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# Impact of concurrent training on the functional fitness of older women in the post pandemic scenario

## Impact of concurrent training on the functional fitness of older women in the post pandemic scenario

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**ABSTRACT**

**Introduction:** The decline in functional capacity in the elderly is related to neuromuscular and metabolic changes, making concurrent training (CT) a promising option. However, there is still a lack of investigations analyzing its real effects on multisystem responses directed to the daily activities of untrained older women. **Objective:** To verify the effects of concurrent training on the functional fitness of untrained older women. **Methods:** Forty older women completed eight weeks of training, being randomized into two groups: Concurrent training (CT: n = 26; 66.54 ± 5.76 years) and Control Group (GC: n=14; 68.29±5.97 years). Functional fitness was verified by means of the following tests: Test putting on and taking off the shirt; Lift off the ground; Gallon-jug shelf-transfer; Time-up-go; Sit to stand and Walking speed in 10 m. **Results:** At the end of the intervention, the CT showed statistically significant improvements in all variables in relation to the initial values. When compared to the CG, the CT promoted statistically significant adaptations in the variables: 1-Test on and off the shirt (CT: 14.38 ± 2.60 vs CG: 15.52 ± 2.79 sec; Δ%: 7.9; $p \leq 0.05$); 2-Lifting from the ground (CT: 2.99 ± 0.70 vs CG: 3.72 ± 0.76 sec.; Δ%: 24.4; $p \leq 0.01$); 3-Walking speed in 10 meters (CT: 5.38 ± 0.62 vs. CG: 6.01±1.02 sec; Δ%:11.7; $p \leq 0.02$); 4- Time up go (CT: 6.06 ± 0.67 vs. CG: 6.50 ± 0.98 sec.; Δ%: 7.2; $p \leq 0.05$); 5-Sit to stand (CT: 5.34 ± 0.95 vs. CG: 6.20 ± 1.54 sec; Δ%: 16.1; $p \leq 0.03$); 6-Gallon-jug shelf-transfer (CT: 9.67 ± 1.29 vs. CG: 11.31 ± 1.94 sec.; Δ%: 17.5; $p \leq 0.01$). **Conclusion:** Concurrent training has been shown to be effective in improving functional fitness in untrained older women.

**Keywords:** resistance training; aging; daily activities; quality of life.

**RESUMO**

**Introdução:** O declínio da capacidade funcional em idosos está relacionado com alterações neuromusculares e metabólicas, fazendo do treinamento concorrente (TC) uma opção promissora. Porém, observa-se ainda uma carência de investigações analisando seus reais efeitos em respostas multisistêmicas direcionadas as atividades cotidianas de idosas destreinadas. **Objetivo:** Verificar se o treinamento concorrente é eficaz em melhorar a aptidão funcional de idosas destreinadas. **Métodos:** Quarenta idosas concluíram oito semanas de treinamento, sendo randomizadas em dois grupos: Treinamento Concorrente (TC: n = 26; 66,54 ± 5,76 anos) e Grupo Controle (GC: n = 14; 68,29 ± 5,97 anos). A aptidão funcional foi verificada por meios dos seguintes testes: Teste vestir e tirar a camisa; Levantar do solo; Transferência de galões; *Time up go*; Sentar e levantar da cadeira e Velocidade de marcha em 10 m. **Resultados:** Ao final da intervenção, o TC apresentou melhoras estatisticamente significativas em todas as variáveis com relação aos valores iniciais. Quando comparado ao GC, o TC promoveu adaptações estatisticamente significativas nas variáveis: 1-Teste vestir e tirar a camisa (TC: 14,38 ± 2,60 vs. GC: 15,52 ± 2,79 seg; Δ%: 7,9; $p \leq 0{,}05$); 2-Levantar do solo (TC: 2,99 ± 0,70 vs. GC: 3,72 ± ,76 seg.; Δ%:24,4; $p \leq 0{,}01$); 3-Velocidade de marcha em 10 metros (TC: 5,38 ± 0,62 vs GC: 6,01 ± 1,02 seg; Δ%:11,7; $p \leq 0{,}02$); 4-Time up go (TC: 6,06 ± 0,67 vs. GC: 6,50 ± 0,98 seg.; Δ%:7,2; $p \leq 0{,}05$); 5-Sentar e levantar da cadeira (TC: 5,34 ± 0,95 vs. GC: 6,20 ± 1,54 seg; Δ%: 16,1; $p \leq 0{,}03$); 6-Transferência de galões (TC: 9,67 ± 1,29 vs. GC: 11,31 ± 1,94 seg; Δ%: 17,5; $p \leq 0{,}01$). **Conclusão:** O treinamento concorrente demostra-se eficaz na melhora da aptidão funcional em idosas destreinadas.

**Palavras-chave:** treinamento resistido; envelhecimento; atividades diárias; qualidade de vida.

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## Introduction

Biological aging is associated with declines in neuromuscular components such as maximum strength, power, muscle mass and quality, as well as cardiorespiratory components, resulting in impairments in the ability to perform simple day-to-day tasks [1,2].

From this perspective, a combination of aerobic and resistance exercises in the same session, which is characterized as Concurrent Training (CT), can be considered an interesting proposal to improve the functionality of the elderly, as it induces both neuromuscular and cardiorespiratory gains [3,4].

In senile populations, relevant studies have demonstrated similar effects between CT and isolated resistance training on maximal strength and muscle mass [5,6]. Likewise, there are important investigations clarifying the order of exercises, weekly frequency and ideal workload [7-9]. However, there is still the absence of a systematized and easy-to-apply CT model in the studies available in the literature, as well as a lack of investigations analyzing its effects on specific tests to verify functional performance for daily activities in untrained elderly women in the post-pandemic period.

The results of the present study can provide support to professionals in the field, based on understanding the effects of a training protocol with particularities that are rarely described in current literature. Therefore, the objective of the present study was to verify whether concurrent training is effective in improving the functional fitness of untrained older women. We work with the hypothesis that training protocols that stimulate different components of physical fitness in the same session are effective in adaptive responses related to the functionality of older women

## Methods

This is a randomized and controlled clinical trial carried out over 12 weeks, with eight weeks dedicated to the application of the CT, two weeks used for data collection and two for familiarization (Figure 1). The dependent variables were measured using standardized and reliable tests in a spaced manner, aiming to detect variations in response to interventions and minimize the effects of intervening factors.

The investigation was conducted in accordance with the declaration of Helsinque (1964, revised in 2001) and approved by the Ethics Committee of the Federal University of Sergipe (nº 3.225.938), registered in Brazilian Clinical Trials Registry (ReBEC) under protocol RBR-2d56bt. This clinical trial proposal complies with the recommendations of the CONSORT (http://www.consort-statement.org) and some hypotheses on the topic were published before this project [4,10,11].

## Participants

Participants who met the following criteria were included in the intervention: (a) aged between 60 and 80 years, (b) female, (c) not engaged in physical training programs in the six months prior to the start of the study, (d) able to walk 100 m without using a cane and climb 10 steps without resting; (e) with a score ≥ 14 on the mini mental state exam [12]; and (f) with medical clearance. Those who presented any of the following conditions were not included in the study: (a) hypertension ≥ stage 2 (systolic ≥ 160 mmHg and diastolic ≥ 100 mmHg), (b) degenerative joint disease or joint implants, (c) cardiovascular disease and/or or pulmonary disease that prevented the practice of high-intensity exercise, or (d) neurological deterioration. Furthermore, participants who missed any stage of the intervention and those who completed less than 90% of the training sessions were excluded from the analyses.

Recruitment was carried out through advertisements on social networks, radio and leafleting in residential neighborhoods close to the university center. Sixty-two untrained older women showed interest in participating in the study. Of these, 12 were excluded because they did not meet the inclusion criteria and 10 did not complete all stages of the intervention. Thus, 50 were allocated by stratified randomization into blocks, in which participants were equally distributed according to the strength of the lower limbs into two distinct groups: Concurrent training (CT: n = 26; 66.54 ± 5.76 years; 28.39 ± 4.01 $kg/m^2$) and Control Group (CG: n = 14; 68.29 ± 5.97 years; 29.94 ± 4.01 $kg/m^2$).

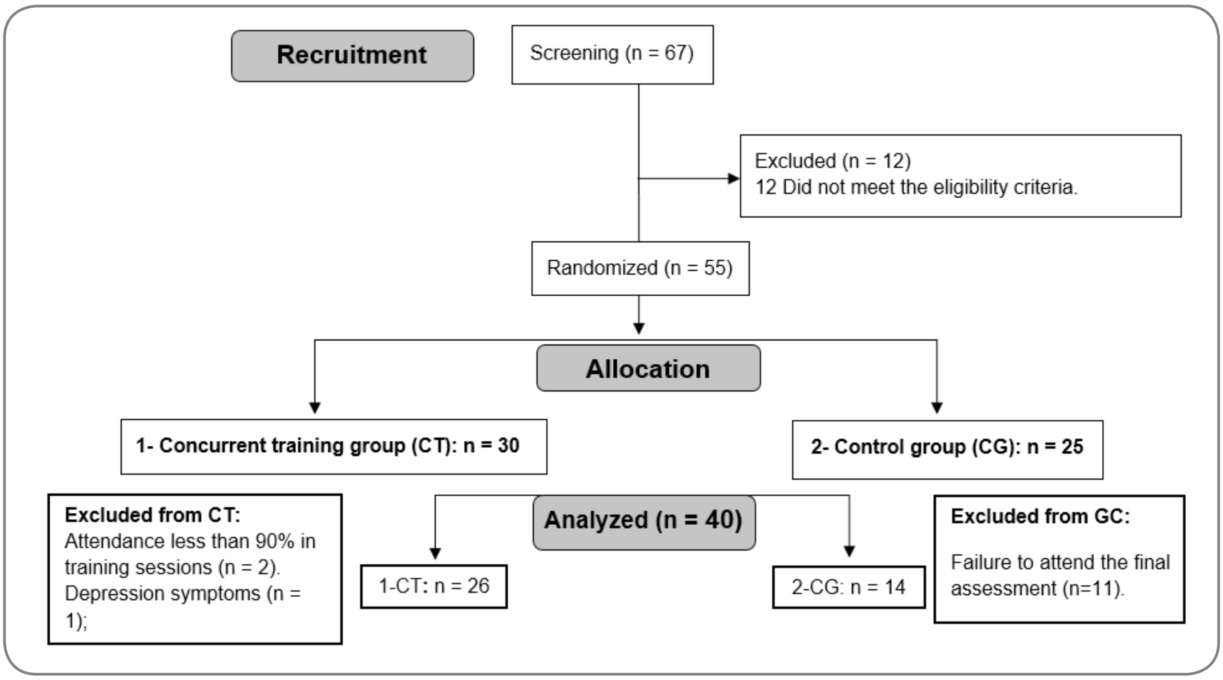


**Figure 1 -** Schematic representation of the study screening, allocation and intervention processes

## Intervention

After the initial assessments, the CT individuals underwent two weeks of familiarization, in which 50% of the intensity planned for the 1st session was applied and completed 24 training sessions, lasting 50 min. The OMNI-GSE scale was used to control intensity, guiding volunteers to choose a single score that reflected their degree of fatigue, during and after each training block [13].

### Concurrent training

The protocol was structured into four blocks, with specific objectives, within the same training session, namely: 1st block – general and specific warm-up; 2nd block – application of resistance training on machines, for the main muscle groups in circuit form; 3rd block – endurance training through interval running; and 4th block – submaximal stretching for the main muscle groups [14,15]. The detailed description of the training protocol can be seen in Chart 1.

**Chart 1 –** Detailed description of the concurrent training protocol

| Blocks | Block 1 | Block 2 | Block 3 | Block 4 |
| --- | --- | --- | --- | --- |
| Sessions | 1st to 24th | 1st to 24th | 1st to 24th | 1st to 24th |
| Exercises | 2 min walk + 15 squats at maximum concentric speed. | Articulated bench press (Machine)<br>45º bilateral leg press (Machine)<br>Front pronated pull-down (Machine)<br>Bilateral plantar flexion (Machine)<br>Bilateral extension chair (Machine)<br>Abductor Chair (Machine)<br>Bilateral flexor chair (Machine)<br>Free squat (Sit and stand) | jogging/ walking | Active submaximal amplitude stretching for the upper limbs (pectoral, deltoid, biceps and triceps) and lower limbs (hamstrings, quadriceps, iliopsoas, gastrocnemius and anterior tibialis), 1 series lasting 15 s in each position. |
| 1st phase of Training (1st to 24th session ). | Total time: 3 min; 2 min - walking; 1 series – 15 squats; SPE: 4-5. | Total time: 32 min; exercises; 2 passages; 40s / 80s by season (20s shift) - Density 1/2; SPE: 7-9. | Total time: 18 min; 30s/60s - Density 1/2; SPE: 6-7. | Total time: 2 min; Density 1/1; SPE 4-6. |

min = minutes; s = seconds; SPE = subjective perception of effort

The training was carried out in circuit form and based on a range of maximum repetitions (8 to 12) to control the load with a cadence of 1 second in the concentric phase and 2 in the eccentric phase. In this sense, whenever participants performed more repetitions than expected, the weight was increased by between 5 and 10%, or the way the exercise was performed was adjusted to maintain the pre-determined repetition range. Similarly, when the desired rep range was not achieved, there was a reduction in the weight used.

From this perspective, trained and experienced physical education professionals supervised the entire exercise protocol. Specifically, there was one professional for every two participants in the concurrent training, as the activities were carried out in pairs. This distribution was used to ensure adequate training execution, participant safety and application of changes to protocols during the intervention to promote training variability.

Finally, the CG was instructed to maintain their daily activities and, with the aim of maintaining the sample during the intervention, relaxation practices were offered every 15 days throughout the eight weeks of intervention.

### Measurements

The performance tests were carried out at three different moments: initial moment of the study (M1); retest after two weeks of familiarization (M2) and after eight weeks of intervention (M3). The evaluators were blinded to the intervention carried out by the volunteer and for all performance tests, the participants were verbally encouraged to do their best.

For anthropometric characterization, body weight (kg) was determined using an electronic scale (Lider®, P150C, Ribeirão Preto, São Paulo, Brazil) with a precision of 0.01 kg, while height was determined using a stadiometer (Sanny®, ES2030, Araraquara, São Paulo, Brazil) with an accuracy of 0.1 cm, based on the perpendicular distance between the transverse plane that crosses the vertex and the point immediately below the feet. Waist and hip perimeters were assessed according to the World Health Organization protocol [16].

To verify functional fitness, tests were used to evaluate components of physical fitness to perform normal daily activities safely and independently, without undue fatigue. Below is a detailed description of all battery tests:

#### *1) Dressing on and taking off a t-shirt*

The assessment of upper limb functional autonomy emphasized mobility, agility and coordination. To do this, the participant was asked to stand, with her arms extended at her sides and with a t-shirt in her dominant hand. At the evaluator's signal ("go") she had to put on the shirt completely and immediately take it off, returning to the starting position. Two attempts were performed with an interval of 1 min between them and the shortest time was considered for analysis. The measure was invalidated if the participant did not put on the shirt completely. Furthermore, this test has an intraclass correlation index (ICC) of 0.75, demonstrating good reliability [17].

#### *2) Rising from prone position*

The participant was instructed to get up from the floor without assistance at the evaluator's command ("go"). The time it took the participant to leave the floor until she was completely standing was considered. It should be noted that three attempts were made and the lowest value was considered for analysis purposes [17].

*3) Walking speed in 10 m*

Maximum walking speed was measured using the 10-meter walk test. Namely, the participant was instructed to walk as quickly as possible along a 14-meter path without any assistance [18]. The test was carried out with the volunteer walking 2 m for acceleration, 10 m for recording time and 2 m for deceleration. This adjustment was made to minimize the effects of acceleration and deceleration when performing the test. The time to cover the intermediate 10 m was recorded using photocells. Two attempts were made with an interval of two min. The measure was invalidated if the participant performed a flight phase, characterizing a race [19].

*4) Time up go*

The functional fitness of the lower limbs was assessed with an emphasis on agility, mobility, dynamic balance and speed. In this sense, the participant began the test sitting on a chair (45 cm, fixed base, AT51, Araquari, Santa Catarina, Brazil) and at the evaluator's command ("go") she had to get up, walk for 3 meters, go around a cone, return to the chair and sit down again. Three attempts were made with an interval of 1 min between them and the shortest time was recorded for analysis. This test has high reliability with an ICC of 0.99. [20].

*5) Five times sit to stand test*

This test measured the functional fitness of the lower limbs with a focus on muscle strength and power in a functional action. For this measurement, the participant was asked to sit and stand up on a chair (45 cm, fixed base, AT51, Araquari, Santa Catarina, Brazil) five times as quickly as possible with arms crossed over the torso after the evaluator's command ("go"). Three attempts were made with an interval of 1 min and the shortest time was considered for analysis. The measurement was invalidated when the participant did not lean back on the seat or remove her arms from her torso. This is a test with good reliability, ICC of 0.95, and a minimum detectable difference of 2.5 s [21].

*6) Gallon-jug shelf-transfer*

Functional fitness with an emphasis on the upper limbs was assessed in an everyday action of transferring gallons on a shelf. To carry out the test, the participant was instructed to stand positioned laterally to a bookcase (2.13 x 1.06 m with adjustable shelves) with one shelf positioned at patella height, another at shoulder height and five gallons (4 kg each) positioned on the bottom shelf next to each other.

Before carrying out the test, the evaluator demonstrated how the test should be performed and instructed the participants to keep their backs straight, not change hands to move the bags, use the lower limbs to help with the movement and in case of discomfort or pain, stop the test execution. Furthermore, a test was carried out during which the evaluator gave feedback for better execution of the test, as during the attempts only guidance was given to use the lower limbs in the movement, without additional corrections.

After that, the test began at the evaluator's command ("go") and two attempts were made with a two min interval between measurements. This was a time-based test and the lowest value was considered for analysis. The attempt was invalidated when the participant moved more than one gallon at a time or changed hands to perform the movement. Furthermore, this test has excellent reliability with an ICC of 0.97 [22].

### Statistical analysis

Descriptive analysis with mean, standard deviation and percentage delta was used to characterize all variables obtained. The reproducibility of the measurements was assessed based on the analysis of the Intraclass Correlation Index (ICI), adopting ≥ 0.90 as the acceptance criterion. The Shapiro-Wilk test was applied to confirm normality and, in case of non-normal data, these underwent a logarithmic adjustment. For the analyses, a 2x2 ANOVA with Bonferroni post-hoc for multiple comparisons was performed. The data were tabulated and analyzed using the Statistical Package for the Social Sciences (SPSS), version 22, adopting a significance level of 5% ($p \leq 0.05$). All tests were two-tailed and the effect size (ES) was calculated according to the methodological procedures defined by Cohen [23].

The sample calculation was performed using the G*Power program version 3.1.9.2 (Erdfelder, Faul, & Buchner, 1996; Kiel, Germany) on all functional fitness variables based on the results obtained by Balachandran et al. [24], expecting an average increase of 10% in the participants' performance, therefore, we considered for the sample size of the present study a power of 0.80 for the analyzes performed.

## Results

The exercise protocol carried out was adhered to by 96% of participants. The CT suffered two losses due to medical exemptions and two due to attendance below 90%. While the CG had 11 losses due to non-compliance with all stages of the study. The average participation rate was 22.5 sessions out of 24 total and the sample loss was 15 individuals.

**Table I -** Characteristics of participants in the groups Concurrent (CT) and Control (CG) at the start of intervention. Values presented as mean and standard deviation (M ± SD)

| Variables | CT (n = 26) | CG (n = 14) | p |
|---|---|---|---|
| **Age (years)** | 66.54 ± 5.76 | 68.29 ± 5.97 | 0.380 |
| **Body mass (kg)** | 65.76 ± 10.89 | 68.02 ± 12.87 | 0.582 |
| **Height (m)** | 1.52 ± 0.07 | 1.50 ± 0.08 | 0.507 |
| **BMI (kg/m²)** | 28.39 ± 4.01 | 29.94 ± 4.01 | 0.225 |

BMI = body mass index

At the end of the intervention, the CT showed statistically significant improvements in all variables in relation to initial values. When compared to the CG, the CT promoted statistically significant adaptations in the variables: 1) Dressing on and taking off a t-shirt (Δ%: 7.9; $p \leq 0.05$); 2) Rising from prone position (Δ%: 24.4; $p \leq 0.01$); 3) Walking speed in 10 m (Δ%: 11.7; $p \leq 0.02$); 4) Time up go (Δ%: 7.2; $p \leq 0.05$); 5) Five Times Sit to Stand Test (Δ%: 16.1; $p \leq 0.03$); 6) Gallon-jug shelf-transfer (Δ%: 17.5; $p \leq 0.01$). The detailed results of the interventions in the physical tests applied are presented in table II.

**Table II -** Changes after eight weeks of concurrent training in physical fitness related to activities of daily living in untrained older women. Values presented as mean and standard deviation (M±SD)

| Variables | Concurrent training (n = 26) | | | | Control group (n = 14) | | | |
|---|---|---|---|---|---|---|---|---|
| | Pre | Post | Δ% | ES | Pre | Post | Δ% | ES |
| Dressing on and Taking off a T-Shirt | 16.02 ± 2.51 | 14.38 ± 2.60*,# | 11.40 | 0.65 Mod | 16.13 ± 2.79 | 15.52 ± 2.79 | 3.93 | 0.21 Triv |
| Rising from prone position | 3.41 ± 0.77 | 2.99 ± 0.70*,# | 14.05 | 0.54 Mod | 3.64 ± 0.62 | 3.72 ± 0.76 | -2.20 | -0.12 Triv |
| Walking speed in 10 m | 5.89 ± 0.56 | 5.38 ± 0.62*,# | 9.48 | 0.91 Gran | 6.07 ± 1.01 | 6.01 ± 1.02 | 1.0 | 0.05 Triv |
| Time up go | 6.47 ± 0.79 | 6.06 ± 0.67*,# | 6.77 | 0.51 Mod | 6.70 ± 0.82 | 6.50 ± 0.98 | 3.08 | 0.24 Triv |
| Five Times Sit to Stand Test | 5.97 ± 1.20 | 5.34 ± 0.95*,# | 11.80 | 0.52 Mod | 6.17 ± 1.43 | 6.20 ± 1.54 | -0.49 | -0.02 Triv |
| Gallon-jug shelf-transfer | 11.09 ± 1.77 | 9.67 ± 1.29*,# | 14.68 | 0.80 Gran | 11.29 ± 1.54 | 11.31 ± 1.94 | -0.18 | -0.01 Triv |

*Significant difference pre vs. post intervention ($p \leq 0.05$); # Significant difference between groups ($p \leq 0.05$); Δ% = pre and post-test change; ES = effect size from pre to post-tests

## Discussion

The main result of the present study is the positive effects on all components of functional fitness from a CT protocol. In fact, programs that stimulate the different components of physical fitness seem to be the most effective intervention for improving general physical status and preventing disabilities [2,25].

The adaptations observed in the present investigation can be justified by the combination of neuromuscular and metabolic exercises in the same session [26]. The organization of the session into distinct blocks followed recommendations aimed at functionality, previously published by our group [4,10,11], which aim to include different types of exercise in a short period of time and apply them in a sequence that allows gradual increase of intensity and complexity, respecting the particularities of the senile. In this way, it can be inferred that there was no stagnation in the effects arising from the CT throughout the intervention period.

Specifically, the CT response in functional tests that depend on variables such as speed, agility and dynamic balance can be attributed to its relationship with muscular power [27], whose stimulus was the focus in the resistance training applied. Exercises performed at maximum concentric speed contribute to better neuromuscular performance through increased activation of type II fibers and excitability of alpha moto neurons in the spinal cord, decreased antagonist coactivation and consequent improvement in neuromuscular coordination [28].

In this perspective, Ramírez-Campillo et al. [29] compared the effects of 12 weeks of high and low speed resistance training, observing that exercises performed at high speed induce more effective changes in muscle power and functionality in older women. Therefore, given the information presented, we suggest repetitions at maximum concentric speed in multi-joint exercises, as an essential factor to minimize physical disability in senile individuals.

The adaptations provided by CT in functional tests that depend on muscular strength and endurance can be justified by adaptations commonly observed from traditional resistance training, such as increased recruitment of motor units, improved intra and intermuscular coordination, reduction in the number of non- contractile and better energy availability [30,31]. With an intervention similar to that of the present study, Resende et al. [10] found increases of 26.62% in the functional strength of the lower limbs and 17.72% in the functional strength of the upper limbs in physically active older women, after 12 weeks of training.

Regarding cardiorespiratory capacity and performance in walking ability, the positive effect of CT can come from stretching exercises, especially for the ankle and hip joints [32], added to the metabolic characteristics of walking/running [33] and resistance training in circuit format [34], promoting changes in muscle elasticity and in the mechanisms responsible for the transport and use of oxygen. Suggesting some of the main adaptive responses to combined aerobic and resistance exercise protocols, three times a week, also at an intensity of 80%, Frontera et al. [35] observed an improvement in $VO_{2max}$, accompanied by a 15% increase in the number of capillaries per fiber and a 38% increase in the activity of oxidative enzymes.

In the present study, the CT was effective in improving glenohumeral joint mobility, evidenced mainly by the increase in performance in the test of putting on and taking off the shirt, and this adaptation may be due to the stretching exercises performed at the end of the session and the performance of multisegmental exercises in large joint ranges [36]. In this perspective, Correia et al. [37] stated that strength training is effective in increasing joint range of motion and muscle elasticity in the elderly, regardless of the exercise protocol applied. Furthermore, evidence shows that regular strength training can increase range of motion by a similar magnitude to static stretching protocols [38], as it acts by reducing passive tension and stiffness of tissues around joints [37].

The present investigation focused on analyzing the adaptive responses to a training protocol with particularities that have not yet been scientifically elucidated and, although it provided important information about the benefits of CT on the functional fitness of untrained elderly women in the post-COVID period, it is worth highlighting limitations such as the relatively short intervention period, absence of men in the sample and body composition measurements. Furthermore, future studies should compare the present protocol with traditional training methods (slow concentric phase) for a more robust dose-response analysis.

## Conclusion

Concurrent training has been shown to be effective in improving functional fitness in untrained older women. The present investigation shows that a physical training program designed to promote health benefits in senile individuals should focus on the integrated improvement of the components of neuromuscular and cardiorespiratory fitness.

**Potential conflict of interest**
No conflicts of interest potentially relevant to this article were reported.

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**Authors' contributions**
**Conception and design of the research:** Resende-Neto AG, Mota MM, Netto SB, Da Silva-Grigoletto ME; **Data acquisition:** Resende-Neto AG, Netto SB; **Analysis and interpretation of data:** Resende-Neto AG, Da Silva-Grigoletto ME; **Statistical analysis:** Cruz ANB; **Manuscript writing:** Resende-Neto AG; **Critical review of the manuscript for important intellectual content:** Mota MM, Netto SB, Da Silva-Grigoletto ME

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