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original article

Effects of concurrent training on health aspects of elderly women

Efeitos do treinamento concorrente sobre aspectos da saúde de idosas

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Abstract – Training programs that include aerobics and strength exercises, either at the same session or alternate days are defined as concurrent training (CT). The objective of this study was to verify the effects of a CT program on biochemical parameters, cardiovascular fitness, body composition and neuromuscular aspects. Twenty two elderly women physically active were randomly allocated to one of the five groups: AS (aerobic exercises followed by strength training; n=5), SA (strength activities followed by aerobics exercises; n=5), AG (aerobics exercise only; n=5), SG (strength activities only; n=4), CG (control group; n=3). The program lasted 12 weeks. Tests of dynamic and static strength, flexibility, aerobic power, body composition and biochemical parameters were conducted. In the aerobics power test, AS and SA groups showed differences in the post-test compared to the CG. In dynamic strength test of upper limbs, the groups S, SA, AS showed statistical differences from the CG in the post-test (p=0.009, 0.006 and 0.002 respectively). Only the AS group presented some difference from the pre to post-tests (P=003). AG, SG, SA, AS showed differences in the post-test in relation to the CG for the lower limbs strength test (p<0.001). From pre to post-test within the same group, the groups SG, SA and AS showed differences (p=0.001, 0.03, 0.02). Stretching, static strength, biochemical factors and body composition showed no association with any of the groups. We concluded that CT was equivalent to the strength and aerobics exercises performed exclusively.

Key words: Aging; Physical exercise; Physical fitness.

Resumo –*Programas de treinamento, incluindo exercícios aeróbios e de força, seja em uma mesma sessão ou em dias alternados, é definido como treinamento concorrente (TC). O objetivo do presente estudo foi verificar os efeitos de um programa de TC sobre parâmetros bioquímicos, condicionamento cardiovascular, composição corporal e aspectos neuromusculares. Vinte e duas idosas fisicamente ativas foram aleatorizadas para um dos cinco grupos: AF (atividade aeróbia seguida de treinamento de força N=5), FA (treinamento de força seguido de atividade aeróbia N=5), GA (treinamento aeróbio N=5), GF (treinamento de força N=4) e GC (grupo controle N=3). O programa teve duração de 12 semanas. Foram realizados testes de força dinâmica e estática, flexibilidade, potência aeróbia, avaliação da composição corporal e bioquímica. No teste de potência aeróbia, os grupos AF e FA apresentaram diferenças no pós-testes quando comparado ao GC. Na força dinâmica de membros superiores, os grupos, F, FA, AF apresentaram diferença no pós-teste em relação ao GC (p= 0, 009; 0,006 e 0,002). Quando analisada a diferença pré e pós-treinamento no mesmo grupo, apenas AF apresentou alterações (p=0,03). Na força dinâmica de membros inferiores, os grupos A, F, FA, AF apresentaram diferença no pós-teste em relação ao GC (p< 0,001). Foram encontradas diferenças entre o pré e pós-treinamento apenas em F, FA, e AF (p= 0,001; 0,03; 0,02). Nas variáveis flexibilidade, força estática, fatores bioquímicos e composição corporal não foram observadas diferenças estatísticas. Conclui-se que o TC foi equivalente aos exercícios de força e aeróbios realizados de forma isolada.*

Palavras-chave: *Aptidão física; Envelhecimento; Exercício físico.*

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INTRODUCTION

Concurrent training (CT) is a model of exercise prescription that combines strength training and aerobic capacity in the same period of time and that has been extensively investigated in recent years1-3. Studies have shown that CT does not affect the development of aerobic capacity and may even improve it4. But when it comes to strength capacity, some authors suggest that CT may reduce the development of strength gain, muscle hypertrophy and power when compared to strength training alone1,5. Jeffrey6 claims that the aerobic exercise model applied to CT may influence the development of strength, and that cycling exercises would be superior to the treadmill in the development of strength in the lower limbs since it reproduces the biomechanical motion of exercises like leg press or squat with the greatest similarity.

Studies investigating CT in the elderly are hardly mentioned in the scientific literature, but some studies have observed that this type of training is capable of developing strength and aerobic capacity[7,8]. Conversely, Cadore et al.[9] found that, in elderly males, CT (aerobic before strength training) can negatively interfere with strength gain when the same muscle group is activated. From the perspective of health promotion, CT appears to be an alternative option to improve cardiorespiratory fitness and strength gain.

Given these discrepancies found in the literature, the present study aimed to assess the effects of a CT program on biochemical, cardiovascular fitness, body composition, and neuromuscular parameters in elderly women, comparing them to the effects of strength programs and aerobic exercises exclusively.

METHODOLOGY

An experimental study with random allocation was carried out. Women aged 60 years or more and physically active, i.e., engaged in at least 150 minutes per week of moderate to vigorous intensity activity in the last six months (estimated by the short version of the International Physical Activity Questionnaire) was allocated to one of the experimental groups. Women allocated to the control group (CG) had the same age but were not physically active, as they held only one session per week of 50min of hydrogymnastics.

Thirty women were selected and throughout the study there were eight dropouts, leaving the program with 22 participants distributed as follows: AS (aerobic activity followed by strength training, n = 5), SA (strength training followed by aerobic activity, n = 5); A (only aerobic training, n = 5), S (only strength training, n = 4), and CG (control group, only hydrogymnastics, n = 3).

The exercise sessions took place in the afternoon (between 2:00 and 5:00 p.m.), with 48-hour of interval between sessions. Both groups were instructed to maintain their basic activities of daily living (BADLs) and not perform any other type of physical exercise during the experimental protocol period. The study was approved by the Research Ethics Committee of Physical Education School from the Federal University of Pelotas under the protocol number 020/2011.

Training protocol

An adjustment period lasting two weeks was conducted so the participants could get a better assimilation of the order and execution of the exercises as for equipment familiarization. Shortly after, the participants were invited to go to the Laboratory of Research and Extension in Measurements and Evaluation to carry out the pre-testing.

The training program lasted 12 weeks, comprising three weekly sessions with a 25% maximum limit of absences as a criteria to remain in the program.

The AS group performed aerobic training by walking on a treadmill followed by strength training, which consisted of eight exercises involving large and small muscle groups: chest press, behind-the-beck bat bull-down chest press, behind-the-beck bat bull-down, knee extension, knee flexion, biceps pulley, triceps pulley, leg press and curl abdominal on the ground. The SA group performed the same activities of the AS group but in a reverse order (strength training followed by aerobic exercise). The ST group performed only strength training and the TA group only aerobic exercise.

The program began after the adaptation period and the initial and final five minutes were always used to warm-up and cool-down respectively. The remaining time was divided between aerobic and strength training, excepting abdominal exercise (three sets of 30 repetitions). At the end of the study participants were submitted to a new section of evaluation for the post-testing.

The schedule of the training program consisted of three workouts per week, strength trainings were executed in three series. In weeks 1 and 2: 18 to 20 RM (repetition maximum) plus 20 minutes of aerobic training at 65% of MHR (maximum heart rate); in weeks 3 and 4: 15-17 RM plus 25 min of aerobic training at 65% MHR. In weeks 5 and 6: 12-14 RM plus 25 min of aerobic training at 75% MHR; in weeks 7 and 8: 8-10 RM plus 30 min of aerobic training at 80% MHR; in weeks 9 and 10: 6-8 RM plus 30 min of aerobic training at 85% MHR, and ending with weeks 11 and 12 performing between 4 and 6 RM plus 30 min of aerobic training at 85% MHR.

Biochemical analysis of blood

Blood samples were collected after fasting for 12-14 hours at night and 24h-abstinence of exercise. In all cases, blood samples were obtained by venipuncture from a forearm vein. The blood sample was centrifuged at 3,000 rpm for 15 minutes and the resulting serum was then removed and stored at -70 °C until further analysis. Serum concentrations of TC, TG, HDL, LDL and GLU were assessed using an automated analyzer (Labtest, Labmax240 from Tokyo, Japan).

Muscle Strength

The static strength of the lower limbs and lumbar spine was assessed using a Baseline® dynamometer with a resolution of 10 kgf and handgrip strength using the Jamar® handgrip dynamometer with resolution of 2 kgf. The dynamic force was measured using the 1RM for bench press exercises and bilateral knee extension, where the elderly women held 5 minutes of general warm-up on the treadmill followed by stretching and warming-up on specific machines, the maximum load was defined after three attempts with three minutes of pause in both test and retest.

Body Composition

Muscle, bone and residual mass and fat percentage were measured following the Drinkwater and Ross[10] protocol, by which the total body mass is subdivided into fat mass, muscle mass, bone mass and residual mass. For this purpose, subcutaneous fat and bone weight were estimated. With this information and the total body mass, muscle and residual mass were also estimated by taking measurements of the following skinfolds: triceps, biceps, subscapular, suprailiac, pectoral, midaxillary, abdominal, medial thigh and medial leg. Skinfold were measured using with a Harpenden skinfold caliper type with precision of 0.1 mm (Sanny). For measuring waist circumference, hip, thigh, leg medial and arm medial an inelastic metal tape (Sanny) was used. The bone diameters were measured with a caliper (Sanny) in the in bistyloid and bicondylar femoral points, biacromial, biiliac-crest, biepicondylar humerus, bimalleolar, transversus thoracic, anterior-posterior diameter of the chest[11].

Cardiovascular fitness and flexibility

The cardiovascular fitness was estimated with the six-minute-walk test and the intensity of the aerobic workout through the maximum heart rate. Wells and Dillon's[11] 'sit and reach test' was applied to measure the flexibility.

Statistical Analysis

Data were analyzed using the statistical software STATA 9.0. The normality of the sample was checked with the Shapiro-Wilk's. The comparison between the average percentage change in each group was assessed through paired t-tests. Analysis of variance (ANOVA) for comparisons between the groups with post hoc of Bonferroni was used when the p value was $<0,05$. The accepted significance level was $p < 0.05$.

RESULTS

Because eight participants dropout during the period of intervention, a total of 22 elderly women were analyzed: five in AS group, five in the SA group, five in group A, four in group S and three in the CG, as shown in Table 1.

Regarding the lipid profile, no statistically significant differences were found either within groups or between groups (Table 2).

Table 1. Characterization of the sample at the baseline presented in mean and standard deviation.

Groups (n)	Body mass (Kg)	Height (m)	BMI (Kg/m²)	Age (years)
Aerobic training (5)	67.42±18.03	1.56±0.61	27.4±6.62	63.6±2.51
Strength training (4)	64.84±11.90	1.59±0.30	25.32±4.24	70±6.27
Strenght/aerobic training (5)	66.68 ±14.20	1.59±0.45	26.24±4.90	66±3.50
Aerobic/strenght (5)	81.15±16.10	1.57±0.75	28.58±7.63	62±2.50
Control group (3)	70.6±17.27	1.57±0.30	28.58±7.30	74±4.35

BMI = Body Mass Index.

Table 2. Comparison of lipid profiles means of pre- and post-test by group and between groups.

Groups		TC (mg/d/L)	HDL(mg/d/L)	LDL (mg/d/L)	TRI (mg/d/L)	GLU (mg/d/L)
A	Pre-	171.6±33.4	54.6±10.9	89.0±23.6	140.2±78.6	100.2±6.8
	Post-	176.6±30.5	59.1±7.2	89.5±20.0	135.4±66.5	98.0±8.0
S	Pre-	178.5±8.2	51.7±13.4	106.0±8.7	104.2±45.4	97.8 ±7.8
	Post-	184.7±13.7	55.7±12.1	106.0±2.6	116.0±23.8	88.5±8.3
SA	Pre-	200.6±27.3	54.8±9.2	107.6±24.2	190.6±79.9	108.8±31.6
	Post-	189.2±30.6	52.0±9.5	118.2±42.7	167.2±72.5	114.4±44.6
AS	Pre-	204.0±25.4	55.6±12.3	114.2±21.3	170.6±71.7	115.2±13.8
	Post-	188.8±26.9	57.3±4.55	99.7±21.5	159.2±87.2	104.2±13.5
CG	Pre-	244.3±21.4	72.0±16.4	136.3±13.6	179.7±40.4	103.3±6.5
	Post-	229.5±8.7	62.3±7.1	129.5±4.5	183.3±34.0	95.7±5.9

TC = total cholesterol; HDL = High-density lipoprotein; LDL = Low-density lipoprotein; TRI = triglycerides; GLI = glucose; A = Aerobic training; S = Strength Training; SA = Strength followed by aerobic, AS = aerobic followed by strength; CG = Control Group

The results for the variables body composition; fat, muscle, bone and residual mass and percentage, body weight and waist circumference are shown in Table 3. Regarding the components of body composition, none of the four exercise programs proved to be effective for a modification of the variables under this study, since it showed no differences between groups or from pre- to post-test in the same group.

As shown in Table 4, after analyzing the static strength and flexibility variables, no significant differences were found from pre- to post-test in the same group. However in the test of aerobic power estimated by the six-minute-walk test, group AS and SA showed differences in post-test when compared to CG with p values of 0.01 and 0.04 respectively.

The dynamic force was measured before and after training. In the upper limb strength represented by bench press exercises, groups S, SA, AS showed statistical difference in post-test when compared to the control group (p = 0.009, 0.006 and 0.002 respectively). After analyzing the difference pre- and post- training in the same group, only the AS group showed significant changes (p = 0,03) as shown in Figure 1.

As for the lower limb strength represented by leg press exercises, groups A, S, SA, AS showed statistical differences in the post-test when compared to the control group (p <0.001). After analyzing the pre- and post-training difference in the same group, only the groups S, SA and AS showed significant changes (0.001, 0.03, 0.02 respectively) according to Figure 1.

Table 3. Comparison of body composition variables in pre- and post-tests (data are presented in means with their respective standard deviations).

Groups		Total Body Mass (Kg)	Waist circum-ference (Cm)	Relative body fat (%)	Absolute fat mass (kg)	Bone Mass (kg)	Residual Mass (kg)	Muscle Mass (kg)
A	Pre-	67.4±18.0	91.4±10.5	35.6±11.3	22.6±2.9	7.7±1.4	15.2±2.9	22.0±16.2
	Post-	67.1±17.8	90.3±12.4	31.2±7.0	20.2±3.2	7.9±1.4	15.1±2.9	23.9±13.0
S	Pre-	64.8±11.9	91.4±6.7	40.1±12.8	27.0±13.0	8.6±0.6	15.6±2.9	13.6±4.8
	Post-	64.5±11.8	91.5±8.8	38.3±15.5	26.0±15.0	8.4±0.8	15.5±2.9	14.5±6.5
SA	Pre-	66.7±14.2	93.5±12	39.6±6.8	26.8±9.4	8.0±0.8	16.1±3.4	15.7±3.9
	Post-	65.8±13.3	96±11.8	33.6±5.4	22.6±8.2	8.2±0.9	15.9±3.2	19.2±2.2
AS	Pre-	81.1±16.1	103±10.6	33.2±8.0	26.1±4.2	8.5±1.6	18.3±2.4	28.2±13.4
	Post-	80±15.1	103±10.4	31.0±7.1	24.2±4.7	8.5±1.7	18.0±2.4	29.3±12.5
CG	Pre-	70.6±17.3	95±22	46.4±9.8	33.7±14.6	8.0±0.5	17.0±4.2	11.9±3.1
	Post-	73.3±15.6	96±21	46.9±10.8	35.4±15.1	8.2±0.6	17.6±3.8	12.0±3.2

A = Aerobic training; S = Strength Training; SA = Strength followed by aerobic, AS = aerobic followed by strength; CG = Control Group

Table 4. Comparison of static strength, flexibility and aerobic power within and between groups.

Groups		Handgrip (Kgf)	Lower limbs (kgf)	Lumbar (kgf)	Flexibillity (cm)	Six minutes (m)
A	Pre-	24.8±3.8	54.8±40.6	58.0±27.3	21.4±2.9	464.1±70.8
	Post-	25.4±1.5	55.6±16.6	54.2±11.3	23.4±2.6	519.6±7.3
S	Pre-	24.7±2.2	53.7±26.9	47.5±13.2	21.7±4.3	489.0±52.6
	Post-	26.1±3.6	51.7±12.9	53.7±14.4	23.0±5.7	495.2±47.6
AS	Pre-	28.1±3.9	66.0±19.49	53.2±24.1	18.2±7.6	519.3±76.7
	Post	27,6 ± 3,5	74,6 ± 33,5	66,4 ± 30,7	19,8 ± 7,8	567,8 ± 94,2*
SA	Pre-	28.3±6.9	61.0±29.7	62.0±10.4	19.6 ±2.8	527.4±45.2
	Post-	28.1±7.6	63.6±17.4	69.8±10.8	20.6±1.5	542.7±58.5*
CG	Pre-	31.5±3.6	49.3±9.0	40.0±5.0	22.0±3.6	410.7±35.8
	Post-	28.7±1.4	47.0±13.9	38.6±2.3	21.3±3.8	403.3±31.7

Kgf = Kilogram-force; * Statistically significant difference (p <0.05) when compared to the Control Group. A = Aerobic training; S = Strength Training; SA = Strength followed by aerobic, AS = aerobic followed by strength; CG = Control Group

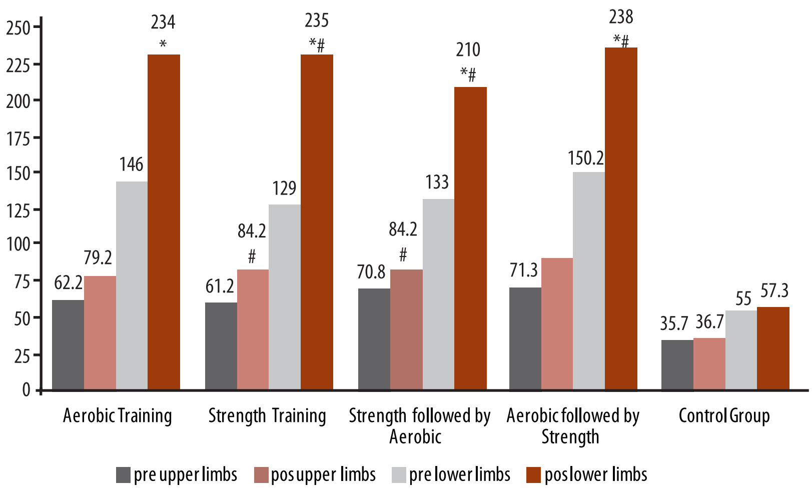

Figure 1. Comparison of dynamic strength of upper and lower limbs means of the pre- and post-test by group and between groups.

UL = Upper limbs, LL = lower limbs; * Significant difference between pre- and post-training (P <0.05), # Significant difference when compared to control group (p <0, 001).

DISCUSSION

The consistency of finding from studies investigating the effects of concurrent training is still conflicting, thus the establishment of training criteria and their influence on practitioners' health promotion is hindered. Although several studies have been published on the subject of concurrent training, only a few reports investigated the elderly population, especially regarding the order of exercises execution [12-15]. The advantages of performing CT in this population are related to the fact that this model of exercise program might result in similar gains in aerobic capacity when compared to an isolated training model[1,7,16].

The present study did not verified changes in levels of static strength. These results corroborate with the ones reported by Souza et al.[17] in the sense that performing aerobic exercises previously to the strength model was not able to change the strength rates for the lumbar region. However, most studies seeking to determine the influence of the aerobic component into the strength levels show that there is a decreased rate of strength gains in lower limbs[18]. However, we have found contrasting results where the AS group showed improvements from the pre- to the post-test ($p=0.02$) for the 1RM test for leg press exercise.

Similarly, Wood et al.[7], submitted elderly individuals to ST and CT for 12 weeks; the TS group performed 2 sets and CT group performed a series. After this period, a similar gain in muscle strength was observed in both groups (38-44%, respectively), but no differences between groups. Izquierdo et al.[12] investigated elderly individuals, divided into two groups: a group performing two sessions and another performing CT, that is, a session of ST per week and another of AT on ergometer. After 16 weeks of training, no differences were observed regarding gains in muscle strength between groups. In this study, differences were only found when comparing to the CG regarding the dynamic muscular strength, results that resemble the findings by Wood and Isquierdo[7].

Still, gender differences, number of sessions and series and the aerobic training model should be noted, since in the present study only women participated and all groups performed three weekly sessions with the same volume of strength and aerobic training, unlike the mentioned studies[7,12] in which CT groups performed a smaller volume of sets per exercise when compared to ST ones. This is one aspect that limits comparisons between studies. Another important parameter to be discussed is the model of aerobic training, since in this study was performed on a treadmill, what according Jeffrey[6] would be a disadvantage when compared to the cycle ergometer for the development of strength in the lower limbs because it reproduces with better similarity the leg press motion exercises.

Concerning the results of the variable fat percentage, the present study matches the findings by Viana et al.[19], which showed no significant differences regarding the body fat component in adult men when comparing the concurrent training to the strength or aerobic training, separately. Our study also found similar results to Rossato et al.[20] who concluded that the performance of a combined training of strength and aerobic, in a same session, was not able to lead to significant modifications in relative body fat, lean mass and bone mass in adult women.

On the other hand, Sillanpaa et al.[21] analyzed the body composition changes, through DEXA, skinfolds, bioimpedance and waist circumference of 53 men aged between 40 and 65 years during 21 weeks of concurrent training. The researchers noted that the percentage of fat decreased, on an average of 5-8% in all groups, concluding that concurrent training (aerobic and strength) was more efficient to decrease the percentage of fat when compared to isolated training.

Our findings also diverge from the 10-week-study by Dolezal & Potteiger[22], who found differences in the percentage of fat in the three studied groups: strength, aerobic and concurrent. It is important to highlighting the difficulties of comparing studies, since gender relations, mainly driven by hormonal issues as well as time, intensity and duration of sessions influence the energy expenditure. Furthermore, according to the ACSM[23], to reduce the percentage of fat, regular exercise and nutritional control should be associated. Because the diet of the participants was not controlled, this could be an explanation to the fact that this research has not found any significant change in the values of fat percentage.

Statistically significant changes were not found for any of the variables in the biochemical profile as in body composition, which is in contrast with LeMura et al.[24] since in their study with sedentary young women showed that the aerobic group decreased TRI and increased HDL. Likewise Ghahramanloo et al[25] observed that sedentary young males showed significant improvements in HDL and LDL in the aerobic group and concurrent training. One of the difficulties in comparing the current study with findings from LeMura and Ghahramanloo is the age and fitness of participants. The fact that both studies assessed sedentary individuals suggests that these acute responses to the exercise are faster in sedentary individuals than physically active.

Regarding aerobic capacity, the present study showed a difference in the post-test between groups AS and SA compared to the CG (p=0.01 and 0.04 respectively), but no improvements from pre- to post-training. Similar results were found by Maiorana et al.[26] verified improvements in aerobic capacity in older adults with heart failure after eight weeks of concurrent training. Moreover, Campos et al.[27] assessed the effects of a concurrent training program where hypertensive women with a minimum age of 50 years were submitted to a muscle endurance training followed by aerobic training, resulting in differences in VO_{2max} of 1.48 to 1.87 ($L.min^{-1}$). Yet, differences in training intensities among studies make it difficult to compare their results.

Regarding the levels of flexibility from pre- to post-test and between groups, no differences were observed at the post test. Similar results were reported by Da Silva et al.[28], who found no changes in AS and SA groups after 12 weeks of intervention in their study with adult women. Rebelato et al.[29] found no difference in levels of flexibility of elderly women who participated in a fitness program involving strength workouts and aerobic power in the same session. Contradicting the results of the present study, Boganha et al.[30] found improvements in flexibility when studying the effects of 10-week-program with three sessions of CT (strength and aerobic) in postmenopausal women, thus a plausible explanation for the difference between the results may be the fact that the study by Boganha et al.[30] assessed sedentary women.

Some limitations of this study should be observed. The small sample size per group influenced negatively in the statistical power and may have left out some important differences as well as statistically significant. The lack of a nutritional control of the participants' diet is also another aspect that may have negatively influenced the results.

Regarding dynamic strength, the study's results suggest that the physical exercise program was effective only when compared to the CG, except for the A group in upper limb strength testing, although no differences were found between the trained groups. As for cardiovascular fitness, AS and SA were different compared to the CG, but no improvement was observed from pre- to post-training. In sum, our findings suggest that CT in elderly women was similar to performing either aerobic and strength exercises separately. Further studies are warranted, including nutritional control and a larger sample size, to increase the power of statistical analyses.

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