Motriz, Rio Claro, v. 28, n. Especial 2, 2022, e10220001922 *DOI: http://dx.doi.org/10.1590/s1980-657420220001922*
Special Issue: Physical Training in Older Adults

Acute and Chronic Effects of Exercise in Health

The execution order of the concurrent training and its effects on static and dynamic balance, and muscle strength of elderly people

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Abstract - Aim: Assess the effect of the performance order in the Concurrent Training (CT), Aerobic-Strength (AS), and Strength-Aerobic (SA), in the static balance, dynamic balance, and muscle strength in elderly people. **Methods:** The study involved 38 elderly people (men and women) aged 60 to 75 years old, divided into SA (n = 19) and AS (n = 19). Within 12 weeks, the aerobic training consisted of walking with intensity prescribed by the Borg's Rating of Perceived Exertion (6-20) and the strength training consisted of six exercises, with intensity controlled by Repetition Maximum training zones. Static balance (plantar pressure center area and displacement in bipedal support with eyes closed and open), dynamic balance (Timed Up and Go and Tandem Gait), and maximum dynamic strength of knee extension and bench press have been evaluated. For data analysis, Generalized Estimating Equations with Bonferroni's complimentary test have been used ($\alpha = 0.05$). **Results:** For static and dynamic balance there hasn't been an effect on the 12 weeks of combined training, regardless of the performance order. Both groups maintained the balance variables within the intervention period. When it comes to strength, there has been a noticeable improvement in lower limbs (SA: 16%; AS: 11%; $p < 0{,}001$) and upper (SA: 22.0%; AS: 8.7%; $p < 0.001$), without any differences between the groups. **Conclusion:** So there is no difference between the order of performance of the CT in the variables of static and dynamic balance and strength of upper and lower limbs. Furthermore, after training, there have been significant improvements in the variables of strength and maintenance of static and dynamic balance.

Keywords: combined training, aging, balance, maximum strength.

Introduction

Aging is a natural progressive and dynamic process that causes functional changes that impair sensory, cardiovascular, bone and muscle systems[1]. In this case, the abilities of the central nervous system, in charge of the control of body balance, are impaired as age advances. Moreover, balance impairments are associated with muscle weakness, because changes in the neuromuscular system can harm the center of mass[2]. These changes impair the sensory system that sends information to the motor system, in addition to altering muscle recruitment patterns, so it can affect even simple activities, such as standing up or getting up from a chair[3].

It is important to mention that falls are the sixth cause of death in elderly people[4]. Approximately 28% to 35% of people aged 65 and over suffer this type of accident each year, and such rate rises to 32% to 42% in individuals over 70 years old[5]. Regular physical activity practice is considered a way to maintain the physical capability in elderly people, reverse the loss of muscle mass, and contribute to the preservation of functional autonomy[6].

In this regard, the American College of Sports Medicine[7] recommends that elderly people receive stimulation in training both to optimize global muscle strength and to get cardio-respiratory conditioning. Thus, the combination of Strength Training (ST) and Aerobic Training (AT) appears to be the best alternative for elderly populations[8,9]. Some studies have acknowledged that the combination of ST and AT in the same session and this order has been showing more benefits in neuromuscular and cardiorespiratory functions than in the opposite order[10,11]. This difference in the orders can be explained by the training configuration itself, such as training volume, intensity, and frequency[10]. Thereby, it has been demonstrated that when training AT at higher intensities, the fatigue accumulated is greater and it may impair the performance in the ST[9-11].

As far as we concern, we haven't found enough theoretical foundations to discuss the relation of the order of performance of concurrent training on the balance variables. Bearing in mind that depending on the order of the training performance there may be different responses of the neuromuscular functions[9-11] and that muscle strength gains are often associated with better balance[12], it would be important to investigate if the static and dynamic balance isn't affected by the order of the concurrent training (CT) as well.

Therefore, because the CT is beneficial and contributes to reducing the deleterious effects of aging, being able to improve cardio-respiratory responses concomitantly with neuromuscular responses, and that the physical activity practice can improve the balance in elderly people, it is important to investigate and get to know the influence of the order of the CT over the balance in senior people. These results will allow better organization and prescription of the CT for this population. Given the above, the aim of the study has been the assessment of the effect of the order of performance of the strength and aerobic exercises of the CT on static and dynamic balance and muscle strength in elderly people. The hypothesis is that CT, regardless of the order of performance, will improve static and dynamic balance and muscle strength in older adults.

Material and methods

Research design

This is a quasi-experimental study, quantitative in nature, done within a 12 weeks training length. It was carried out at the Physical Education and Physiotherapy School of the Federal University of Uberlândia (FAEFI/UFU) and approved by the Research Ethics Committee (CEP) with Human Beings, under the Certificate of Presentation of Ethical Appreciation (CAAE) n. 00651718.8.0000.5152 and opinion n. 3.353.225.

Participants

The volunteers recruited for the study were part of the Physical and Recreational Activities for the Elderly (AFRID) extension program held at Faefi/UFU. The promotion was done through verbal communication at the program's office from August 2018 to September 2019. In such context, the sample was selected on a non-random and voluntary basis, in which men and women aged 60 to 75 years old without joint, musculoskeletal, or cardiovascular complications that would restrain the performance of physical exercises could participate - they should have been without practicing systematic physical activities for at least three months. This period was coincidentally for most of them, the vacation period of the extension program. Thus, in Table 1, the modalities practiced by the elderly people in the year prior to the study and what type of physical activities were performed will be shown, in case they had done it during the vacation period. Before starting the training program, participants should read and sign the Informed Consent Form (Termo de Consentimento Livre e Esclarecido - TCLE) and present a medical authorization to participate in the activities.

Table 1 - Sample characterization of the participants.

Variables	**SA**	**AS**	**p**
	M = 9 /F = 10	**M = 9 /F = 10**	
	Mean ± SD	**Mean ± SD**	
Age (years)	65.3 ± 4.1	66.5 ± 5.5	0.453
BM (kg)	71.5 ± 14.1	74.8 ± 14.9	0.493
Height (cm)	164.1 ± 9.4	161.3 ± 9.8	0.379
BMI ($kg.m^{-2}$)	26.7 ± 5.2	28.6 ± 5.0	0.259
BF (%)	33.1 ± 9.2	36.4 ± 10.1	0.329
MM (kg)	26.4 ± 6.8	26.6 ± 6.0	0.912
Illnesses			
None n (%)	8 (42)	7 (36)	
Diabetes n (%)	2 (10)	5 (26)	
Hypertension n (%)	9 (47)	7 (36)	
Experience time with some sort of physical exercise			
Zero	3 (15)	4 (21)	

(*continued*)

Table 1 - continued

Variables	**SA** **M = 9 /F = 10** **Mean ± SD**	**AS** **M = 9 /F = 10** **Mean ± SD**	**p**
< 4 months	6 (31)	3 (15)	
≥ 4 months	10 (52)	12 (63)	
	Physical exercise modality*		Weekly frequency
None n (%)	3 (15)	4 (21)	0
Water aerobics n (%)	3 (15)	4 (21)	2-3
Dance n (%)	1 (5)	0 (0)	2
Stretching n (%)	2 (10)	3 (15)	2
Bodybuild n (%)	9 (47)	7 (36)	2-3
Functional training n (%)	1 (5)	1 (5)	2
	Physical activities performed on vacations		Weekly frequency
None n (%)	16 (84)	14 (73)	0
Walking n (%)	1 (5)	4 (21)	1-4
Bike riding n (%)	2 (10)	0 (0)	3-7
Soccer n (%)	0 (0)	1 (5)	1

SA: Strength training followed by Aerobic; AS: Aerobic training followed by Strength; M: Males; F: Females: BM: Body Mass; BMI: Body Mass Index; BF: Body Fat; MM: Muscle Mass:
*Physical activities carried out in the extension program before the three months vacation period before the study start.

Sample size

The sample calculation was done through the software GPOWER® (version 3.1), based on a similar study[9], in which α = 0,05 was adopted, a power of 80% and effect size of 0,8; so “n” has been defined in 17 elderly people for each group. With a sample loss prediction of 20-26% based on research with elderly people previously carried out[13,14], additional participants were included in the total sample, in order not to reduce the statistical power of the tests - in this case, “n” was composed of 20 volunteers in each group, at least.

The participants of the study were 51 elderly who were divided into two groups: Aerobic-Strength (AS; n = 25) and Strength-Aerobic (SA; n = 26). This division was due to the availability of time for the participants to perform the training since the study was carried out within a university extension program.

Sample characterization

Before the assessment tests, the elderly answered an anamnesis with questions related to aspects such as age, the practice of physical activities (practice time, weekly frequency, and modality), history of illnesses, use of medication, and time availability to participate in the training.

Body composition consisted of measuring Body Mass (BM), Body Fat (BF), Muscle Mass (MM), and Body Mass Index (BMI) through tetrapolar bioimpedance (In Body 230 Trepel®, Perafita, Portugal) provided by the device's reading software, while height (cm) was obtained from a wall-mounted stadiometer (Sanny®, São Bernardo do Campo, SP, Brazil).

Static balance

Static and dynamic balance assessments were performed at the Faefi/UFU Biomechanics Laboratory. Regarding the assessment of static balance on the force plates (Biomec®400-412), were the evaluators blinded by the interventions, volunteers were asked to go up, position their feet on the indicated markings and maintain an upright and quiet position, with the least possible movement, their gaze fixed at a marked spot on the wall and arms relaxed on the side of their bodies.

For data acquisition and processing EMGlab2 System® software from Brazil (version 3.0 – 2016) was used, with a sampling frequency of 200 Hz and acquisition time for each collection of 30 s, in which there were two attempts with eyes closed and open, following that order, totalling four measurements at the end of the process[15,16]. The signal was filtered in the program itself, which was set to perform a band pass filter from 0 to 35 Hz. For analysis, the initial and final five seconds were excluded to avoid any postural interference. Afterward, the data were exported to a Microsoft Office Excel® spreadsheet, and, from this, the values of the total displacement and the area of the Foot Plantar Center of Pressure (COP) of the two attempts in each situation were obtained - eyes open and closed - and the averages were calculated.

Through this assessment, the movement of the COP is quantified and body oscillations are detected, based on the point of application of vertical forces on the support surface. Higher sway rates may indicate a more unstable postural control pattern[17].

Dynamic balance

The dynamic balance assessment used the Tandem Gait test, which evaluates the gait time according to the performance when walking on a three meters tape. For the task, the volunteer was asked to walk on the tape, as the heel was directly in front of the toes of the other foot at each step, in addition to looking straight ahead, without changing the focus to their feet. As standards of the procedure, the use of a stopwatch and the verbal command for the volunteer to start the test were established (counting started as soon as the first step was taken on the line). Two measurements were performed, presented in seconds, with a one-minute interval between them - for the analysis the attempt with the lowest value was considered[18].

Other than that, the *Timed Up and Go* (TUG) test was also used, consisting of getting up from a chair without any help of the arms, walking a three meters distance as fast as they could without running, turning around the cone, returning, and sitting again on the chair. In a standardized way, the verbal command for the volunteer to start the test was established, one, two, three, and in the "go" the volunteer should walk the requested path, the counting started as soon as the back started to leave the back of the chair and ended when returning, sitting down on the chair and leaning the back against the chair again. For that matter, a familiarization was carried out and the measure was presented in seconds[19]. For the Tandem and TUG dynamic balance assessments, the raters were not blinded.

Dynamic maximum strength

The maximum dynamic strength was evaluated through the One-Repetition Maximum test (1RM) in the knee extension exercises (FreeStyle - Righetto) and bench press (FreeStyle - Righetto). Before and after training, two familiarization sessions were performed with both exercises. In the knee extension exercise, men performed the unilateral test with the dominant leg, and women, bilaterally. During this procedure, no pause was allowed between the eccentric and concentric phases, which were controlled by a metronome, with two seconds for the eccentric phase and the other two for the concentric one. For a successful repetition, a complete motion range was necessary and, in order to obtain maximum effort from the volunteers, the researchers verbally encouraged the participants during the assessment.

Before the test, volunteers went through a warm-up session consisting of 20 repetitions of the exercise with minimal load and one minute of rest for the first attempt - a total of five attempts were allowed, with a five minutes rest between them. After the warm-up, an initial load was placed, with which the volunteers could not perform more than 10 repetitions - if they exceeded this number, a new five minutes interval was taken and a new load was adjusted. To estimate the loads during the test, Lombardi's coefficients[20] were used and, if the 1RM load was not found, the test would proceed on a different date, with a minimum interval of 24 hours[21].

Interventions

Before the interventions started, the elderly performed two sessions of familiarization with the AT and ST. The CT took place twice a week, with a 45 min length (20 min of AT and 25 min of ST) - if the elderly were absent, they could replace the missed class another day. Before starting the class, Borg's scale of perceived exertion (PE) (6-20) was displayed to show the intensity to be worked on in that session and, at each mesocycle, the explanation about the scale was resumed.

The AT consisted of a walk on the athletics track, guided by professionals and students of the Physical Education school, experienced in the given modality. As mentioned before, exercise intensity was prescribed by PE. In the first mesocycle (week 1-4), the continuous class strategy was adopted, with intensity kept at 13 (lightly intense) for 20 min; in the second (week 5-8), the interval strategy was used, with four blocks of four minutes at 15 (intense) and one minute at intensity 11 (light); and, in the third (week 9-12), there was a continuous strategy, with intensity kept at 15 (intense) for 20 min. During training, the elderly received verbal stimulation about changes in intensity.

The ST was performed at the bodybuilding gym and led by a professional and two physical education students, who had experience with the modality. This training consisted of six exercises that aim to work the main muscle groups - knee extension, horizontal leg press, vertical pull, bench press, lateral elevation, and plank exercise - and Maximum Repetitions (MR) was adopted for the training prescription. In the first mesocycle (week 1-4), the volunteers performed two sets of 15 MR; in the second (week 5-8) three sets of 12 MR; and in the third (week 9-12) four sets of eight MR were performed.

Statistical analysis

Descriptive statistics were used, with values presented as Mean and Standard Deviation (SD). For normality, the Shapiro-Wilk test was adopted, and the sample characterization data were analyzed using Student's T-test. To analyze the interventions, the data were analyzed with per-protocol analysis, using a linear model the Generalized Estimating Equation (GEE) method, with the factors group and time - to locate the differences, Bonferroni's complementary test was used. The level of significance adopted was $\alpha = 0.05$, and all statistical tests were performed using the SPSS® software (version 23.0). Effect size was calculated by the “Cohen's d” method: < 0.19 = insignificant; 0.20-0.49 = small; 0.50-0.79 = medium; 0.80-1.29 = large; and > 1.30 = very large. From the values obtained for effect size, the power was determined with the GPOWER® software (version 3.1).

Results

Figure 1 shows the flowchart with the distribution of participants in the study. Recruitment was carried out in two moments (August 2018 and March 2019). From this on, a total of 294 elderly people who were regularly enrolled in the extension program have been reached.

The sample characterization can be seen in Table 1, in which no significant differences have been found between the groups for all variables presented.

The results of static balance are described in Table 2. In the variables of the total displacement of the COP and area of the COP, both with eyes open and closed, values were maintained after training, with no difference between groups. Effect size values ranged between small and medium, and power between 0.43 and 0.99.

Table 3 specifies the results of dynamic balance and maximum dynamic strength. In the TUG variable, there is a difference between the groups (p = 0.044), with lower initial values for the SA group and no difference between pre and post-training. Furthermore, maintenance of values was observed with both pieces of training. Maintenance was also observed for the Tandem Gait values, in addition to not having found any difference between the groups. In maximum dynamic strength, there is a significant difference in time to strength in the bench press exercise (SA:

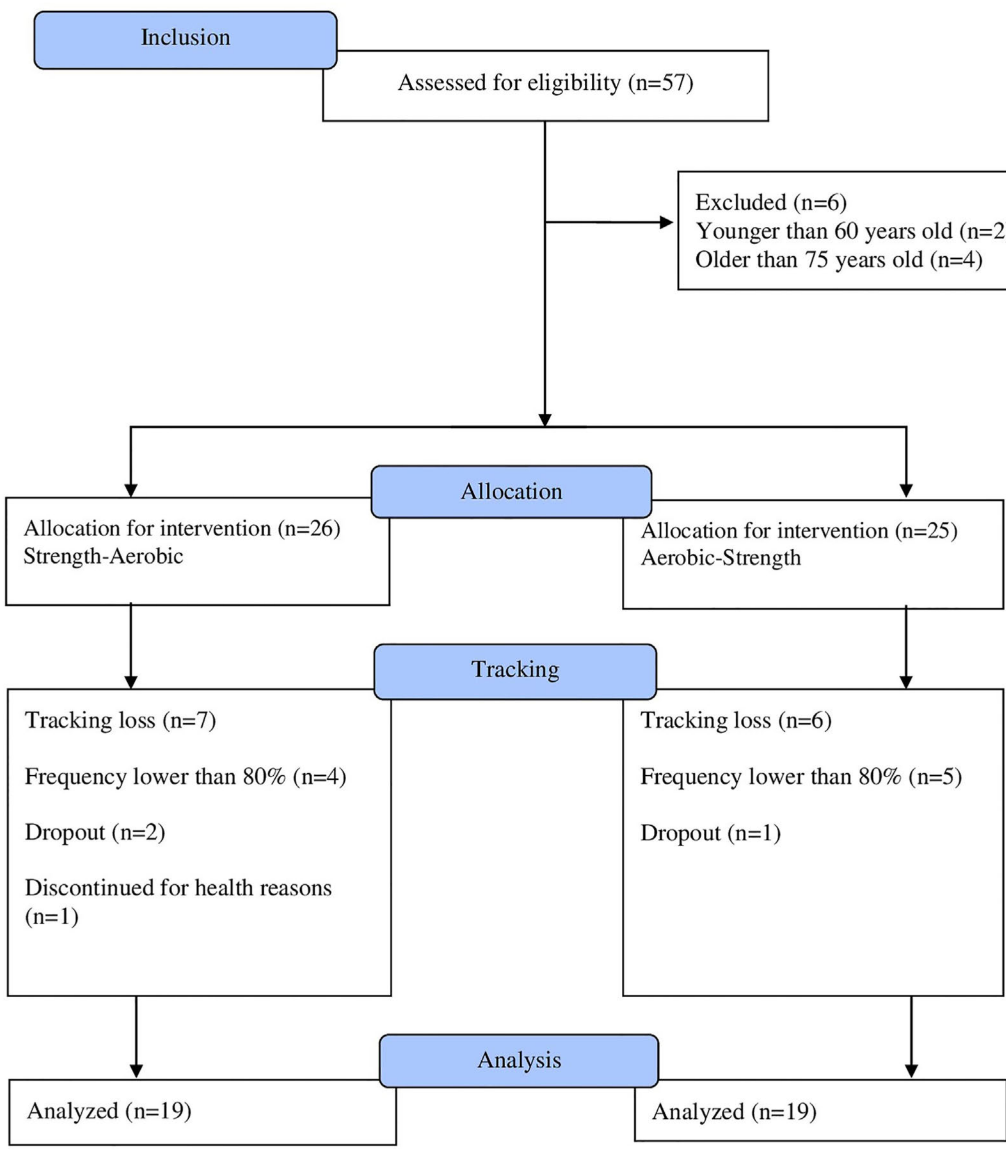

Figure 1 - Flowchart of the Consolidated Standards of Reporting Trials, CONSORT, with the selection and allocation of volunteers.

Table 2 - Static balance variables with eyes closed and open from older people. SA: Strength-Aerobic; AS: Aerobic-Strength; COP_DISP: total displacement of the Foot Plantar Center of Pressure; COP_AREA: area of the Foot Plantar Center of Pressure.

Variables	Group	Pre	Post	Δ	d of Cohen	Power
		Mean ± SD	Mean ± SD	Mean ± SD		
Eyes closed						
COP_DISP (cm)	SA	28.1 ± 5.1	27.9 ± 4.2	-0.1 ± 2.6	-0.23	0.78
	AS	30.6 ± 8.2	33.8 ± 18.7	-0.6 ± 11.0		
COP_AREA (cm^2)	SA	1.3 ± 0.7	1.1 ± 0.6	-0.2 ± 0.7	-0.08	0.16
	AS	1.9 ± 2.4	1.9 ± 1.8	-0.01 ± 3.0		
Eyes open						
COP_DISP (cm)	SA	25.3 ± 3.0	25.1 ± 2.8	-0.3 ± 2.4	-0.11	0.26
	AS	26.3 ± 4.0	26.9 ± 4.4	0.5 ± 4.3		
COP_AREA (cm^2)	SA	1.0 ± 0.6	1.2 ± 0.7	0.1 ± 0.5	0.27	0.89
	AS	1.5 ± 1.1	1.3 ± 0.7	-0.1 ± 1.3		

Table 3 - Dynamic balance variables and maximum dynamic strength of upper and lower limbs from older people.

Variables	Group	Pre	Post	Δ	d of Cohen	Power
		Mean ± SD	Mean ± SD	Mean ± SD		
TUG (s)	SA	6.3 ± 0,8[#]	6.5 ± 1.4	0.13 ± 0.8	0.18	0.57
	AS	7.1 ± 1.2	7.1 ± 0.9	-0.01 ± 0.7		
T.G. (s)	SA	10.8 ± 3.7	11.3 ± 5.4	0.49 ± 4.07	0.39	0.99
	AS	13.0 ± 4.7	11.9 ± 3.5	-1,06 ± 3.36		
B.P. (kg)	SA	22.6 ± 14.1	27.1 ± 16.3[*]	4.5 ± 3.9	0.14	0.38
	AS	23.6 ± 14.0	25.9 ± 15.0[*]	3.68 ± 7.06		
K.E. (kg)	SA	55.0 ± 12.1	64.6 ± 12.7[*]	9.2 ± 2.1	0.44	0.99
	AS	52.5 ± 20.5	58.8 ± 20.8[*]	5.9 ± 7.06		

SA: Strength training followed by Aerobic; AS: Aerobic training followed by Strength; TUG: *Timed Up and Go*; T.G.: Tandem Gait; B.P.: Bench Press; K.E.: Knee Extension;
[*]represents the difference between time ($p < 0.05$);
[#]represents the difference between groups ($p < 0.05$).

22.0%; AS: 8.7%; $p < 0.001$) and in knee extension (SA: 16%; AS: 11%; $p < 0.001$), with increased values in both groups after training, however without difference between groups. Effect size values ranged between small and medium, and power, between 0.13 and 0.99.

Discussion

The main objective of this research was to evaluate the effect of the order of performance of strength and aerobic exercises of the CT on static and dynamic balance and muscle strength in elderly people. After 12 weeks of intervention with CT, regardless of the order in which the CT was performed, static and dynamic balance variables were maintained. For the maximum dynamic muscle strength of lower and upper limbs, there was an improvement after 12 weeks in both groups, with no difference between the performance orders.

Age advances are followed by a balance decline, which is directly associated with a major cause of falls in elderly people[22]. According to Melzer, Benjuya, and Kaplanski[23], this decline may be associated with more COP oscillations, which displays a more unstable pattern of postural control. Physical exercises promote various benefits for the elderly, as they work to maintain and/or improve balance and prevent falls[24]. Literature has shown that some modalities present maintenance and/or improvements in static balance when they work on balance concomitantly with ST[25-27] and concomitantly with AT[28,29].

Regarding the effect of CT order on static balance, as far as we are concerned, no study has been found in the literature. Looking for CT studies, the study by Holviala et al.[30], for example, assessed the effect of CT (SA order) on static balance variables, and, after 21 weeks, they found maintenance, as in the findings of the present research. Marques et al.[31] found significant improvements in static balance variables after 32 weeks of ST in elderly women.

However, the authors evaluated the static balance in a one-legged stance, which presents greater instability when compared to the bipedal stance used in this study. Thus, possibly in the present study, the chosen assessment was not sensitive enough to detect improvements in static balance, since bipedal support does not generate major challenges for the maintenance of posture in elderly people who do not present any sensorimotor impairment. Furthermore, the different responses between the studies can be justified by methodological differences such as the type of training and the length of the study.

One aspect that may have influenced the lack of improvements in the static balance is because the elderly people, who were the subject of this study, already have good balance. In literature, for example, Oliveira et al.[32], compare the responses of different modalities of physical training (mini-trampoline, aquatic gymnastics, and general gymnastics) on the static balance of the elderly and noted significant improvements in the balance after training. The initial values of the COP area with eyes open in the groups assessed in this study were approximately 1.8 cm^2, whereas, in the present study, it was 1.0 ± 0.6 cm^2 for the SA group and 1.5 ± 1.1 cm^2 for the AS group. Thereby, it is believed that the elderly started this study with values that were considered good, which reduces the adaptation window for these outcomes. It is noteworthy that to date, there is no reference data for the classification of balance based on COP values.

Regarding the dynamic balance (TUG), the study carried out by Wilhelm et al.[13], assessed the effect of the order of 12 weeks of CT on the dynamic balance (TUG) of 36 elderly and found no significant differences in time and between orders (Pre- AS: 5.19 ± 1.30 s; SA: 4.96 ± 0.65 s; Post- AS: 4.98 ± 0.95 s; SA: 4.98 ± 0.61 s). These findings are in line with the present research, which, in this variable, also showed maintenance in both groups (Pre- SA: 6.39 ± 0.89 s; AS: 7.16 ± 1.26 s; Post- SA: 6.52 ± 1.4 s; AS: 7.14 ± 0.93 s)) the absence of changes could be due to the ceiling effect of the test to capture changes. The study by Varela et al.[33] researched the effect of TUG in 27 elderly people and found significant reductions (Pre: 11.96 ± 2.4 s; Post: 9.9 ± 2.3 s).

The training was carried out for 12 weeks, but the initial balance values of the elderly were above ten seconds, which demonstrates a larger window for improvement when compared to the present study and the study by Wilhelm et al.[13]. Other than that, the training carried out by Varela et al.[33] took place three times a week, which may also have generated greater adaptation when compared to the twice-a-week frequency used in this research. In this regard, it is noteworthy that, when it comes to the normative values of the TUG test, the elderly in this study did not have compromised balance, as TUG values lower than ten seconds suggest that these individuals are healthy and have no risk of falls and functional dependence[19].

In the present study, the dynamic balance was also assessed using the Tandem Gait test, a reliable measure to verify dynamic balance[34,35], in which there was the maintenance of the variable in both groups. No studies with CT that have evaluated this outcome have been found; however, the maintenance of such responses is a relevant result in favoring the autonomy of the elderly, since the reduction in gait speed jeopardizes their daily activities[36].

Overall, the CT performed in this study did not show improvements in static and dynamic balance variables. It should be noted that the specificity of training may be a factor that has influenced, as there was no specific balance training. Nevertheless, after training, these variables were maintained, which is important because, as a person ages, there is a significant drop in these parameters. Clearly, the benefits will affect the quality of life and functional capacity of the elderly, as well as reducing the risk of falls[38].

The results showed an increase in lower limb strength values (SA: 16%; AS: 11%) after the interventions, regardless of the order. In the study by Wilhelm et al.[10] significant improvements were found in the maximum dynamic knee extension strength in the groups (SA: 11%; AS: 14%), with no difference between orders. The study by Campos et al.[14], comprised 12 weeks of CT with 22 physically active elderly women, in which they observed an increase in knee extension strength from the pre to the post-training period in both groups (SA: 57%; AS: 58%), without differences between orders.

On the other hand, Cadore et al.[9] investigated the effects of different orders of combined exercises on neuromuscular adaptations with 26 elderly people within 12 weeks. They observed a significant increase in the maximum dynamic strength of knee extensors (SA: 35%; AS: 21%), with a significant difference between the higher orders and values for the SA group, since this order is beneficial to the result of the dynamic strength of the lower body[10]. In this case, the AT occurred in a cycle ergometer and with high intensity (second ventilatory threshold), which may have generated fatigue in the muscles of the lower limbs and limited the greater strength gains in the lower limbs in the AS group. When AT is performed at high intensities before ST, the “interference effect” may occur, which reduces the magnitude of muscle strength or power development, compared to strength training performed alone[38,39]. In this research, there has not been such interference, probably because the AT was prescribed at lower intensities, with the use of walking/running as an exercise, without generating enough fatigue in the muscles of the lower limbs that could impair performance in the subsequent ST. Although no significant difference was found, absolute and relative changes were observed between orders (SA: 9.6 kg; AS: 6.3 kg) and an effect size of 0.44.

Finally, the maximum dynamic strength of upper limbs also showed improvements after training in both groups (SA: 22.0%; AS: 8.7%), with no difference between them. Cadore et al.[9], corroborate the findings of this research, as both groups improved the strength of upper limbs after training (AS: 15.0%; SA: 11.5%), with no difference between groups. The non-interference of the performance order in the improved strength of the upper limbs was expected since the AT performed did not generate localized fatigue in this musculature, thus, it was not expected that there would be a compromise in the strength gains of the upper limbs.

The main limitations of the study are the absence of blinding of outcome assessments and the randomization of groups. However, the study has strengths, such as the assessment of balance after CT, which still has scarce data in the literature, and also the assessment of balance using a force plate, considered the gold standard assessment for this variable. In addition, the prescription of individualized and easy-to-apply training for elderly groups is highlighted, making it an interesting methodology considering physical exercise programs for the elderly.

Conclusions

Given the results obtained in this research, the conclusion is that there is no difference between the CT performance orders for static and dynamic balance, as well as for the muscle strength of the lower and upper limbs. However, both training orders improved the strength of lower and upper limbs and maintained the static and dynamic balance of the elderly.

Acknowledgments

This research has been funded by grants from the Coordination for the Improvement of Higher Education Personnel (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - CAPES) and the National Council for Scientific and Technological Development (Conselho Nacional de Desenvolvimento Científico e Tecnológico-CNPq).

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Manuscript received on February 16, 2022
Manuscript accepted on May 30, 2022