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Combined strength and step aerobics training leads to significant gains in maximal strength and body composition in women

A. PEREIRA [1, 2], A. M. COSTA [2, 3, 4], M. IZQUIERDO [5], A. J. SILVA [1, 2], M. C. MARQUES [2, 3], J. H. H.WILLIAMS [6]

Aim. **Examine the effects of 8 weeks of strength training program alone or combined exercise (step aerobics exercise and strength training) on Body Mass Index (BMI), waist circumference (WC), and maximal strength (1RM) in lower- and upper-body extremities.**

Methods. **Thirty-six women were randomized into three groups: strength training (S, N.=13; age: 61.0±9.3 years, BMI: 27.3±4.7 kg/m²), combined step aerobics training and strength training (SE, N.=11; age: 58.3±8.1 years, BMI: 27.8±3.7 kg/m²), or control (C, N.=12; age: 59.0±7.2 years, BMI: 29.5±4.8 kg/m²) groups. Subjects from both experimental groups performed 3 training sessions per week for 45-60 minutes per session. The S was submitted to a high-speed training that consisted of 40% to 75% of 1RM (3 sets 4–12 reps). The SE group combined aerobic exercise using step platform plus strength training.**

Results. **Both training groups significantly improved leg press (S, 80.7% and SE, 42.4%, P<0.001 respectively) and leg extension strength (S, 71% and SE, 35.7%, P=0.000 respectively). However, only the S group showed a significant increase in seated bench press maximal strength (S, +116.7%, SE, +13.6%, P=0.266 and P=0.000 respectively). Over the 8-week training period, the SE group showed significant changes in BMI and in waist circumference (-5.3%, P=0.016 and -3.0%, -2.5 cm, P=0.005, respectively). No significant differences were found in the S or C groups.**

Conclusion. **Decreases in body fat and waist circumference were more evident following combined training. In contrast, higher strength gains particularly for the upper body occurred following 8 weeks of strength training alone compared to combined training.**

KEY WORDS: Aged - Female - Training - Body Mass Index - Waist circumference.

Corresponding author: A. Pereira, Department of Sport Sciences, University of Trás-os-Montes e Alto Douro, Vila Real, Portugal.
E-mail: anapereira@utad.pt

[1]Department of Sport Sciences
University of Trás-os-Montes and Alto Douro
Vila Real, Portugal
[2]Research Centre in Sports
Health and Human Development
Vila Real, Portugal
[3]Department of Sport Sciences
University of Beira Interior, Covilhã, Portugal
[4]CICS-UBI, Health Sciences Research Center, Portugal
[5]Department of Health Sciences
Public University of Navarre, Navarre, Spain
[6]Chester Centre for Stress Research
University of Chester, UK

Age-related changes in body composition have been previously reported in older populations (*i.e.*, increase in fat mass and decrease in muscle mass).[1-3] Impairment refers to the physiological mechanisms that include alterations in individual muscle fiber contractile properties and modifications in neuromuscular function.[2] Losses can lead to increase the risk of physical function and deterioration of strength performance especially in older women [4] as well as to an increase in metabolic disorders and mortality. Recently, muscular adaptation to resistant training as shown to be useful in strength gains with substantial improvements in dynamic exercises in upper and lower limbs (44.1-61.8%) over 12 weeks of training period in older people.[5]

Abdominal obesity is also a key feature in cardiovascular risk assessment, a growing epidemic that affects more than 300 million people worldwide,[6] particularly in women after menopause.[7] In previous studies, waist circumference has been proposed as the best simple anthropometric index of abdominal visceral adipose tissue accumulation in the elderly, being also related to heart and vascular risk.[8-10]

Aerobic training is one of the most popular exercises,[11-13] but in women to our knowledge, no studies have observed the effect of step aerobics training combined with strength exercise on muscular performance and body composition. It is known that combined training may lead to lower strength or muscle power gains,[14, 15] as well as lower magnitude of endurance [15, 16] compared with pure strength training programs or endurance alone. Nevertheless, the variability between exercise programs characteristics may partly explain some mixed findings.[17]

There are studies about different types of training in older women, but to date, we are unaware of any research investigating the whole-body combined training-induced pattern of strength response between the lower and, especially, the upper extremity muscles in previously untrained women. The aim of this innovative study was to examine the effects of 8-week of combined three-weekly step aerobics exercise and resistance training on maximal strength of the lower- and upper-body extremities and waist circumference (WC), compared with three-weekly strength training program alone and a control group. It was hypothesized that specific combined training in women would lead to similar gains in maximal strength of the lower-extremity muscles, but better improvements in body composition, compared with strength training alone.

Materials and methods

Participants

Thirty-six women volunteered (60.0±8.5 years old) to participate in this study. All participants fulfilled the inclusion criteria: living independently in the community, being without contraindications to cardiorespiratory fitness assessment and not having history of regular exercise. Before inclusion in the study, all candidates were thoroughly screened by a physician. Each woman also answered a face-to-face questionnaire addressing medical history and medication use.

Participants were then randomized into two training groups and one control group: strength training (S, N.=13; age: 61.0±9.3 years, BMI: 27.3±4.7 kg/m^2), combined endurance and strength training (SE, N.=11; age: 58.3±8.1 years, BMI: 27.8±3.7 kg/m^2), or control (C, N.=12; age: 59.0±7.2 years, BMI: 29.5±4.8 kg/m^2) groups (Table I). Subjects were informed about any potential risks and/or discomforts associated with participation in the study and were required to complete informed consent form before being included in the study. All physical or psychological diseases that may have precluded ability to perform the requested training exercises and testing were considered exclusion criteria. The experimental procedures were approved by the University of Trás-os-Montes and Alto Douro, Department of Sport Sciences, following the Helsinki declaration.

Procedure

To test the stability and reliability of all variables, individuals were evaluated at same time and location and supervised by the same researchers at pre- and post-interventions. Subjects were evaluated twice before the start of training (two weeks before and at baseline), and this served as a control period. Tests were applied to both groups at two intervals: before the experimental period (T1) and after the 8-week experimental period (T2).

Anthropometric assessment

The anthropometric assessment was carried out in a separate room by a single trained examiner. A detailed description of the testing procedures has been given elsewhere.[4] The waist circumference (WC) was measured with a flexible and inelastic measuring tape (Hoechstmass-Rollfix®, Germany) with a precision of 0.1 centimeters, taking the necessary care not to compress tissues. The WC was measured at the midpoint between the iliac crest and the last rib [18] and was carried out at the end-expiratory position. The intra-class correlation coefficient (ICC) for BMI and WC was 0.91and 0.93, respectively.

Strength Test

A detailed description of the testing procedures has been given elsewhere.[4, 17] In brief, lower- and upper-body maximal strength was assessed using one-repetition concentric maximum (1RM) actions in a leg press ($1RM_{LP}$), leg extension ($1RM_{LE}$) and in a bench-press ($1RM_{BP}$) position, respectively.

Table I.—*Physical characteristics of the control (C), strength (S) and combined endurance and strength (SE) training groups at baseline and after 8 weeks of training.*

Variable	Group	T1	T2	P
		x±σ	x±σ	(T1-T2)
Age (years)	C (*n*=12)	59.0±7.2	59.1±7.2	0.877
	S (*n* =13)	61.0±9.3	61.1±9.3	0.979
	SE (*n* =11)	58.3±8.1	58.4±8.1	0.879
Body Mass (kg)	C	72.7±12.9	72.8±13.3	0.667
	S	66.8±12.0	67.2±11.3	0.413
	SE	65.8±7.8	65.8±7.9□	0.336
Total Standing Height (m)	C	1.56±0.08	1.56±0.07	0.989
	S	1.56±0.06	1.56±.07	0.786
	SE	1.57±0.04	1.57±0.03	0.765
BMI ($kg \cdot m^{-2}$)	C	29.5±4.8	29.6±5.0	0.696
	S	27.3±4.7	27.4±4.4	0.836
	SE	27.8±3.7	26.3±3.6	**0.016**
WC (cm)	C	86.1±5.9	87.6±7.0[b]	0.106
	S	83.9±9.9	84.1±10.1[c]	0.733
	SE	83.0±5.08	80.5±5.6	**0.005**

P (T1-T2)- P value between 2nd and 1st moment; BMI = body mass index.a weight-to-height ratio.calculated by dividing one's weight in kilograms by the square of one's height in meters; C – Control Group. S – resistance training group. SE - combined endurance and strength training; ₮Significant changes (P₮0.05) between the groups; [a] $P<0.05$.C significantly different from S; [b] $P<0.05$.C significantly different from SE; [c] $P<0.05$. S significantly different from SE.

Specific warm-up was allowed consisting of 1 set of 5 repetitions at 40–60% of the perceived maximum. Separate attempts were performed to determine the one repetition maximum until the subject was unable to extend the leg and arm muscles to the required position. The intra-class correlation coefficient (ICC) for $1RM_{LP}$, $1RM_{LE}$ and $1RM_{BP}$ was 0.94, 0.95 and 0.93, respectively.

High-speed strength training

The subjects included in the S group were asked to report to the training facility three times per week for 8 weeks, on nonconsecutive days. Each training session included 2 exercises for the leg extensor muscles (leg extension and leg press) and 1 exercise for the arm extensor muscles (the bench press) and finished with abdominal crunches and trunk extensors. An interval period of at least 2 min was permitted between sets and between exercises. During the first 2 week of the training period, the subjects trained with loads of 40–50% of the individual 1RM, 10-12 repetitions per set, and 3-4 sets of each exercise, and progressively increase to 75% of 1RM, 3 sets by 4–6 reps. Subjects were performing all exercises at high velocity, with instructions to do them "as fast as you can".

Combined strength and step aerobics training

The training protocol for the step aerobics group (SE) consisted of 3 sessions per week, 45 to 60 minutes per session for 8 weeks with the same certified instructor. The aerobic component within the training program included 30 minutes of cardiovascular exercises using a step platform. Each session included 10 minutes of warm-up and 20 minutes of step aerobics training. In the first 2 weeks of exercise, participants were initiated to the basic movements and choreography with continuous movement of legs and alternating movement of the arms (bicep curls and lateral raises at shoulder level and above the head) simultaneously with the selected steps. Exercise included movements of conventional basic step; "V"; "A"; "L"; turn step (right and left lead); alternating knee-lift, leg up and down; alternating kicks and lateral lunge. The aerobic session started with a work heart rate (HR) of 40-50% HR (1-3th week), increasing progressively to 50-70% HR (4-6th week),

TABLE II.—*Mean ± standard deviation of upper and lower limbs strength at all three assessment moments.*

	Group	T1	T2	P
		x±σ	x±σ	(T1-T2)
1 RM_{BP} (kg)	C (n=12)	12.1±3.5	11.6±3.2[a]	0.339
	S (n =13)	12.6±4.8	27.3±8.3[c]	<0.001
	SE (n =11)	12.5±2.6	14.2±5.1*	0.266
1 RM_{LE} (kg)	C	21.7±8.1	21.6±5.7[a, b]	0.989
	S	20.7±8.1	35.3±4.3c	<0.001
	SE	22.1±6.1	30.0±6.7*	<0.001
$1RM_{LP}$ (kg)	C	22.9±8.2	23.3±7.1 [a, b]	0.674
	S	23.8±7.4	43.0±6.3c	<0.001
	SE	24.3±5.4	34.6±4.1*	<0.001

P (T1-T2)- p value between 2nd and 1st moment; WC – Waist Circumference; C – Control Group. S – resistance training group. SE - combined endurance and strength training; *Significant changes (P<0.05) between the groups; [a] P<0.05.C significantly different from S; [b] P<0.05.C significantly different from SE; [c] P<0.05. S significantly different from SE.

and then to 70-85% HR (7-8th week). The perceived exertion was 11 to 13 (6 to 20 point, Borg scale). Heart rate reserve was determined by the Karvonen formula.[19] HR monitoring equipment (Accurex plus, Polar Electro Oy, Finland) was used to monitor and keep records during exercise. Music was selected to increase work heart rate and the cadence of the sessions was between 120 and 128 foot-strikes per minute. Then, subjects performed the same resistance exercise prescription applied to the S group. Each training session was closely supervised and monitored by two researchers, specialized in physiology and in aerobic-dance instruction to direct and assist each subject towards achieving the appropriate work rates and loads.

Statistical analysis

The Kolmogorov-Smirnov test was used to evaluate the normality of the distribution of the variables. The intra-individual reproducibility of the measurements was assessed by the intraclass correlation coeficient (ICC). Descriptive statistics (mean±SD) were calculated for all variables. To assess any differences among the three groups' initial anthropometry or performance variables a one-way analysis of variance (ANOVA) was used. When significant differences were found, Tukey's post-hoc test was used to identify which groups differed among them. For the variables that did not pass the normality test, Kruskall-Wallis test and Dunn's post-hoc test were used. Two-way ANOVA with repeated measures (groups x moments) was used to assess the training related effects. To establish statistical significance, a P≤0.05 criterion was used. All data were analyzed using SPSS 17.0.

Results

At baseline evaluation, no significant differences (P>0.05) were observed between the exercise and control groups in any of the studied variables. From pre- to post-training period, the S group significantly increased (P<0.001) their dynamic strength performance in $1RM_{BP}$ (116.7%), $1RM_{LE}$ (71.0%) and $1RM_{LP}$ (80.7%), whereas the SE group also significant increased maximal strength performance but only in lower limbs ($1RM_{LE}$: 35.7% and $1RM_{LP}$: 42.4%, P<0.001 respectively and $1RM_{BP}$: 13.6%, P=0.266). No significant changes were observed for the C group (Table II). No significant changes (P>0.05) in height or body mass were observed (Table I) between the first (T1) and the second evaluation (T2) in all the groups. However, BMI showed a significant decrease between T1 and T2 only in SE group (-5.6%, P=0.016). Likewise, significant decreases (P<0.05) were observed only in the SE group for WC by -3% (-2.5 cm, P=0.005) (S: +0.2% and C: +1.7%, P=0.106 and P=0.733, respectively) (Table II).

Discussion

The primary findings of the present study demonstrated that 8 weeks of strength training alone is an effective way to enhance maximal dynamic strength with only two exercises of resistance training for upper and lower extremities per session. Additionally, combined step aerobics exercise and strength training was not effective in increase maximal strength in upper limbs but induced significant improvements in the body composition, mirrored here by the reduction in waist circumference.

Significant improvements in maximal dynamic strength in upper body extremity performed by bench press exercise were only observed in the S group. This suggests a positive effect of strength training on upper-extremity in women. Our findings agree with previous studies that used bench press exercise.[20, 21] Therefore, both S and SE training groups significantly improved lower-extremity strength ($1RM_{LP}$: 42.4-80.7% and $1RM_{LE}$: 35.7-71%). Our results are comparable with recent studies on previously untrained women after 8-24 weeks of strength training.[22-24]

As results achieved were greater in magnitude in bench press exercise it may indicate differential changes in activity patterns between upper and lower muscles and perhaps lesser strength in the arms compared to the legs.[25, 26] Moreover, the alternating movement of the arms during step workout could also cause greater weariness at the end of the aerobic training session, and, consequently, induce declines in muscle performance and self-motivation to perform the rest of the strength exercises. Thus, as the present study demonstrated, strength training alone is more favorable to increase muscular performance in upper extremity in women.[27, 28]

Relatively to body composition, there were significant changes in BMI and in waist circumference only in SE group. This can be partially explained by the efficacy of the combined training. Since step aerobic exercise does not appear to significantly prevent the age-related decrease in muscle mass and strength in the older population,[29] the decreased that we observed may be explained by the loss of some fat mass. Previous studies on age-dependent height have suggested that an incorrect overestimation of adiposity may induce a false BMI by more than 2.5 kg/m^2 in women across aging,[30] being a weak predictive indicator of obesity particularly in populations of short stature as the Portuguese.[31] Nevertheless, as the accumulation of intra-abdominal fat seems to persist even without significant body mass changes,[32] weight losses may be necessary, especially when the optimization of the musculoskeletal function in aging is essential.[3] Results of the present study indicate that baseline WC values are above the threshold value for the European women (80 cm), which suggests an increased risk of cardiovascular disease.[33, 34] The present study has shown that combined training may potentially countering the age-related increase in abdominal fat (-2.5 cm) in older women and emphasizes the importance of concomitant training-induced changes in body composition in the prevention and treatment of metabolic risk factors. Ours results also contribute to a novel finding in the prescription of exercise especially to older obese individuals – aerobic workout using step platforms may have a better effect in mobilization of the major muscles groups in upper limbs, leading to better physical condition and also providing greater effects in weight loss.

Some studies related to the effects of step aerobics training on body mass and body fat percentage have failed to find any significant changes,[13, 35] although, as our study verified, strength training after step aerobics session may be essential to improve body composition. Thereafter, strength stimulus in combined training may help explain the additional beneficial outcome of muscular improvement in lower and upper extremities.[36, 37]

The first limitation constraint of the present study was that the fat and lean mass was not measured because BMI and waist circumference cannot predict total body composition. Also Karvonen formula was used to evaluate heart rate for older adults but this have some constraints in this population, in future studies different protocols should be used. A second limitation is that the level of functional capacity and balance of the participants were not measured. With this mind, further research with step aerobics training or multicomponent training should be developed in order to determine if this type of exercise could be applicable to older persons with balance problems or low functional fitness.

Conclusions

As a means of evaluating the specificity of each type of training proposed here, it seems that combined training can be a useful working tool for health and sports professionals, contributing to a better way of prolonging functional independence and quality of life in older adults.

Practical applications

Step aerobics training can be considered an effective exercise modality to prevent the loss of muscular performance and its associated consequences. Understanding the nature of combined or multicomponent training may help choreographers and professionals in sport science to develop exercise combinations that are more useful and helpful to increase strength in older people and to prevent the age-related changes in body composition.

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