Effects of Two Training Modalities on Body Fat and Insulin Resistance in Postmenopausal Women

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Effects of Two Training Modalities on Body Fat and Insulin Resistance in Postmenopausal Women

Sandra Henríquez,[1] Matías Monsalves-Alvarez,[1] Teresa Jimenez,[1] Gladys Barrera,[1] Sandra Hirsch,[1] María Pia de la Maza,[1] Laura Leiva,[1] Juan Manuel Rodriguez,[1] Claudio Silva,[2] and Daniel Bunout[1]

[1]*Nutrition and Physical Activity Laboratory, Institute of Nutrition and Food Technology, University of Chile, Santiago, Chile; and* [2]*Imaging Service, Clínica Alemana, Santiago, Chile*

Abstract

Henríquez, S, Monsalves-Alvarez, M, Jimenez, T, Barrera, G, Hirsch, S, de la Maza, MP, Leiva, L, Rodriguez, JM, Silva, C, and Bunout, D. Effects of two training modalities on body fat and insulin resistance in postmenopausal women. *J Strength Cond Res* 31(11): 2955–2964, 2017—Our objective was to compare the effects of a low-load circuit resistance training protocol and usual aerobic training in postmenopausal women. Postmenopausal women with at least 1 feature of the metabolic syndrome were randomly allocated to a low-load circuit resistance training protocol or traditional aerobic training in a braked cycle ergometer. The intervention consisted in supervised sessions lasting 40 minutes, 3 times per week, during 6 months. At baseline and at the end of the intervention, fasting serum lipid levels, serum interleukin 6, C-reactive protein, 8 isoprostanes, and insulin resistance (assessed through QUICKI and HOMA-IR) were measured. Body fat was measured by double-beam X-ray absorptiometry and by computed tomography densitometric quantification at lumbar 3 vertebral level. Twenty-one women aged 58 (54–59) years were allocated to aerobic training and 21 women aged 55 (52–61) years were allocated to the low-load circuit resistance training protocol. Eighteen and 16 women in each group completed the 6 months training period. Women in both groups experienced significant reductions in blood pressure, total body, subcutaneous, and intraabdominal body fat. Reductions in total cholesterol and triacylglycerol levels were also observed. No changes in insulin resistance indexes, 8 isoprostanes, C-reactive protein, or interleukin 6 were observed in either group. No significant differences between treatment groups were observed in any of the measured parameters. We conclude that low-load circuit resistance training and aerobic training resulted in the same reductions in body fat and serum lipid levels.

Key Words metabolic syndrome, exercise, body composition

Introduction

Lifestyle modification is the mainstay of metabolic syndrome and insulin resistance management (4). However, the results of behavioral interventions are hampered by poor compliance and motivation of participants (25) and the long-term results depend on permanent adherence to dietary and physical activity prescriptions (21). Despite these limitations, behavioral treatments are as effective as pharmacological interventions to prevent the consequences of metabolic syndrome (30). Moreover, exercise is an effective intervention to reduce visceral fat, the most likely culprit of causing the unhealthy consequences of this syndrome (38).

A relevant aspect is the selection of the best training strategy to obtain metabolic benefits while maintaining a reasonable adherence. The usually accepted concept is that resistance training should improve muscle strength and eventually mass (6) and aerobic training should increase maximal oxygen consumption and improve cardiovascular risk factors (19). A combination of both types of exercise seems to be more effective than aerobic training alone to reduce visceral fat and insulin resistance (10). Moreover, circuit training may improve cardiovascular endurance and strength with short training sessions lasting 25–30 minutes (15).

The threshold to define high and low loads during resistance training has been set at 65% of 1 repetition maximum (RM). Resistance training performed with low loads may achieve similar gains in muscle strength and mass when compared with high loads (33). Also, this low-load strategy could even be more effective to reduce fat mass accrual and insulin resistance than continuous aerobic modalities of exercise (14). From a practical point of view, this form of training can be performed with low-cost implements such as dumbbells and elastic bands (37), can be

Address correspondence to Daniel Bunout, dbunout@inta.uchile.cl.

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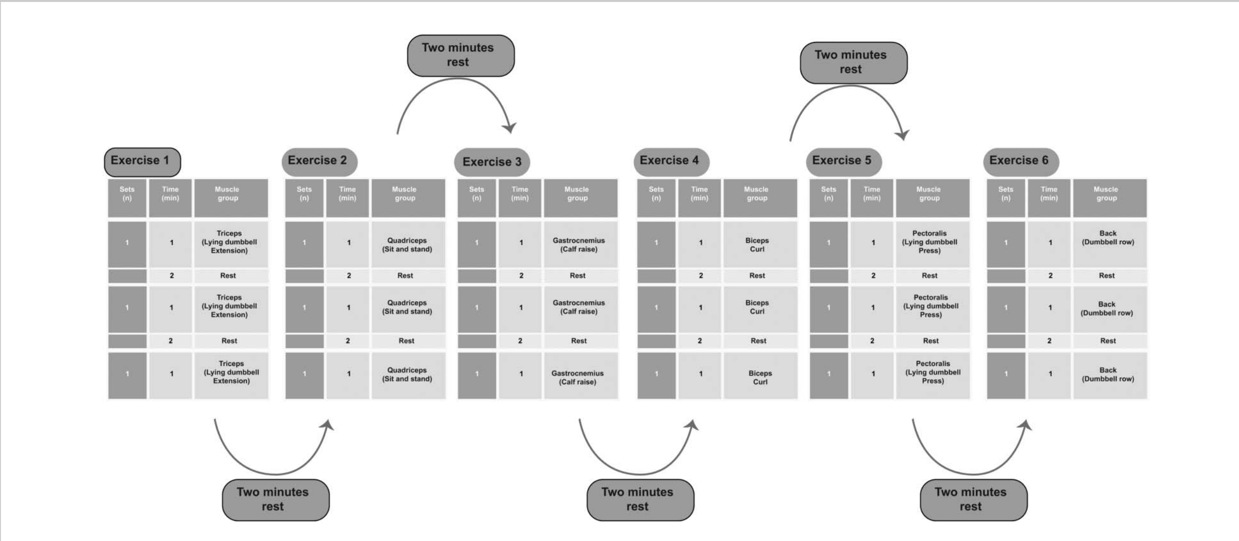

Figure 1. Low-Load Circuit Resistance Training (30%RM) sets, time and exercises, separated by each muscle group. On the first month, only 4 muscle groups where trained (triceps, quadriceps, gastrocnemius, and biceps). Back and pectoralis muscle exercises were added during the second month of training, until the end of the study. ANOVA = analysis of variance; RM = repetition maximum.

implemented in community centers, and can be used with primary care unfit patients with moderate obesity (with a body mass index under 33 $kg \cdot m^{-2}$) (32), who cannot access paid facilities. The American College of Sports Medicine has clearly defined the optimal training progression models to improve both strength and endurance (24).

However, which type of exercise is more efficient to reduce total and visceral fat, is not clear. Although there are studies showing that both low-load circuit (16) and aerobic training (8) are effective for this purpose, their direct comparison in a controlled trial is worthwhile.

Therefore, the aim of this study was to compare the effects of low-load circuit resistance training and aerobic training protocols, on aerobic capacity, fat mass, insulin sensitivity, serum lipid levels, and inflammatory markers in postmenopausal women with at least 1 feature of the metabolic syndrome. We hypothesized that, in sedentary participants, beneficial effects should be achieved, no matter which type of training is used. The main outcome sought in these women was a reduction in body fat with exercise.

Methods

Experimental Approach to the Problem

In a randomized trial, we compared the effects of 6 months of supervised aerobic and low-load circuit resistance training on body fat, insulin sensitivity, serum lipids in postmenopausal women.

Subjects

We invited sedentary women aged 45–60 years, living in the community to participate in the study. As inclusion criteria, the presence of at least 1 criterion to diagnose metabolic syndrome, according to the National Cholesterol Education Program guidelines (31), was required. We excluded women with diabetes mellitus, chronic kidney disease stage II or higher, cancer, cardiac or hepatic failure. We also excluded women taking beta-blockers, metformin, statins, antidepressants, or hormone replacement therapy, those with a history of excessive alcohol consumption or smokers and those that had any impediment to participate in exercise training sessions. The study was approved by the Institute of Nutrition and Food Technology Ethics Committee and Institutional Review Board. Signed informed consent was obtained from all subjects.

Procedures

Participants were cited after an overnight fast for assessment. After signing written informed consent explaining the risks and benefits of the protocol, an electrocardiogram was obtained to discard conditions that could predispose to arrhythmias during exercise training such as prolonged QT or Brugada syndrome (17). Afterward, they were subjected to the following assessments:

Clinical Assessent

Clinical history and physical examination including measurement of blood pressure, weight, height, waist circumference, and a questionnaire about usual physical activity (International Physical Activity Questionnaire or IPAQ) (23). Withdrawal of 3 fasting blood samples within 30 minutes, to calculate the Homeostasis Model Assessment (HOMA) (27) and Quantitative insulin sensitivity check index (QUIKI) (22) indexes of insulin resistance from glucose (measured using the hexokinase method) and insulin

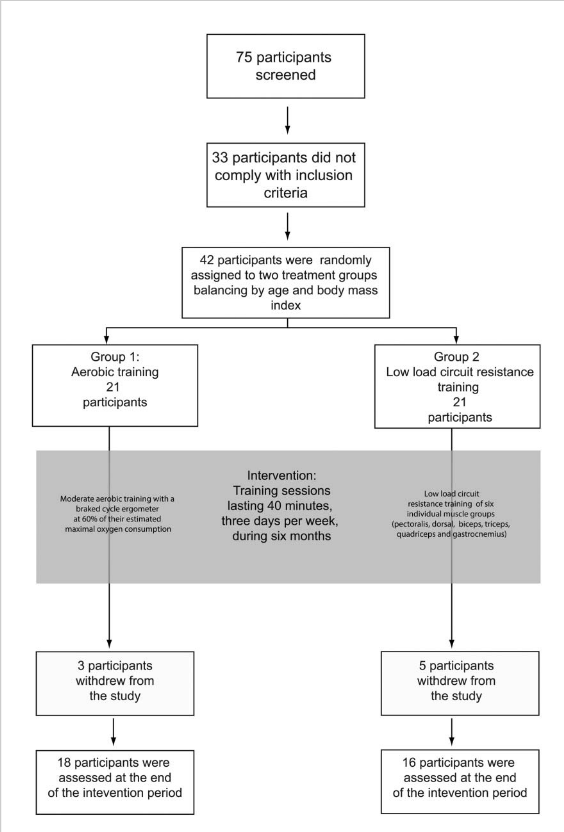

Figure 2. Participant flow.

levels (measured using an electrochemiluminescence immunoassay). Serum creatinine (measured using the Jaffe kinetic reaction), thyroid-stimulating hormone (measured using an electrochemiluminescence immunoassay), and serum lipids (measured using enzymatic methods) were also measured in 1 of the 3 blood samples. All determinations were performed in a clinical laboratory (Vida Integra), which is certified by local health authorities, reporting intraassay and interassay errors of less than 5% for all determinations. C-reactive protein was measured by ELISA using an ELISA DRG CRP kit, 8 isoprostanes were measured using an EIA kit by Cayman CHEMICAL and interlekin-6, using an IL-6 inmulite kit from Diagnostic Products Corporation, USA. The interassay precisions for C-reactive protein, 8 isoprostanes, and interleukin 6 measurements were 3.2, 9.6, and 5.4%, respectively.

Handgrip Strength Measurement

Handgrip strength was measured using a Therapeutic Instruments (Clifton, NJ, USA) dynamometer. Three measurements were made in each hand and the higher value obtained for each hand was recorded. The measurement error of this parameter in repeated assessments in the same individual was 8.7%.

Body Composition Assessment

Measurement of body composition by double-beam X-ray absorptiometry (DEXA) using a Lunar iDEXA equipment. Subjects were fasting at the moment of the examination and had a normal fluid intake the previous day. A normal hydration status was confirmed clinically, looking for the absence of dehydration signs, peripheral edema, or orthostatic hypotension. GE software version 13.6 was used. The measurement error of the method for body composition is 2.9% in our hands (13).

A single 1.5-mm image at the lumbar spine 3 level was obtained by multidetector computed tomography (CT) (model Definition AS+, Siemens, Munich, Germany). Subcutaneous and intraabdominal (visceral) fat areas were quantified using Slice O Matic software version 5.0 (Tomovision, Magog, Québec, Canada) using −190 Hounsfield Units (HU) and −20 HU as ranges for fatty tissue (20). A second 1.5-mm CT image was acquired at the mid dominant thigh to measure rectus femoris cross-sectional area, and quantified with −29 HU and 150 UH as limits for muscle tissue assessment. The interrater coefficient of variation of the method was less than 3%.

Indirect Calorimetry

Resting energy expenditure and submaximal oxygen consumption after an incremental test in a braked cycle ergometer were measured using a Sensormedics Vmax Encore 29 equipment. The incremental exercise test was started at a 15-watt ramp with 15-watt increases per minute until volitional exhaustion, with a cadence of 60 revolutions per minute. The test was stopped if the participant could not maintain the cadence after the stage change or if the respiratory exchange ratio exceeded 1.3 (3). A facemask was used to collect respiratory gases and the breath-by-breath method was used to measure oxygen consumption and CO_2 production. Peak oxygen consumption was determined at the moment in which the participant was not able to maintain the cycling cadence. Gross work efficiency was calculated as the ratio between work rate and energy expended in joules multiplied by 100, at submaximal work rates. Delta efficiency was calculated as the reciprocal of the slope of the linear relationship between energy expenditure and work rate, multiplied by 100 (28). The rho for concordance of 2 peak oxygen consumption measurements performed in the same individual, separated by 1 month was 0.8.

Intervention

After the baseline assessment, a general recommendation about healthy feeding habits was given to all participants. We recommended a diet providing 80% of total energy expenditure (calculated using measured resting energy expenditure as described before and the level of physical activity derived from IPAQ, which allows to calculate the amount of MET-minutes per week of activity). Carbohydrates, fat, and proteins provided 50, 25, and 25% of the total caloric

TABLE 1. Baseline clinical and body composition features of all participants included in the study.*

	Group 1 aerobic training ($n = 21$)	Group 2 low-load circuit resistance training ($n = 21$)	p†
Clinical and demographic variables			
Age (y)	58 (54–59)‡	55 (52–61)	NS
Weight (kg)	74.5 ± 7.6§	76.3 ± 7.7	NS
Body mass index ($kg \cdot m^{-2}$)	30.6 (28.2–32.3)	30.8 (29.1–33.8)	NS
Waist circumference (cm)	95.4 ± 5.6	96.7 ± 6.2	NS
Systolic arterial pressure (mm Hg)	124 ± 16	127 ± 14.3	NS
Diastolic arterial pressure (mm Hg)	79 ± 10.5	80 ± 8.2	NS
Right handgrip strength (kg)	23.7 ± 3.8	23 ± 5.3	NS
Left handgrip strength (kg)	21.5 ± 4.1	21.4 ± 4.5	NS
Body composition by DEXA			
Fat-free mass (kg)	38.8 ± 3.5	38.6 ± 3.4	NS
Fat mass (kg)	33.8 ± 5.2	35.5 ± 5.5	NS
Abdominal and thigh computed tomography quantification			
Total fat area (cm^2)	74.3 ± 18.1	79.1 ± 12.4	NS
Intraabdominal fat area (cm^2)	24.2 ± 7.1	22.6 ± 7.7	NS
Subcutaneous abdominal fat area (cm^2)	53.01 (35.4–58.9)	52.4 (46.5–59.9)	NS
Rectus femoris area (cm^2)	7.36 (6.71–7.76)	7.61 (6.16–8.53)	NS

*NS = nonsignificant.
†Probability of differences between groups.
‡Median (interquartile range).
§Mean ± standard deviation.

content of the diet, respectively. Diet was prescribed using local staple foods and using photographs to illustrate the portions recommended. Then, participants were randomly divided in 2 groups, balancing for age and body mass index, and were invited to supervised training sessions lasting 40 minutes each, 3 days per week. One group was subjected

TABLE 2. Baseline calorimetry and laboratory values of all participants included in the study.*

	Group 1 aerobic training ($n = 21$)	Group 2 low-load circuit resistance training ($n = 21$)	p†
Indirect calorimetry			
Resting energy expenditure ($Kcal \cdot d^{-1}$)	1,345 ± 175‡	1,364 ± 151	NS
Peak oxygen consumption ($mlO_2 \cdot kg^{-1} \cdot min^{-1}$)	11.7 ± 3.4	11.4 ± 2.9	NS
Peak load (Watt)	75 (65.5–93)§	75 (70–90)	NS
Gross work efficiency ($watts \cdot joules^{-1} \cdot s^{-1} \cdot 100$	27.3 (24.2–30.1)	26.3 (24.9–28.2)	NS
Delta efficiency (%)	35.9 (30.3–40.6)	35.2 (27.8–45.6)	NS
Laboratory values			
HOMA-IR index	2.4 (1.4–3)	2.2 (1.7–2.9)	NS
QUICKI index	0.34 ± 0.03	0.34 ± 0.02	NS
Total cholesterol ($mg \cdot dl^{-1}$)	216 ± 35	198 ± 27	NS
HDL cholesterol ($mg \cdot dl^{-1}$)	52 (43–62)	57 (52–68)	NS
Triglycerides ($mg \cdot dl^{-1}$)	132 (112–159)	97 (84–141)	NS
Interleukin 6 ($pg \cdot ml^{-1}$)	7.5 (1.5–15.2)	14.7 (6.4–22.6)	NS
C-reactive protein ($mg \cdot L^{-1}$)	3.1 (1.45–8.4)	7.1 (1.94–9.7)	NS
8 isoprostanes ($pg \cdot ml^{-1}$)	13.2 ± 4.4	14.7 ± 5.9	NS

*NS = nonsignificant; HDL = high density lipoprotein.
†Probability of differences between groups.
‡Mean ± standard deviation.
§Median (interquartile range).

Table 3. Changes in clinical and body composition parameters among participants who completed the intervention period.*

	Group 1 aerobic training ($n = 18$)		Group 2 low-load circuit resistance training ($n = 16$)		
	Baseline	End	Baseline	End	Repeated series ANOVA†
Clinical variables					
Weight (kg)	75 ± 7.9‡	71.8 ± 8.2	77.1 ± 8.3	74 ± 7.7	Intervention effect $p < 0.01$
Waist circumference (cm)	96.1 ± 5.1	89.3 ± 7.3	96.5 ± 5.9	89.6 ± 6.2	Intervention effect $p < 0.01$
Systolic blood pressure (mm Hg)	124.3 ± 16.3	117.9 ± 14.6	127 ± 16.2	120.4 ± 18.3	Intervention effect $p < 0.01$
Diastolic blood pressure (mm Hg)	78.9 ± 10.7	75.2 ± 8.3	80.7 ± 8.8	74.4 ± 9.1	Intervention effect $p < 0.01$
Right handgrip strength (kg)	23.6 ± 4	23.3 ± 3.9	23.6 ± 5.6	24.1 ± 4.3	NS
Left handgrip strength (kg)	21 ± 4.2	20.8 ± 4.1	21.1 ± 4.2	21.8 ± 4.9	NS
Body composition					
Total fat-free mass (kg)	38.6 ± 3.6	38.4 ± 3.4	38.3 ± 3.6	38.3 ± 3.5	NS
Total fat mass (kg)	34.4 ± 5	31.6 ± 5.4	36.6 ± 5.7	33.7 ± 5.5	Intervention effect $p < 0.01$
Total abdominal fat surface (cm^2)	503.2 ± 117.6	465.1 ± 108.3	529.4 ± 83.9	489.6 ± 94.8	Intervention effect $p < 0.01$
Intraabdominal fat surface (cm^2)	160.4 ± 46.9	139 ± 39.6	148.1 ± 49.3	135.2 ± 45.2	Intervention effect $p < 0.01$
Subcutaneous abdominal fat surface (cm^2)	323.7 ± 90.8	304.6 ± 82.5	364.2 ± 77	338.6 ± 70.1	Intervention effect $p < 0.01$
Rectus femoris surface area (cm^2)	7.3 (6.2–7.8)§	7.9 (6.8–8.4)	7.2 (6.1–8.2)	7.2 (6.5–8.3)	NS

*ANOVA = analysis of variance; NS = nonsignificant.
†Repeated series ANOVA analyzing the effect of intervention (regardless of the type of training), type of training effect or both.
‡Mean ± standard deviation.
§Median (interquartile range).

to a moderate aerobic training with a braked cycle ergometer at 60–65% of their estimated maximal oxygen consumption, continuously during 40 minutes (group 1). The other group (group 2) was subjected to a low-load circuit resistance training protocol, which was performed until voluntary exhaustion, considered as the moment when the range of motion could not be completed, on 6 individual muscle groups (pectoralis, dorsal, biceps, triceps quadriceps, and gastroctnemius) (2,39). At the beginning of the study, an indirect maximum strength test was performed to set the workload (10RM) (11). The 10RM test was carried out for all muscle groups except gastrocnemius and quadriceps, which were evaluated determining the number of self-weight lift repetitions performed in 1 minute. The later 2 muscle groups where trained in the same way that they were evaluated. The intensity was regulated by promoting to achieve as much repetitions as the participants were able to perform in the assigned time. For all the other evaluated muscle groups, the load was set at 20% of the 10RM obtained at the baseline evaluation for the first 2 weeks and then increased to 30% for the rest of the intervention. Each set of exercises consisted in 1-minute repetitions, with 2 minutes of rest and repeated 3 times for each muscle group (Figure 1) (1). During the first month, participants trained only 4 muscle groups (quadriceps, biceps, triceps and gastrocnemius). Pectoralis and dorsal muscles where included from the second month until the end of the intervention The training period lasted 6 months and was monitored and guided by one of the authors who encouraged daily participation by setting the time for work (1 minute), rest (2 minutes), and the circuit stations on each session. The trainer also encouraged the attendance to training sessions, educating participants about the health benefits of their activity and promoting social interactions between participants. The workload of both groups was increased along with the improvement in exercise capacity of participants. Heart rate,

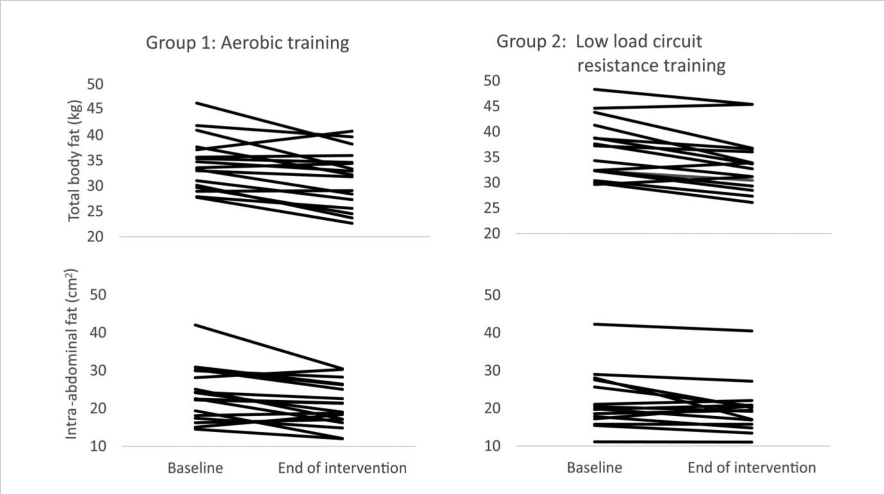

Figure 3. Graphical representation of changes in total body fat measured by double-beam X-ray absorptiometry and intraabdominal fat measured by computed tomography in both treatment groups. Each line represents 1 participant.

repeated 10RM measurements for each muscle group and Borg scale were used to adjust the progression of exercise intensity every month. Attendance to each training session was recorded to calculate compliance with the exercise program, which was calculated as the percentage of programmed sessions that each participant really attended. When participants completed 6 months of training, and within 1 week of finishing the last training session, all assessments done at baseline were repeated. During all the follow up period, a dietitian attended participants every 2 weeks, who performed a dietary survey determining the food intake in the previous 48 hours and quantified the compliance with dietary indications from 0 to 100%. The intervention was carried out during southern autumn and winter in 2 consecutive years.

Statistical Analyses

All participants who had the assessment at 6 months were included in the statistical analysis, regardless of their compliance with training sessions. Variable distribution was determined using the Shapiro-Wilk test. Normally distributed variables are expressed as mean ± *SD*, otherwise as median (interquartile range). Differences between normally distributed variables were analyzed using *t* Student's and differences between variables with a non-normal distribution were analyzed using Kruskal Wallis tests. Associations between parametric variables were determined using univariate or multivariate linear regression analyses. A mixed model repeated-measures analysis of variance, detecting between-subjects and within treatment effects was used to assess changes in parameters during the intervention period. A symmetric within-subjects covariance structure was assumed. A probability of 5% or less to reject the null hypothesis was considered significant. The sample size was calculated to detect a 20% difference in total fat mass between groups at the end of the intervention period.

Results

Participant flow is shown in Figure 2. We screened 75 participants and 42 met the inclusion criteria. Thus, 21 were randomized to aerobic training and 21 to a low-load circuit resistance training protocol. Eighteen participants with aerobic training and 16 with low-load circuit resistance training were assessed at the end of the intervention period. The baseline clinical, body composition, and laboratory features of participants admitted to the study are show in Tables 1 and 2. No significant differences were observed between groups. Fourteen participants in the aerobic training group and 13 in the low-load circuit resistance training group were classified as sedentary according the IPAQ. The questionnaire classified only 1 and 2 participants in each group as having a high physical activity.

During the intervention, participants reported no adverse events. Compliance with dietary prescription was similar in both study groups. Table 3 shows the changes in clinical and body composition parameters after the training period. Regardless of the type of training, participants lost weight, reduced their blood pressure, and lost fat mass measured by DEXA. There was also a significant reduction in abdominal total, subcutaneous, and intraabdominal fat areas measured by CT quantification (Figure 3). Handgrip strength and rectus femoris surface area did not change significantly. No significant differences were observed between treatment groups in parameter changes after the intervention.

Table 4 shows the changes in indirect calorimetry and laboratory parameters. There was a significant improvement in gross work efficiency and reduction in cholesterol and triglyceride levels in both groups. No significant changes were observed in insulin sensitivity, inflammatory, or oxidative stress parameters in both groups. No differences between groups were detected.

During the intervention period, compliance with training sessions was 45 ± 11.6 and 48.4 ± 8.7% in groups 1 and 2, respectively (p = NS). Compliance with dietary indications was 62.8 ± 17 and 62.2 ± 14% in groups 1 and 2, respectively (p = NS). On a secondary analysis, there was a significant association between compliance with training sessions and changes in gross work efficiency ($r = 0.50$, $p < 0.01$),

TABLE 4. Changes in calorimetry and laboratory parameters among participants who completed the intervention period.*

	Group 1 aerobic training ($n = 18$)		Group 2 low-load circuit resistance training ($n = 16$)		
	Baseline	End	Baseline	End	Repeated series ANOVA†
Indirect calorimetry					
Peak O_2 consumption ($mlO_2 \cdot kg^{-1} \cdot min^{-1}$)	11.4 (9.9–12.8)‡	13.5 (9.4–15.3)	10.7 (8.8–13.9)	12.5 (11–16.1)	NS
Gross work efficiency (watts·joules^{-1}·s^{-1}·100	26.6 (24.0–29.2)	30.7 (27.0–36.6)	26.6 (25–29.3)	29 (25.3–31.2)	Intervention effect $p < 0.01$
Delta efficiency (%)	32.7 (30.3–40.4)	38.2 (32.9–53.7)	33.7 (27.8–53.0)	35.6 (31.8–40.8)	NS
Laboratory values					
Total cholesterol (mg·dl^{-1})	221 (204–229)	216 (206–230)	206 (185–220.5)	197 (174–204.5)	Intervention effect $p < 0.01$
HDL cholesterol (mg·dl^{-1})	52.5 (44–69)	57.5 (50–65)	59 (51–69)	57 (53–70.5)	NS
LDL cholesterol (mg·dl^{-1})	132.5 (117.6–157.2)	135.7 (109.6–147.2)	125.3 (106.4–135)	112.7 (88.9–128.4)	Intervention effect $p < 0.01$
Triglycerides (mg·dl^{-1})	133 (112–159)	119 (95–169)	94 (83.5–135.5)	81.5 (73.5–112.5)	Intervention effect $p < 0.01$
HOMA-IR	2.5 (1.2–3.4)	2.4 (1.3–2.9)	2.2 (1.7–2.7)	2 (1.5–2.7)	NS
QUICKI	0.3 (0.3–0.4)	0.3 (0.3–0.4)	0.3 (0.3–0.4)	0.3 (0.3–0.4)	NS
Interleukin 6 (pg·ml^{-1})	7.5 (1.5–15.2)	8.8 (2.8–17)	14.7 (6.4–22.6)	13.6 (6.9–20.7)	NS
8 isoprostanes (pg·ml^{-1})	12.4 (9.4–15.7)	10.9 (9.9–14.3)	13.8 (11.1–17.3)	11.3 (8.8–16.5)	NS
C-reactive protein (mg·L^{-1})	3.1 (1.5–8.4)	4.2 (1.7–8.1)	4.2 (1.9–9.7)	2.9 (1.6–7.7)	NS

*ANOVA = analysis of variance; HDL = high density lipoprotein; LDL = low density lipoprotein; NS = nonsignificant.
†Repeated series ANOVA analyzing the effect of intervention, type of training effect or both.
‡Median (interquartile range).

total abdominal fat area ($r = -0.58$, $p < 0.01$), and subcutaneous fat area ($r = -0.46$, $p < 0.01$) in both treatment groups. Compliance with dietary indications was significantly associated with changes in total and subcutaneous fat areas ($r = 0.47$ and 0.42, respectively, $p = 0.01$). A multiple regression model showed that compliance with exercise and diet were both significantly and independently associated with changes in total and subcutaneous fat areas. In a sensitivity analysis, repeated-measures analysis of variance analyses were carried out dividing each exercise group in subgroups with a compliance with diet of 50% or more or less than 50%. The effect of exercise was not modified by the compliance with the diet. No significant associations were observed between changes in body fat, adherence to training sessions, or compliance with the diet with changes in HOMA or QUICKI.

Discussion

This study shows that a 6-month supervised and progressive exercise training program in postmenopausal women resulted in reductions of body fat, blood pressure, serum cholesterol, and an improvement in gross work efficiency, regardless of the type of training performed.

The main outcome of the study, namely the reduction of total, subcutaneous, and intraabdominal fat was accomplished in both training groups. There was also an effect of the diet on fat mass as demonstrated by the association between compliance with the dietary prescription and reduction in total fat mass and subcutaneous fat surface. We were able to show that both exercise and the diet had and independent effects on fat reduction. The fat reducing effect of exercise has been reported previously (29). Moreover, the reduction of intraabdominal fat is even more advantageous since this type of fat accrual is the responsible for most of the metabolic and circulatory adverse effects of obesity (12). Both aerobic and low-load circuit training followed the expected patterns of adaptation in fat mass and cardiorespiratory parameters.

Noteworthy is that classical aerobic training and low-load circuit resistance training resulted in similar dropout rates and compliance with training sessions and had the same effect of body fat. This is a novel finding and should help in decision making about exercise interventions for sedentary women. We are not aware of studies comparing both types of training in postmenopausal women. A recent meta-analysis showed that low-load circuit resistance training in older people leads to improvements in muscle strength but that the changes in aerobic capacity are not significant, as we also found (5). In a controlled trial performed in adolescents, no differences in body fat reduction were observed after 6 months of aerobic, resistance, or combined training. These participants were also advised to reduce their calorie intake (36). Thus, the argument that low-load circuit resistance training is more efficient and better tolerated that traditional aerobic training may not be true for participants similar to those studied by us. The vast majority of our participants were sedentary at baseline, according to the physical activity questionnaire. In these highly inactive populations, even minor exercise interventions have positive effects.

A desirable effect of training is to improve muscle efficiency, defined as the percentage of total energy expended that produces external work. In our participants, gross work efficiency improved in both groups; however, delta efficiency and peak oxygen consumption did not improve. Gross efficiency improvement is indicating a reduction in the energy cost of muscle work (9). Previous studies by Schumman et al. showed that performing endurance and strength training on alternative days was the most efficient means to increase both muscle efficiency and peak oxygen consumption (34). Therefore, it is worth testing this training modality. These same results have been reported previously, only using classical resistance training (18). Unfortunately, muscle mass measured either by DEXA or cross-sectional area of rectus femoris, did not increase in our participants. Despite the good results in terms of muscle strength or functional capacity, in previous studies with resistance training we have not been able either to elicit changes in muscle mass in older people of both genders (7).

Other unanticipated result of this trial was the lack of effect of training and subsequent reduction of body fat on insulin sensitivity and inflammatory markers. We measured insulin sensitivity with fasting glucose and insulin levels, using 3 blood samples to minimize errors. We have reported that although the method has a degree of variability, it has a good correlation with other assessment methods of insulin sensitivity such as the Matsuda index (26). This is especially true for the formula used to calculate the QUICKI index. Although most reports show that training and body fat reduction improve insulin sensitivity, this is not a universal finding (35). The lack of significant changes in inflammatory markers is not surprising because these parameters had great variability among our participants, and huge changes would have been necessary to detect significant differences. Other possibility is that the light weight lifting used in this study did not activate a very high number of motor units and part of the muscles remained unaffected by contractile exposure or adaptive needs.

This study has the strength of assessing 2 modes of exercise training in controlled conditions, in groups of perfectly balanced participants and that could be performed in different care centers without expensive equipment. Training sessions were supervised by one of the authors to avoid any bias related to lack of adherence to the planned exercise protocols. Therefore, this work contributes to answer an important issue about the best modality of exercise in sedentary women to elicit positive health effects.

Practical Applications

In these highly sedentary populations, any type of exercise is useful insofar as it changes lifestyles. Therefore, exercise interventions should be planned based on the available resources and equipment and every effort must be made to maintain an adequate compliance with training sessions.

Acknowledgments

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