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Effect of a 1-year elastic band resistance exercise program on cardiovascular risk profile in postmenopausal women

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Abstract

Objective: The aim of this study was to investigate the effects of a 1-year progressive resistance training program using elastic bands on cardiovascular profile parameters in sedentary postmenopausal (>12 months' amenorrhea) women.

Methods: This longitudinal prospective experimental study included 38 menopausal women who were randomly divided into two groups: an intervention group (IG, n = 18), who completed a progressive resistance training program with elastic bands over the course of 12 months (six exercises for whole body training, three sets × 10 repetitions), and a control group (CG, n = 20) that did not perform any training. Blood analysis and body composition were determined at baseline and 1 year after intervention.

Results: After the 1-year training program, weight, waist circumference, total cholesterol, low-density lipoprotein cholesterol, and C-reactive protein showed a decrease compared with baseline values in the IG, showing a significant ($P < 0.05$) improvement in cardiovascular profile. Very-low-density lipoprotein, high-density lipoprotein, and triglycerides showed a nonsignificant ($P > 0.05$) improvement. The CG increased significantly in weight and waist circumference, whereas the rest of the variables remained unchanged.

Conclusion: One year of progressive resistance training with elastic bands has beneficial effects on anti-inflammatory and anthropometric cardiovascular risk factors in menopausal women, including changes in lipid profile.

Key Words: Body composition – C-reactive protein – Resistance training.

Menopause represents a critical period in a woman's life which marks an increase in the risk of cardiovascular disease (CVD).[1] This increase in CVD risk is a consequence of a series of physical, hormonal, and reproductive changes[2] that promote chronic low-grade inflammation, endothelial dysfunction, weight gain, and increased intra-abdominal fat, sedentary lifestyle, increased blood pressure, increased insulin resistance, and a more atherogenic lipid profile.[3]

Abdominal obesity is the fundamental clinical manifestation of this syndrome. In fact, waist circumference (WC) has been consistently associated with risk markers.[4,5] Recently, it has been suggested that new inflammatory biomarkers be added to metabolic syndrome due to their pathological influence, with the concentration of C-reactive protein (CRP) being of particular note.[5] This marker, nonspecific in inflammatory processes, increases with age, and is associated with incidental cardiovascular disease[6] and death.[7]

Physical exercise, specifically strength training, has a positive influence on cardiometabolic risk in menopausal women.[8,9] It should be considered a key tool in the management of CVD risk in menopausal women.[10,11] Its benefits at the metabolic and cardiovascular level have been shown to be coadjuvant in the reduction of cardiovascular risk.[12] In recent years, strength training has gained greater interest in clinical and research settings due to the benefits reported in menopausal women, including improvement in cardiovascular profile.[9,13-15] A large proportion of menopausal women do not perform physical exercise, and the possibility of carrying out a strength-training program with auxiliary elements such as elastic bands could be relevant, given that it could be done at home. However, there is little information on the effects of strength training on cardiovascular parameters in postmenopausal women. Consequently, the objective of the present study was to determine the effects of a structured, progressive strength-training program consisting of resistance band exercises on the cardiovascular risk profile of menopausal women.

METHODS

Study design and sample

The present work is a longitudinal prospective experimental research study. All procedures performed in this study were in accord with the ethical standards of institutional and

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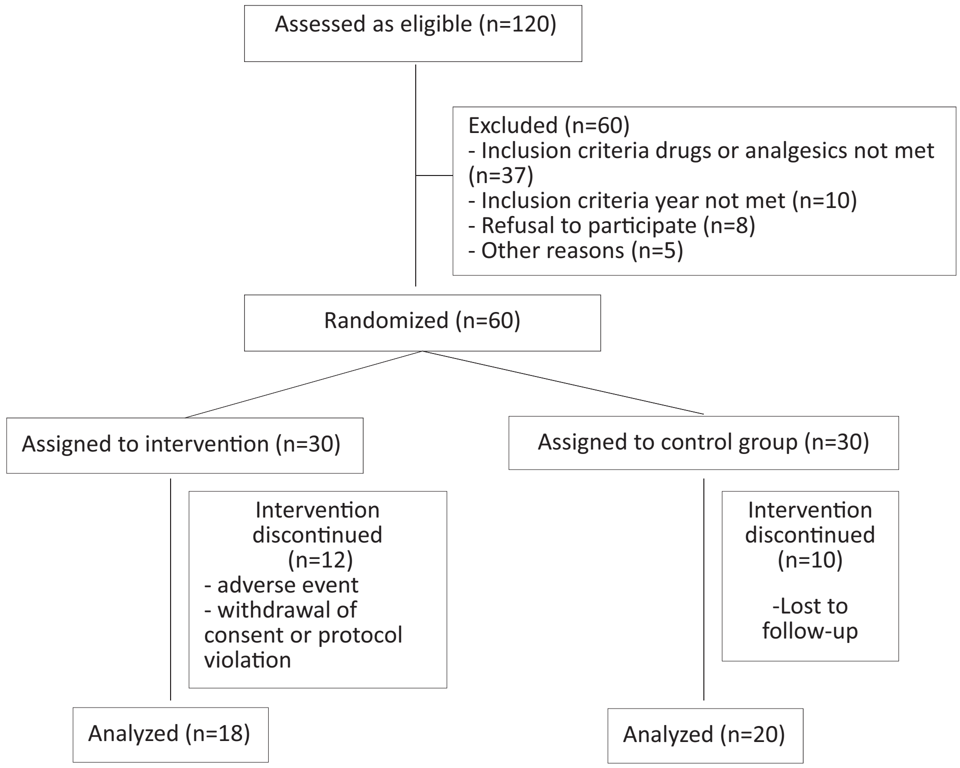

FIG. 1. Flow diagram of participants.

national ethics committees, the Declaration of Helsinki of 2013, and pertinent Spanish law. The experimental protocol was approved by the ethics committee of Dr Peset University Hospital in Valencia, Spain (Ceic code: 99/12) and the Research Ethics Committee of San Antonio Catholic University of Murcia. The study was carried out from 2013 to 2014 in the Department of Physiotherapy at the University of Valencia. Study volunteers were recruited from the general population through advertisement in the Department of Obstetrics and Gynecology at Dr Peset University Hospital. All participants were postmenopausal women. Participants were also provided with information about the study's objectives, methods, estimated benefits, and possible risks and inconveniences derived from the experiment. They were able to ask questions about the experimental protocol to clarify any doubts. Finally, informed consent was obtained from all participants included in the study. Diagnostic tests and blood sample collection were performed at Dr Peset University Hospital in Valencia, always by the same faculty.

An a priori power analysis was conducted in G*Power software (version 3.1.9.2) to calculate the sample size. Assuming an analysis of variance (ANOVA) of repeated measurements, a medium effect size ($f = 0.25$; $\eta_p^2 = 0.06$), $\alpha = 0.05$, power $= 0.95$, and correlation among repeated measurements of 0.5, the total sample size required is 54 participants.

The initial study population was made up of 120 women with an age range of 65 to 79 years. Sixty women were selected as meeting all inclusion criteria to participate in the study. The participants were then randomly divided into two groups (intervention group [IG, n = 30] and control group [CG, n = 30]) using computer-generated random binary numbers (1 = intervention, and 0 = control). CG did not take part in any structured physical activity. Thirty-eight women completed the study and 22 women dropped out of the study because of failure to follow-up, adverse event, withdrawal of consent, or protocol violation (Fig. 1).

The inclusion criteria were as follows: age 65 years or older; in the postmenopausal period (defined as $\geq$12 months without menstruation); body mass index (BMI) between 19 and 39; not taking nonsteroidal anti-inflammatory drugs or analgesics; not having clinical signs of illnesses which could prevent them from performing physical activities. The initial characteristics of the studied sample are summarized in Table 1. Exclusion criteria were as follows: undergoing hormone therapy (HT); suffering any pathology contraindicated with the performance of physical exercise, such as uncontrolled hypertension, diabetes, hypercholesterolemia, or a history of cancer.

TABLE 1. *Characteristics of the intervention and control groups*

	IG (n = 18)	CG (n = 20)	*P* [95% CI]
Age, y	70.89 (4.42)	70.45 (5.44)	0.79 [−2.85, 3.72]
Menopausal age, y	48.89 (5.42)	48.45 (4.74)	0.79 [−2.90, 3.78]
Height, cm	158.07 (5.27)	156.10 (5.45)	0.27 [−1.57, 5.50]
BMI, kg/m^2	28.72 (4.48)	30.16 (5.57)	0.39 [−4.80, 1.90]

Data are expressed as mean (standard deviation).
BMI, body mass index; CG, control group; CI, confidence interval; IG, intervention group.

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Biochemical analysis

Blood samples were collected between 7:00 and 9:00 AM after 12 hours of night-time fasting, and participants did not exercise in the 24 hours before collection. The protocols established by the hospital were followed for the proper extraction and storage of the blood samples. From the samples, the following were analyzed: total cholesterol, high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), very-low-density lipoprotein cholesterol (VLDL-C), triglycerides, ultrasensitive CRP. Normal values were established at[16,17] total cholesterol <200 mg/dL or 5.17 nmol/L, HDL >65 mg/dL or 1.55 nmol/L, LDL <150 mg/dL or 2.59nmol/L, and triglycerides <150 mg/dL or 0.45 nmol/L. For ultrasensitive CRP, the value was 1.0 mg/dL.

Waist circumference

Waist circumference was measured after several consecutive natural breaths, parallel to the floor, at the midpoint between the top of the iliac crest and the lower margin of the last palpable rib in the mid-axillary line. The data were analyzed using cut-off points for white (94 cm in men and 80 cm in women) and Asian (90 cm in men and 80 cm in women) individuals.[4]

Training protocol

The strength training program consisted of six exercises which involved the major muscle groups. The exercises were performed with an elastic resistance band (Thera Band) following the considerations that have been previously published.[18] Three phases of 4 months each were established. The load and intensity of the exercises were progressive throughout the different phases. The intensity for each phase was established according to the subjective perception scale[19,20] based on the perceived exertion scale with Thera Band OMNI-Resistance exercise bands (OMNI-RES),[21,22] as show in Table 2.

Exercises were performed 3 days per week (M-W-F) and each session lasted 50 minutes. The exercise technique was in accordance with previously described protocols and guidelines.[18,23] Ten repetitions of each exercise were performed at a cadence of 1 second for the concentric phase and 1 second for the eccentric phase. To control the exercise speed, a metronome set to 60 beats per minute was used. Each set of 10 repetitions was performed three times. A rest period of 90 seconds was allowed between sets. The intensity of the exercise was adjusted based on the participant's perceived exertion, applying scaling and anchoring procedures to the *Omni Perceived Exertion for resistance training* (OMNI-RES) pictogram.[24] Participants were asked to report their perceived exertion in their body and in the active muscle upon completing each exercise. If the desired intensity was not reached or was exceeded, the woman was instructed to adjust the resistance band to alter the intensity of the exercise. In this way, all training sessions were monitored by the principal investigator, who ensured the exercises were correctly executed with the appropriate intensity.

TABLE 2. *Planning of the intervention, load, and intensity of the resistance band training in each phase of the study*

Phase, mos	OMNI-RES[a]	Thera band color	Resistance in kg (100% elongation)
1 (1-4)	3-4	Yellow	1.5
2 (5-8)	5-6	Red	2
3 (9-12)	6-7	Green	2.5

OMNI-RES, OMNI-Resistance exercise bands.
[a]Omni perceived exertion for resistance training.

Statistical analysis

Data analysis was performed using the statistics package SPSS version 24 for Windows (SPSS Inc., Chicago, IL, with license from the University of Valencia). The normality of the data was checked using the Kolmogorov-Smirnov test with the Lilliefors correction. Descriptive variables from both groups were compared using an unpaired *t* test. To evaluate the effect of the intervention on weight, waist circumference, and biochemical variables, a two-factor ANOVA (pre-post [2] × group [2]) with repeated measurements in the pre-post factor was performed. Post hoc analysis with the Bonferroni correction was used in the case of significant differences in the ANOVA models. In addition, effect size was calculated using partial eta-squared (η_p^2) interpreted as small ($\eta_p^2 = 0.01$), medium ($\eta_p^2 = 0.06$), and large ($\eta_p^2 = 0.14$). Data were presented as mean (standard deviation). The significance level alpha was set at $P < 0.05$.

RESULTS

Nonsignificant differences were found in participant characteristics, indicating that both groups were comparable in terms of age, menopausal age, height, and BMI (Table 3).

The ANOVA analysis showed that, at baseline, there were no statistically significant differences between the CG and IG groups for any variable ($P > 0.05$). After the 1-year training program, weight, waist circumference, total cholesterol, LDL-C, and CRP showed a decrease compared with baseline values in the IG ($P < 0.05$). The decrease was 1.31 (1.49) kg in weight, 2.67 (2.61) cm in waist circumference, 15.72 (46.47) mg/dL in total cholesterol, 16.77 (41.74) mg/dL in the LDL-C, and 0.81 (1.78) mg/L in the CRP. The effect size was medium ($\eta_p^2 = 0.107$) in total cholesterol and large ($\eta_p^2 > 0.14$) in the other variables. On the contrary, no significant differences were found in HDL-C, VLDL-C, or triglycerides ($P > 0.05$). Regarding the CG, when comparing pre-post periods, weight and waist circumference increased significantly ($P < 0.001$, large effect size), whereas the rest of the variables remained unchanged. Finally, postintervention, the between-group analysis showed differences in waist circumference ($P = 0.012$, $\eta_p^2 = 0.163$), VLDL-C ($P = 0.032$, $\eta_p^2 = 0.122$), triglycerides ($P = 0.038$, $\eta_p^2 = 0.114$), and CRP ($P = 0.019$, $\eta_p^2 = 0.143$), with the CG having higher values.

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TABLE 3. *Results of the comparison for the different variables studied*

	Pre	Post	P^a [95% CI]; η_p^2
Weight, kg			
CG	73.32 (12.83)	75.88 (12.35)	<0.001[b] [1.76, 3.36]; 0.539
IG	71.55 (9.92)	70.24 (9.35)	0.003[b] [−2.15, −0.46]; 0.215
P^c [95% CI]; η_p^2	0.64 [−9.37, 5.84]; 0.006	0.13 [−12.90, 1.64]; 0.064	
Waist circumference, cm			
CG	102.67 (12.06)	105.97 (11.32)	<0.001[b] [2.14, 4.45]; 0.482
IG	99.66 (8.73)	96.99 (9.35)	<0.001[b] [−3.89, −1.45]; 0.355
P^c [95% CI]; η_p^2	0.39 [−10.00, 3.99]; 0.021	0.012[b] [−15.85, −2.10]; 0.163	
Cholesterol, mg/dL			
CG	205.35 (32.32)	207.50 (31.75)	0.77 [−12.40, 16.70]; 0.002
IG	222.72 (42.88)	207.00 (34.77)	0.045[b] [−31.06, −0.39]; 0.107
P^c [95% CI]; η_p^2	0.16 [−7.46, 42.20]; 0.053	0.96 [−22.38, 21.38]; <0.001	
HDL-C, mg/dL			
CG	57.80 (12.84)	57.85 (13.67)	0.98 [−3.13, 3.23]; <0.001
IG	60.56 (17.06)	63.39 (12.43)	0.09 [−0.52, 6.19]; 0.075
P^c [95% CI]; η_p^2	0.56 [−7.12, 12.63]; 0.009	0.20 [−3.09, 14.17]; 0.045	
LDL-C, mg/dL			
CG	126.30 (28.21)	128.40 (26.34)	0.75 [−10.96, 15.16]; 0.003
IG	142.54 (35.86)	125.78 (33.15)	0.018[b] [−30.53, −3.01]; 0.145
P^c [95% CI]; η_p^2	0.13 [−4.87, 37.36]; 0.063	0.79 [−22.23, 16.98]; 0.002	
VLDL-C, mg/dL			
CG	20.95 (6.26)	21.25 (5.57)	0.85 [−2.92,3.52]; 0.001
IG	19.11 (14.05)	17.22 (5.52)	0.27 [−5.29,1.51]; 0.034
P^c [95% CI]; η_p^2	0.60 [−8.87, 5.19]; 0.008	0.032[b] [−7.68,−0.37]; 0.122	
Triglycerides, mg/dL			
CG	106.60 (31.55)	108.50 (30.90)	0.81 [−13.59, 17.39]; 0.002
IG	96.94 (69.81)	87.72 (28.40)	0.26 [−25.55, 7.11]; 0.035
P^c [95% CI]; η_p^2	0.58 [−44.69, 25.38]; 0.009	0.038[b] [−40.38, −1.18]; 0.114	
CRP, mg/L			
CG	4.05 (2.73)	4.40 (2.58)	0.23 [−0.23, 0.92]; 0.040
IG	3.35 (1.61)	2.54 (2.02)	0.010[b] [−1.41, −0.20]; 0.169
P^c [95% CI]; η_p^2	0.35 [−2.19, 0.79]; 0.025	0.019[b] [−3.39, −0.32]; 0.143	

Data are expressed as mean (standard deviation).
η_p^2, Partial eta squared; 95% CI, 95% confidence interval; CG, control group; CRP, C-reactive protein; HDL-C, high-density lipoprotein cholesterol; IG, intervention group; LDL-C, low-density lipoprotein cholesterol; VLDL-C, very-low-density lipoprotein cholesterol.
[a]Corresponds to the differences between pre and postevaluation.
[b]Indicates significant differences.
[c]Corresponds to the differences between IG and CG.

Due to the fact that the final sample size is smaller than what was initially calculated, a post hoc power analysis was performed based on the obtained effect sizes. The minimum effect size obtained in the variables with significant pre-post differences in the IG was $\eta_p^2 = 0.107$ (cholesterol). With this effect size, the final sample (38), and a correlation of 0.30 in pre-post cholesterol, the power was 0.94. On the contrary, for the maximum effect size in the IG ($\eta_p^2 = 0.355$), corresponding to waist circumference, the power was 1.0.

DISCUSSION

The main finding of this study was that postmenopausal women showed an improvement in body composition, CRP values, and changes in lipid profile after 1 year of progressive resistance training using elastic bands.

Improvement in the biochemical profile of menopausal women is a very important factor for reducing their risk of cardiovascular pathology. Physical exercise is one of the ways in which this improvement may be achieved. The objective of this study was to analyze the effects of a 1-year progressive resistance training program using elastic bands. For this reason, an analysis of CRP levels was considered to be of interest, given that it is a marker of inflammation that has been associated with the development of metabolic syndrome, high risk of cardiovascular disease, and sarcopenia in postmenopausal women.[25-28]

To date, the impact of physical exercise on inflammatory markers has been underestimated.[27] To explore this theory in greater depth, CRP levels were measured before and after the physical exercise program. In the pre-test, mean CRP values were recorded at 3.35 (1.61) mg/L in the IG, which would classify the women in the study as having a high risk of CVD according to the American Heart Association (AHA) and the Centers for Disease Control and Prevention (CDC)[17,28]; specifically, between 1.5 and 4 times the risk of suffering an acute myocardial infarction than in a person with lower levels.[17] After 12 months of the physical exercise intervention, CRP values were measured again, and a mean value of 2.54 ± 2.02 mg/L was obtained. These values place the women in a lower risk state, specifically, medium risk. In line with several studies, the results obtained confirm the existence of an inverse relationship between physical activity and CRP, and, in particular, strength training exercise seems to reduce these values.[9,15,29] Additionally, we were able to confirm that the duration of the training program is essential to obtain significant reductions. In the study by Ahn and Kim,[30] with 12 weeks of training at a frequency of 1 hour per day, 3 days per week in elderly women (age 74.2 ± 3.2 years)

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with osteopenia and osteoporosis, CRP was not significantly reduced; only a tendency towards reduction was recorded. The same results were obtained in the study by Oliveira et al[31] in which 12 weeks of progressive strength training did not result in any significant changes in CRP.

However, in the study by Ribeiro et al,[32] the effects of a 12-month progressive strength training program on CRP, blood glucose, and lipid profile in older women were analyzed. This study divided participants according to their level of experience with strength activities (participants with 6 months of experience in strength activities and participants with no experience). After 2 months, a CRP reduction of 2.6 ± 1 mg/L was recorded in the group with experience. Although the exact physiological mechanisms by which resistance training leads to a reduction in CRP are still not completely understood, there is speculation about various possibilities, most notably the secretion of myokines (which have anti-inflammatory effects that antagonize pro-inflammatory cytokines, thus promoting a reduction in inflammation and in CRP) induced by muscular contraction.[33] Other plausible mechanisms are changes in some components of body composition (such as body fat and skeletal muscle mass)[34] and consistency in performing the exercise. However, it should be noted that some research has observed a decrease in CRP independent of changes in body composition.[29,35]

Abdominal and hip circumference cannot differentiate between lean and fatty tissue[36]; however, these measurements are considered valid substitutes for the volume of visceral adipose tissue and the storage of peripheral fat. Abdominal obesity is an important metabolic risk factor and also an indicator of cardiovascular mortality in postmenopausal women,[36] such that the identification of effective interventions against obesity is necessary for this segment of the population. Resistance exercises have been shown to be an effective strategy against obesity. In this study, a decrease of 2.67 ± 2.61 cm in waist circumference was recorded. The results coincide with multiple studies in which performing physical exercise reduces abdominal circumference, weight and body fat regardless of gender and without calorie restriction. The study by Shaw et al[37] reported a decrease of approximately 5 cm (80.04 ± 8.57-73.19 ± 18.44 cm; $P = 0.045$) in abdominal circumference. To do this, a hypertrophic resistance training program of 10 full-body exercises was performed, carried out in 2 weekly sessions of 40 minutes each, with three sets of 12 repetitions at 67% to 85% of one maximum repetition. The study by Nunes et al[38] analyzed the effect of the volume of resistance training on muscular strength and on abdominal adiposity, metabolic risk, and inflammation in postmenopausal women, as a function of exercise volume. They concluded that the high-volume exercise group went from an initial mean of 88 to 84 cm upon completing the study, whereas the low-volume group showed an increase in strength similar to that of the high-volume group. These studies, along with our results, confirm that the volume and intensity of the exercise seem to play an important role in the magnitude of the response in terms of fat loss.[29,39,40] Although the values after the intervention were still high and constitute a risk factor for the women, the reduction in waist circumference along with the reduction in body weight highlights the importance of strength training in the improvement of phenotypes related to metabolic syndrome in postmenopausal women.[9] In a recent study, Bittar et al[41] were able to show that, after 12 months of supervised strength training 2 days per week, combining resistance bands with free weights, there was an improvement in the body composition of 16 menopausal women, increasing percent muscle mass. This variable, which was recorded using dual energy x-ray absorptiometry (DXA), was not monitored in the present study.

Regarding the lipid profile, the intervention had statistically significant effects on levels of total cholesterol and LDL. The review by Tambalis et al[42] considered the effectiveness of aerobic exercise training with different intensities (moderate and high), and also the type of exercise (aerobic, resistance, and combined) in altering blood lipid profile. Their main finding regarding the influence of resistance training on blood lipids was a marked reduction in LDL-C levels. In fact, 9 of 23 (39%) trials, affecting 191 women and 42 men aged 17 to 87 years, declared significant reductions ranging from 5% to 23%. Similarly, 16 weeks of periodic resistance training improved the lipid profile in sedentary middle-aged men and women, showing a significant decrease in total cholesterol (men 23.61%, women 21.08%; $P = 0.0001$) and in LDL (men 35.68%, women 38.53%, $P = 0.0001$), but no significant changes were observed in HDL or in triglycerides.[43] There is considerable evidence that resistance and combined exercise primarily lower LDL-C. Moreover, slight tendencies towards a decrease in circulating levels of triglycerides and VLDL, and an increase in HDL, were observed. It must be said that at no point were study participants subject to dietary control, which explains the weak alteration in HDL and triglycerides, in line with data previously published by Janssen et al.[44]

Lastly, the study reflects the difficulties associated with adherence. Older people tend to participate more effectively at the start of an exercise program, but their consistency decreases over time.[45] In this study, an abandonment rate of 55% was recorded, similar to the study by Picorelli et al[46] in which participants attended an average of just 43% of the sessions offered, and only 18% of the sample participated in all of the prescribed sessions. Therefore, it is clear that, although older people seem to enjoy this type of physical activity, attendance at the sessions offered is not guaranteed.

Although the present study proposes a physical exercise program that is affordable, versatile, and can be carried out in any location for management of cardiovascular risk in postmenopausal women, its limitations should be noted. One of the limitations of the study was analyzing the results with an analysis by protocol instead of an analysis by intention to treat, given that the number of participants lost was similar in both groups and not removing them would have obscured the benefits of the intervention. Lack of control of nutritional guidelines may have been a bias in the results of our research,

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and so this should also be controlled. The biomarker homocysteine could have been added due to its value in the cardiovascular risk profile.

Future lines of research should include cardiovascular risk evaluation from the European Society of Cardiology SCORE charts for women to understand and quantify the reduction in cardiovascular disease risk.

CONCLUSIONS

Based on the results obtained in this study, it can be said that progressive resistance training with elastic bands has positive effects on body composition and lipid profile in postmenopausal women. Specifically, the benefits are related to a decrease in waist circumference and in body weight. Additionally, CRP values were reduced, but although this is beneficial to phenotypes related to metabolic syndrome in postmenopausal women, it is not sufficient to reduce cardiovascular risk. These findings demonstrate the role of strength training on body composition and its positive influence on the proinflammatory state, with this type of exercise standing out as one important component of overall physical activity for postmenopausal women.

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