineral density (BMD in g/cm^2) were estimated using a dual-energy X-ray absorptiometry scanner, version 4.7 (General Electric Healthcare, Lunar DPX-NT; England). The appendicular body composition was estimated according to Bhupathiraju *et al.*[18] The participants were positioned in a supine position and remained still throughout the examination. To calculate the technical error of measurement of the dual-energy X-ray absorptiometry, two whole-body evaluations were performed, by the same evaluator, on two consecutive days with 12 female subjects. From the results obtained the average error was estimated as follows: ± 0.05 kg for total body fat, ± 0.28 kg for total trunk fat, ± 0.37 kg for total lean body mass, ± 1.06 kg for LLM and ± 0.14 kg for bone mineral content. The test–retest intraclass correlation coefficient of these procedure has been shown reliable for all variables measured in this study (ICC between 0.91 and 0.99).

Twenty-four hour daily dietary records were conducted via 3-day food diaries that consisted of one weekend day (Sunday) and two weekdays (Monday and Wednesday or Tuesday and Thursday) to best reflect typical intakes. Participants were instructed by a nutritionist as to how to complete the dietary questionnaires. Total intake for the three days was then averaged and represented in different moments during the intervention. Questionnaires were analyzed by the same nutritionist using the software NutWin version 1.5 (Programa de Apoio à Nutrição, Universidade Federal de São Paulo, São Paulo, Brazil, 2002).

PA was measured by accelerometers (ActiGraph GT3X. Pensacola. FL). The PA intensity was measured in 60-s epochs, which is related to low intensity and long duration patterns of PA.[19] Accelerometers were placed on the participant's waists using an elastic band. The participants used the equipment for 8 days (only seven were full days). Instructions for use were provided. The accelerometer had to be used all day during the hours that the participant remained awake and was only to be removed when there was contact with water (personal hygiene or water activities).[20] Specific software (The ActiLife5 Data Analysis Software by Actigraph, Pensacola, FL, USA) was used to analyze the data. We included only the full days of monitoring in the database. Sixty consecutive minutes of zero counts were considered to be periods that the individual was not wearing the accelerometer and days containing less than ten hours of monitoring were excluded from the analysis, as they had the power to increase variability. At the end, only the participants who had at least 5 full days of monitoring (including at least one weekend) were included in this analysis.

Blood samples

After an overnight fast (12 h), venous blood samples were collected to measure total fasting cholesterol (Chol; mg/dL), HDL-c (mg/dL), triacylglycerol (TAG; mg/dL) and glucose (mg/dL) using the colorimetric technique and dry chemicals, with equipment of the Johnson and Johnson brand, model Vitros 250. The Friedewald *et al.*[21] formula was used to calculate low-density lipoprotein cholesterol concentration (LDL-c; mg/dL). Serum insulin (0–300 μIU/ml), leptin (2000–31.25 ng/mL), adiponectin (4000–62.5 ug/mL) and plasminogen activator inhibitor-1 (PAI-1 = 20–0.3125 ng/ml) were quantified using enzyme-linked immunosorbent assay with a commercial Kit (RayBio Human ELISA Kit, Norcross, GA, United States) as per the manufacturer's instructions. In addition, the homeostatic model assessment-insulin resistance was calculated according to Lejskova *et al.*[22]

Aerobic training procedures

The intensities of the AT were established according to the anaerobic threshold (LAN) determined by critical velocity protocol proposed by Wakayoshi *et al.*[23] The studied group traveled three distances (400, 800 and 1200 m) on a running track on separate nonconsecutive days. The participants were instructed to cover the distance in the shortest possible time, which was recorded using a digital stopwatch (Polar Electro, model S810i, Finland).[24] The relationship between the distance (m) and the exercise time (s) was linearly adjusted and the critical velocity was assumed to be the slope of this model, which represented the intensity of the AT.[23,24] The intensity of training was 100% of LAN for 50 min/day, three times per week (Monday, Wednesday and Friday) on a running track, including 10 min of warm-up and stretching at the end of the training session. After 4 weeks, the procedures were repeated to adjust the intensities. Participants were instructed to drink water and wear appropriate shoes and clothing during training.

Concurrent training procedures

CT was performed for ~60 min per day with 30 min of strength training and 30 min of AT, three times per week (Monday, Wednesday and Friday). The intensity of training was 100% of LAN and it was established according to the anaerobic threshold, determined by critical velocity protocol, similarly described above for AT. The exercises used in the program were as follows: 45º leg press, leg extension, leg curl, bench press, seated row, arm curl, triceps extension, side lateral raises with dumbbells and abdominal exercises. The strength training program consisted of four progressive phases (phase 1 (1st to 4th week, 3 sets of 15 repetitions); phase 2 (5–8th week, 3 sets of 12 repetitions); phase 3 (9–12th week, 3 sets of 10 repetitions) and phase 4 (13–16th week, 3 sets of 8 repetitions)), 60–90 s of rest was provided between sets and exercises.

The intensity of the strength training was controlled through the zone of repetition maximum (RM). The sets were executed until momentary exhaustion, (that is, when the participants performed the training with repetitions varying from 12 to 15 RM, they were always encouraged to execute at least 12 and no more than 15 RM).[25] In the case of the participants executing more repetitions, the load was increased in order to keep within the training zone.[25]

Statistical analysis

The Levene test was used to analyze the data set homogeneity, and a one-way analysis of variance was used to identify similarity of groups at baseline. Student's *t*-test for independent samples was used for insulin analysis because only two groups were analyzed in this variable. For analysis of the PA level at baseline we utilized Kruskal–Wallis test, as the data presented nonparametric distribution. Linear mixed models were used to compare the aerobic, CT and CG on metabolic profile and body composition. When a significant difference in group or interaction was observed, a Tukey's *post hoc* test was conducted. For all measured variables, the estimated sphericity was verified according to Mauchly's W test and the Greenhouse–Geisser correction was used when necessary. In addition, body composition and metabolic profile were controlled for free-living PA and energy intake after 6 months and 1 year follow-up. Finally, 'mean differences' (1-year follow-up value minus post-intervention value) were calculated and linear regression between fat mass, TFM, LM and metabolic profile were conducted to verify the association between variables after 1 year follow-up. The effect size (ES) was

calculated as the mean pre–post change divided by the pooled pretest standard deviation, and statistical significance was set *a priori* at $P < 0.05$. The data were analyzed using the Statistical Package for Social Sciences 17.0 (*SPSS* Inc. Chicago, IL, USA).

RESULTS

Table 1 presents the mean values for body weight, total and appendicular body composition, and metabolic profile at baseline in the three groups studied. There were no statistically significant differences between groups at baseline for all variables investigated.

In relation to the free-living PA presented in counts per minute, there were no differences at the baseline ($P = 0.116$) and across time in all groups ($P = 0.224$), and there were no observed differences between groups ($P = 0.203$) or interaction (time x group, $P = 0.795$; Figure 2a).

Regarding dietary intake (expressed in kcal), there were no differences at baseline ($P = 0.072$), across time ($P = 0.169$), between groups ($P = 0.105$), or interaction (time x group, $P = 0.082$; Figure 2b).

Table 2 presents the comparison in total and appendicular fat mass, and body weight after 6 months and 1 year follow-up. Table 3 displays the comparison in total and appendicular fat-free mass and BMD after 6 months and 1 year follow-up.

For total and appendicular fat mass, there were statistically significant differences between CT and AT for leg ($P = 0.017$, ES = 0.20) and percentage of fat ($P = 0.011$, ES = 0.22), but there were no significant differences between groups for total fat mass ($P = 0.069$, ES = 0.14). There was a main effect of time for arm ($P = 0.019$, ES = 0.10); however, the Tukey's *Post hoc* was not significant. There were no statistical interactions as displayed in Table 2 ($P > 0.05$). When controlled for free-living PA and energy intake, the significant differences for total and appendicular fat mass after 6 months and 1 year follow-up were maintained ($P < 0.05$).

For total and appendicular LM, there was a main effect of time for arm ($P = 0.002$, ES = 0.13). The *post hoc* test showed to a statistically significant difference after 1-year follow-up compared with baseline ($P = 0.002$) and after 6 months of detraining ($P = 0.005$). LLM decreased significantly after 6 months of detraining in relation to post-intervention ($P = 0.030$, ES = 0.081), and trunk LM increased after training in relation to the baseline ($P = 0.030$, ES = 0.074). There were statistically significant interactions for arm, leg and total LM (Table 3). In addition, when controlling for free-living PA and energy intake, the significant differences in total and appendicular LM after 6 months and 1 year follow-up were maintained ($P < 0.05$). There were no statistically significant differences between groups ($P > 0.05$), and there were no statistically significant differences in bone mass content and BMD.

With regard to the metabolic profile, there were statistically significant differences between groups for glucose ($P = 0.047$, ES = 0.11). *Post hoc* analysis showed significant differences between CT and CG ($P = 0.016$) and AT and CG ($P = 0.038$) but no difference between CT and AT ($P = 0.955$). For TAG, there was a statistically significant difference only between AT and CG ($P = 0.011$, ES = 0.084), and there were no main effects of time for both variables ($P > 0.05$). However, when we adjusted for energy intake after 6 months and 1 year follow-up, there were no significant differences between group for glucose and TAG ($P > 0.05$). There were no main effects of time or statistically

Table 1. General characteristics of the sample at the baseline

Variables	*CG (n = 20)*	*AT (n = 20)*	*CT (n = 20)*	P-*value*
Age (years)	62.8 ± 5.9	60.6 ± 7.9	62.4 ± 5.1	0.622
FSH (mUI/ml)	56.2 ± 12.6	69.0 ± 23.9	71.8 ± 26.7	0.153
Height (cm)	154.9 ± 7.7	156.6 ± 5.7	157.8 ± 6.1	0.437
Weight (Kg)	64.0 ± 11.3	65.3 ± 9.3	60.0 ± 7.6	0.236
Fat mass				
Arm (Kg)	2.5 ± 0.9	2.6 ± 1.0	2.1 ± 0.7	0.147
Leg (Kg)	9.3 ± 3.5	10.0 ± 3.0	8.3 ± 1.7	0.126
Trunk (Kg)	15.2 ± 4.6	14.9 ± 3.3	12.6 ± 3.0	0.061
Total fat mass (Kg)	27.9 ± 8.7	28.5 ± 7.1	24.0 ± 5.0	0.073
Percentage of fat (%)	42.8 ± 6.6	43.1 ± 5.7	39.8 ± 4.1	0.065
LM				
Arms (Kg)	3.9 ± 0.6	4.0 ± 0.5	3.8 ± 0.6	0.706
Legs (Kg)	10.9 ± 1.4	11.3 ± 1.1	11.0 ± 1.3	0.773
Trunk (Kg)	16.2 ± 1.6	15.8 ± 1.6	15.8 ± 1.9	0.898
Total LM (Kg)	34.0 ± 3.4	34.4 ± 3.1	33.7 ± 3.7	0.967
Bone mass				
Total BMC (Kg)	2.0 ± 0.4	2.4 ± 0.4	2.1 ± 0.2	0.110
BMD (g/cm^2)	1.071 ± 0.1	1.148 ± 0.1	1.066 ± 0.9	0.181
Metabolic profile				
Glucose (mg/dL)	99.9 ± 36.0	88.6 ± 13.2	89.6 ± 13.6	0.364
TAG (mg/dL)	154.5 ± 62.8	101.3 ± 34.7	130.5 ± 57.1	0.088
Chol (mg/dL)	207.5 ± 34.8	200.9 ± 41.4	207.0 ± 30.0	0.872
HDL-c (mg/dL)	54.3 ± 13.9	54.7 ± 10.5	53.6 ± 16.1	0.978
LDL-c (mg/dL)	122.4 ± 36.3	126.0 ± 36.2	127.3 ± 27.8	0.923
Insulin (μIU/ml)[a]	–	6.4 ± 2.5	4.3 ± 1.9	0.064
Leptin (ng/mL)	130.6 ± 60.0	107.9 ± 48.1	71.2 ± 44.0	0.216
Adiponectin (ug/mL)	12.3 ± 0.2	11.4 ± 1.9	11.4 ± 2.7	0.885
PAI-1 (ng/mL)	15.0 ± 5.2	12.6 ± 5.3	20.9 ± 23.0	0.667

Abbreviations: AT, aerobic training; BMC, bone mass content (Kg); BMD, bone mineral density (g/cm^2); CG, control group; chol, total cholesterol; CT, concurrent training; FSH, follicle-stimulating hormone (mUI/ml); HDL-c, high-density lipoprotein cholesterol; LDL-c,low-density lipoprotein cholesterol concentration; PAI-1, Plasminogen activator inhibitor-1; TAG, triacylglycerol. [a]Student test for independent sample was performed.

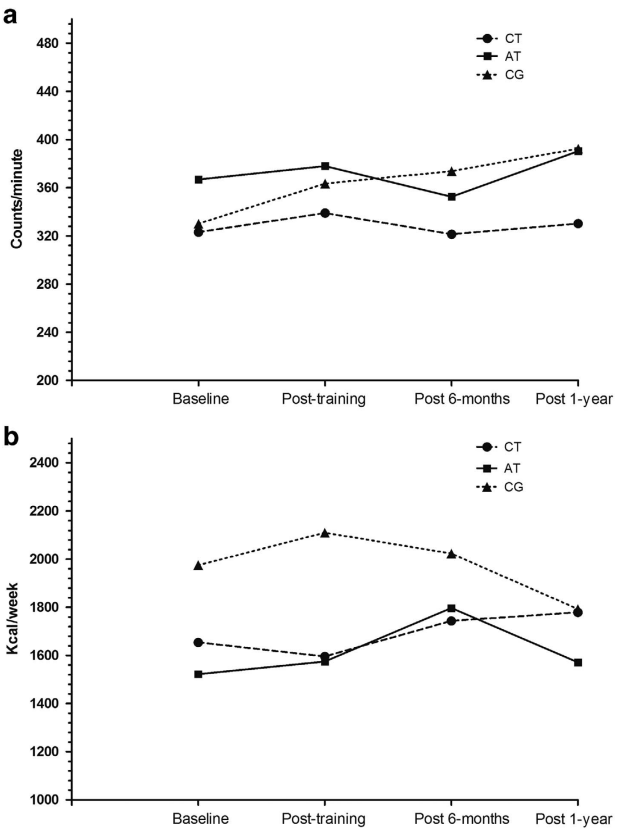

Figure 2. Free-living PA presented in counts per minute/week (**a**) and dietary intake (expressed in kcal/week) (**b**).

Table 2. Comparison in total and apendicular fat mass variables and body weight after 6 months and 1-year follow-up

Variables	*CG (n = 8)*	*AT (n = 8)*	*CT (n = 15)*	*Time x group*
Fat mass				
Arm (Kg)				
Pre	2.1 ± 0.8	2.8 ± 0.9	2.2 ± 0.7	0.790
Post	2.0 ± 0.7	2.6 ± 0.8	2.2 ± 0.8	
After 6-months	2.0 ± 0.7	2.6 ± 0.8	2.1 ± 0.8	
After 1-y	2.0 ± 0.8	2.5 ± 0.8	2.1 ± 0.8	
Leg (Kg)				
Pre	8.2 ± 2.3	10.7 ± 2.3	8.2 ± 1.7	0.572[a]
Post	8.2 ± 2.4	10.5 ± 2.2	8.1 ± 2.0	
After 6-months	8.1 ± 2.2	10.5 ± 3.1	7.8 ± 1.8	
After 1-year	8.3 ± 2.5	10.2 ± 1.8	7.7 ± 2.0	
Trunk (Kg)				
Pre	13.7 ± 4.5	15.6 ± 2.3	12.8 ± 2.9	0.513
Post	14.1 ± 5.8	14.7 ± 1.9	12.2 ± 3.2	
After 6-months	13.9 ± 5.0	15.3 ± 3.3	12.5 ± 3.1	
After 1-year	14.0 ± 5.5	15.0 ± 2.6	12.3 ± 3.1	
Total fat mass (Kg)				
Pre	24.8 ± 7.6	30.1 ± 5.1	24.0 ± 4.8	0.603
Post	25.2 ± 8.9	28.8 ± 4.5	23.3 ± 5.6	
After 6-months	24.9 ± 7.9	29.4 ± 6.7	23.4 ± 5.2	
After 1-y	25.1 ± 8.7	28.8 ± 4.8	22.9 ± 5.5	
Percentage of fat (%)				
Pre	40.4 ± 6.7	45.1 ± 3.2	39.4 ± 4.1	0.164[a]
Post	40.5 ± 7.4	46.1 ± 7.6	37.9 ± 4.8	
After 6-months	40.8 ± 6.4	44.1 ± 5.3	38.5 ± 4.2	
After 1-y	40.5 ± 7.1	43.7 ± 3.8	37.6 ± 5.1	
Weight (Kg)				
Pre	60.5 ± 10.1	66.4 ± 7.6	61.9 ± 8.7	0.087
Post	60.9 ± 11.7	63.0 ± 8.0	60.9 ± 8.9	
After 6 months	60.0 ± 10.7	66.0 ± 8.2	60.3 ± 8.7	
After 1 year	60.7 ± 11.3	65.5 ± 6.6	60.5 ± 8.3	

Abbreviations: AT, aerobic training; CG, control group; CT, concurrent training. [a]Statistically significantly differences between CT and AT groups.

Table 3. Comparison in total and apendicular LM and BMD variables after 6 months and 1-y follow-up

Variables	*CG (n = 8)*	*AT (n = 8)*	*CT (n = 15)*	*Time x group*
LM				
Arm (Kg)				
Pre	4.0 ± 0.7	4.0 ± 0.5	3.8 ± 0.6	0.014
Post	3.9 ± 0.5	4.0 ± 0.4	4.1 ± 0.7	
After 6 months	3.9 ± 0.6	4.0 ± 0.4	4.0 ± 0.7	
After 1-year	3.9 ± 0.7	4.1 ± 0.4	4.1 ± 0.6[a, c]	
Leg (Kg)				
Pre	10.9 ± 1.4	11.1 ± 1.2	11.2 ± 1.5	0.028
Post	10.6 ± 1.3	11.0 ± 1.0	11.6 ± 1.6	
After 6-months	10.5 ± 2.2	10.9 ± 1.1	11.2 ± 1.6[b]	
After 1-y	10.6 ± 2.5	11.0 ± 0.9	11.4 ± 1.5	
Trunk (Kg)				
Pre	15.7 ± 1.6	15.7 ± 1.9	16.0 ± 2.0	0.948
Post	16.0 ± 2.0	16.2 ± 2.0	16.6 ± 2.1[a]	
After 6-months	15.7 ± 2.1	16.1 ± 1.7	16.4 ± 2.3	
After 1-y	15.8 ± 1.7	16.1 ± 1.9	16.5 ± 2.0	
Total LM (Kg)				
Pre	33.6 ± 3.6	34.0 ± 3.3	34.4 ± 4.1	0.027
Post	33.6 ± 3.8	31.7 ± 7.0	35.4 ± 4.3	
After 6-months	33.1 ± 7.9	34.2 ± 3.0	34.6 ± 4.4	
After 1-y	33.5 ± 3.3	34.4 ± 3.1	35.2 ± 4.0	
Bone mass				
Total BMC (Kg)				
Pre	2.0 ± 0.54	2.4 ± 0.13	2.3 ± 0.34	0.875
Post	2.0 ± 0.54	2.3 ± 0.15	2.2 ± 0.34	
After 6-months	2.0 ± 0.56	2.4 ± 0.18	2.2 ± 0.36	
After 1-year	2.0 ± 0.52	2.3 ± 0.15	2.2 ± 0.35	
BMD (g/cm^2)				
Pre	1.042 ± 0.18	1.140 ± 0.06	1.093 ± 0.10	0.115
Post	1.035 ± 0.17	1.137 ± 0.06	1.102 ± 0.01	
After 6-months	1.035 ± 0.17	1.138 ± 0.07	1.104 ± 0.10	
After 1-year	1.033 ± 0.16	1.146 ± 0.07	1.100 ± 0.10	

Abbreviations: AT, aerobic training; BMC, bone mass content (Kg); BMD, bone mineral density (g/cm^2); CG, control group; CT, concurrent training; LM, lean mass. [a]Tukey's *post hoc* test with *P*-value < 0.05 compared with Pre. [b]Tukey's *post hoc* test with *P*-value < 0.05 compared with Post. [c]Tukey's *post hoc* test with *P*-value < 0.05 compared with that after 6 months.

significant differences between groups or interactions for Chol, HDL-c and LDL-c ($P > 0.05$).

There were no main effects of time ($P = 0.118$) or group ($P = 0.603$) for insulin. For leptin there were no main effects of time ($P = 0.896$) or differences between groups ($P = 0.379$). For adiponectin there were no main effects for time ($P = 0.661$) or group ($P = 0.294$). For PAI-1 there were no main effects for time ($P = 0.780$) or group ($P = 0.673$). There were no statistical interactions (time x group) for any metabolic variable (Table 4).

The linear regression analysis (after 1 year follow-up value minus post-intervention value) showed that trunk fat influenced the changes observed for insulin only in CT group ($r = 0.48$; $P = 0.025$).

For adiponectin, the linear regression analysis showed that the variation was influenced by changes in total fat mass after 1 year follow-up in CT group only ($r = 0.50$; $P = 0.025$). There were no statistically significant associations between body composition, leptin, PAI-1 and lipid profile.

DISCUSSION

The main findings of this study were that 16 weeks of AT and CT improved body composition and some measures of the metabolic profile; however, after 6 months of detraining, LLM returned to pre-training in values CT. Furthermore, AT and CT decreased glucose, and TAG was decreased in the AT group below baseline after 1 year of cessation of exercise training.

Several studies have investigated the effects of aerobic and CT with a short-term detraining (4–8 weeks)[26,27] or moderate-term detraining (3–6 months)[28] in women, however, little is known about the effects of long-term detraining (⩾1 year) after in postmenopausal women. Contrary to our results, previous studies have reported a maintenance of fat mass and weight after detraining periods;[26,29] however, the detraining period in the aforementioned studies was of a shorter duration. Exercises that are able to prevent fat mass regain during detraining periods are important for elderly populations because the elderly are most likely to experience interrupts in exercise programs due to hospitalizations, sickness, disabilities, periods of vacations and travel.[26]

We found that AT and CT improved total and appendicular LM; however, LLM decreased following 6 months of detraining. A decrease in LM due to the lower number and size of muscle fibers and a decrease in innervated muscle fibers leads to decrease in strength and functional capacity, and increases the risk of falls and resultant fractures, difficulties during activities of daily living, and can result in diseases such as sarcopenia and osteoporosis.[30] As lean body mass is an important indicator of

mortality,[31] treatments that attenuate or prevent the loss of LM and bone mass are important during the postmenopausal period.[32]

Table 4. Comparison on the metabolic profile after 6 months and 1-year follow-up

Variables	*CG (n = 8)*	*AT (n = 8)*	*CT (n = 15)*	*Time x Group*
Glucose (mg/dL)				
Pre	97.8 ± 32.8	94.5 ± 26.0	89.1 ± 13.4	0.879[a, b]
Post	96.6 ± 20.3	90.5 ± 17.3	88.7 ± 11.4	
After 6 months	93.0 ± 11.9	85.8 ± 11.7	89.6 ± 15.5	
After 1 year	97.9 ± 16.6	81.9 ± 5.3	86.0 ± 13.1	
TAG *(mg/dL)*				
Pre	145.2 ± 62.9	98.6 ± 33.5	125.3 ± 57.6	0.765[b]
Post	129.7 ± 72.5	121.6 ± 63.5	118.5 ± 72.8	
After 6 months	112.6 ± 47.9	87.3 ± 30.4	119.8 ± 55.7	
After 1 year	144.7 ± 77.2	83.0 ± 26.4	106.8 ± 67.1	
Chol (mg/dL)				
Pre	205.5 ± 32.0	198.9 ± 38.3	203.3 ± 32.0	0.912
Post	202.4 ± 40.4	196.2 ± 38.9	200.3 ± 35.0	
After 6 months	188.1 ± 27.5	176.8 ± 24.6	194.2 ± 31.9	
After 1 year	190.1 ± 37.1	189.3 ± 28.4	201.8 ± 31.5	
HDL-c (mg/dL)				
Pre	51.6 ± 14.1	58.1 ± 12.9	53.3 ± 16.0	0.900
Post	50.4 ± 16.2	61.2 ± 12.7	59.2 ± 17.8	
After 6 months	49.9 ± 16.4	60.1 ± 6.1	53.9 ± 16.1	
After 1 year	54.9 ± 25.1	61.4 ± 12.8	55.6 ± 15.9	
LDL-c (mg/dL)				
Pre	125.0 ± 34.0	121.2 ± 35.2	125.0 ± 27.9	0.594
Post	126.0 ± 27.9	111.2 ± 30.7	116.1 ± 31.7	
After 6 months	115.6 ± 29.0	99.1 ± 29.0	116.4 ± 27.2	
After 1 year	106.3 ± 30.8	111.4 ± 31.2	124.8 ± 26.1	
Insulin (μIU/ml)				
Pre	–	5.84 ± 2.7	5.25 ± 1.7	
Post	–	5.00 ± 3.6	5.40 ± 5.6	0.472
After 6 months	–	–	–	
After 1 year	–	7.00 ± 2.3	7.03 ± 3.6	
HOMA-IR				
Pre	–	1.47 ± 1.1	1.15 ± 0.5	
Post	–	1.16 ± 0.9	1.23 ± 1.3	0.714
After 6 months	–	–	–	
After 1 year	–	1.42 ± 0.5	1.41 ± 0.9	
Leptin (ng/mL)				
Pre	94.2 ± 59.8	100.6 ± 48.0	74.7 ± 36.4	
Post	–	83.9 ± 23.3	81.1 ± 36.2	0.587
After 6 months	–	–	–	
After 1 year	–	101.5 ± 43.0	78.5 ± 34.7	
Adiponectin (ug/mL)				
Pre	8.4 ± 4.7	11.6 ± 1.8	10.9 ± 3.5	
Post	–	11.8 ± 0.9	11.0 ± 2.5	0.984
After 6 months	–	–	–	
After 1 year	–	12.3 ± 0.4	11.2 ± 2.3	

Our findings are consistent with the results of the Delshad *et al.*[26] that examined the effect of 12 weeks of resistance exercise training (three sets of 10 repetitions and 80–100% 10-RM), three times a week followed by 4 weeks of detraining, on muscle mass in postmenopausal women and reported that these values were maintained after the detraining period. Melnyk *et al.*[33] investigated the effects of 9 weeks of strength training on regional muscle area in young and older men and women (20–30 years old and 65–75years old) following 31 weeks of detraining and found that strength training induced increases in cross-sectional area of the quadriceps, but after the detraining period these values returned to baseline. In agreement, Correa *et al.*[34] analyzed knee extensors, elbow flexor muscle strength, rectus femoris muscle volume and functional performance in older female adults after 12 weeks of strength training followed by 1 year of detraining and then 12 weeks of retraining. Detraining resulted in a decrease in strength and muscle volume and these parameters were increased after retraining, reiterating that it is important not only to encourage people to start a training program but also to encourage these participants to maintain the exercise program.

In regard to the metabolic profile, plasma glucose was decreased in CT and AT when compared with CG, and TAG was reduced in the AT group in comparison with CG. The hyperglycemic state is a strong indicator of lower insulin sensitivity, and it has been reported that 40% of the population with diminished glucose tolerance develops type 2 diabetes mellitus in 5–10 years.[35] After 1 year follow-up, glucose was reduced by 3% in CT and by 9.5% in AT group when compared with post-intervention period. Insulin-mediated glucose uptake by skeletal muscle is directly related to total muscle mass and inversely associated with fat mass,[36] which is in accordance with our results as we found a strong negative relationship between LM and plasma glucose. The AT and CT groups likely increased glucose uptake via enhanced insulin receptor signaling, messenger RNA expression of the glucose transporter (GLUT-4) and the enzymatic activity of glycogen synthase.[37]

Regular and acute physical exercise promotes a decrease in TAG concentrations.[38] This outcome occurs because physical training promotes a decrease in adipose tissue, especially central adiposity, which is an important source of fatty-free acids to TAG secretion in overweight/obese people.[39] The results of a recent study suggest that exercise can augment VLDL-TAG affinity for LPL, thereby, delivering more TAG toward peripheral tissues for metabolism, which decreases its concentration in plasma.[40]

HDL-c was increased and LDL-c was decreased following 16-weeks of training for CT and AT groups; however, there were no significant differences between groups and after 6 months of detraining HDL-c returned to baseline values. A reduction in HDL-c

Table 4. (Continued)

Variables	*CG (n = 8)*	*AT (n = 8)*	*CT (n = 15)*	*Time x Group*
PAI-1 (ng/ml)				
Pre	26.6 ± 22.7	12.7 ± 4.8	17.7 ± 19.6	
Post	–	15.5 ± 5.2	15.9 ± 6.4	0.917
After 6 months	–	–	–	
After 1 year	–	18.0 ± 15.6	20.3 ± 20.5	

Abbreviations: AT, aerobic training; chol, total cholesterol; CG, control group; CT, concurrent training; HDL-c, high-density lipoprotein cholesterol; HOMA-IR, homeostatic model assessment-insulin resistance; LDL-c, low-density lipoprotein cholesterol concentration; PAI-1, plasminogen activator inhibitor-1; TAG, triacylglycerol. [a]Statistically significant differences between CT and CG groups. [b]Statistically significant differences between AT and CG groups.

and increase in LDL-c increases the risk of developing cardiovascular diseases as the fractions of LDL cholesterol are more susceptible to oxidation and cause greater accumulation in the arterial wall,[41] and the HDL-c fractions perform reverse cholesterol transport.[42] Studies have demonstrated that systematic exercise could increase levels of apo-A1 that protects the arterial walls, and could decrease levels of apo-B that promotes atherosclerosis.[43] Among the inhibitory factors, the rapid acting PAI-1 is one of the most important inhibitors of the plasma fibrinolytic activity,[44] and its expression is significantly enhanced in a variety of clinical conditions such as old age, obesity, insulin resistance and increased inflammation.[45] Despite training, we did not find a significant difference in PAI-1 between pre-training or post-training.

The limitations of this study need to be considered when interpreting the findings. The follow-up time may have been insufficient to verify differences between groups and 16 wks of training may have been insufficient to improve BMD, as one study demonstrated positive effects in this variable only after 12 months of training;[46] thus, we recommend future studies analyze the time-course of CT detraining at more frequent intervals. In addition, the few number of participants in each group after detraining and the differences in body composition results are expected with different energy expenditures, which may be related not only to the type of exercise but also with the energy expenditure associated. In addition, future studies should investigate functional capacity, hemodynamics and performance following detraining.

Despite these limitations, it should be highlighted that this study controlled for dietary intake and free-living PA during the 1 year follow-up to minimize the influence of these variables on the outcomes. Although the tri-axial accelerometer was used to provide a measurement of free-living PA of the participants, the accelerometer is known not to measure all PA, as it underestimates activity conducted primarily above the waist, such as sweeping or carrying a load, and it is possible that these activities could have been used frequently by the participants, especially as 62.5% were retired. Anjos *et al.*[47] investigated the PA level in 1689 men and women of different ages, through 24- h recall, and observed that most of the participants met the 30 min of PA recommended by the ACSM;[48] however, the men accumulated greater moderate to vigorous activity during leisure activities and the women during domestic activities, suggesting that, these patterns could have influenced our results in relation to the gain in arm LM after 1-year follow-up.

In conclusion, both aerobic and CT similarly improved total and appendicular body composition and metabolic profile after 16 weeks of training and some of these values were maintained through the follow-up period; however, after 6 months of detraining there was reduction in LLM. Metabolic profile was influenced by body composition changes after 1 year follow-up and this may have been the result of differences in energy intake. Our results highlight the benefits of regular exercise and emphasize the importance of maintaining an exercise training program over a prolonged period in postmenopausal women.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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