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Impact of Aerobic Training Associated with Muscle Strengthening in Elderly Individuals at Risk of Sarcopenia: A Clinical Trial

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Abstract

Background: Physical exercises are beneficial for healthy aging. The European Working Group on Sarcopenia in Older People recommends the use of an algorithm to identify the risk of sarcopenia.

Objective: To compare an isolated muscle-strengthening program with a concurrent aerobic training and muscle strengthening program.

Design: Non-randomized clinical trial.

Setting: A community at "risk of sarcopenia" according to the European Working Group on Sarcopenia in Older People.

Participants: Sedentary, community-dwelling elderly women (≥ 65 years) with a gait velocity >0.8 m/s and handgrip strength <20 kg/f.

Methods: Isolated training comprised muscle strengthening (75% of the 1-repetition maximum; 3x/week, 10 weeks). Concurrent training comprised muscle strengthening (75% of the 1-repetition maximum) plus aerobic training (30 min; 3x/ week, 10 weeks). We evaluated the pre- and post-intervention mobility and balance (Timed Up and Go test) and estimated the functional capacity and lower limb strength (Chair Stand Test). Between-group comparisons were made using a 2x2 analysis of variance (Bonferroni post-hoc) with a 5% significance level.

Results: Of the 25 participants, 12 and 13 were assigned to the concurrent and isolated training groups, respectively (average age, 70.25 ± 4.78 years, average body mass index = 29.55 ± 4.65 kg/m^2 and 73.00 ± 4.88 years, 29.99 ± 3.81 kg/m^2, respectively). Both groups exhibited post-intervention improvements in mobility and balance (Timed Up and Go), with a higher percentage of improvement in the concurrent training group. The concurrent training group exhibited significant differences in functional capacity and estimated muscle strength (Chair Stand Test; p=0.002).

Conclusion: The 2 training programs provided the benefits of improved mobility and balance in elderly women at "risk of sarcopenia"; concurrent training was more effective in terms of the functional capacity.

Keywords: Frail elderly; Sarcopenia; Resistance training

Introduction

Human muscle strength begins to decline at the age of 40, with a reduction in muscle mass of approximately 5% in each decade of life [1,2]. This decline, which affects mainly the lower limbs, is accentuated after age 65 years and reaches a loss of up to 40% of the muscle mass relative to that during adulthood [3]. These changes may affect the individual's ability to respond to situations in which it is necessary to recover balance because of a reduced ability to develop rapid torque in the joints as well as slowed effectors responses, a decreased functional capacity, and altered gait [4,5]. Recently, in this context, sarcopenia was defined as a loss of muscle mass and associated loss of strength and/or function that occurs with aging [6].

Moreover, lifestyle modification, including physical activity performance, occurs during aging [2]. Most elderly persons adopt mildly to moderately intense activities such as hiking, specific gymnastics, and swimming [7]. This phenomenon has been associated with sarcopenia consequent to the modifications and decreased muscle use. Decreases in the number and quality of muscles fibers are observed; type II fibers, which have a great capacity to generate torque and muscle strength, are primarily affected [8,9]. Furthermore, the maximum aerobic capacity (VO2max) is decreased [10].

Recent studies have emphasized the importance of weight training to reverse muscle losses and improve functional abilities in the elderly and have provided evidence that power training would yield greater functional improvements than would muscular strength training alone [1,2,11,12]. At any age, muscular strength training may be performed with the correct combination of several variables, including the load, repetition number, set number, intensity, sequence, and intervals between sets and exercises. However, the benefits gained in elderly muscle strength are only noticeable after an average of 10 to 12 weeks of training [2,3]. Furthermore, there remains controversy in the literature regarding the best weight training work volume for the elderly, especially those with specific health conditions [13].

On the other hand, it has been established that aerobic exercises, muscle strengthening, flexibility, and balance [10,14,15] should be performed to prevent chronic degenerative diseases and minimize the alterations that occur with aging. Accordingly, there is an assumption

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that aerobic exercise training with a heart rate ≥60% of the VO2max and a frequency of 3 times per week can significantly increase the VO2max in older adults [10,16]. However, the relationships and interactions between activities, such as the influence of aerobic training on muscular strength training, have not been established. Similarly, the order in which the combined training activities should be performed has not been established. Moreover, there is no consensus in the literature regarding which parameters of aerobic exercise and muscle strengthening are the most suitable for elderly populations with specific characteristics such as sarcopenia.

Consequently, the purpose of this study was to compare the effect of an isolated muscle strengthening (IS) program with a combined muscle strengthening and aerobic training (CS) program in elderly residents of a community at "risk of sarcopenia" according to the algorithm developed by the European Working Group on Sarcopenia in Older People (EWGSOP).

Materials and Methods

This clinical trial was approved by the Ethics Committee in Research of the University Center of Belo Horizonte under opinion number 048/2009. This clinical trial was registered with the Brazilian Clinical Trials Registry (ReBEC; RBR2g27zn). Participants were recruited by verbal invitation via phone from an attendance waiting list at the physiotherapy sector of the teaching clinic of 2 universities and were invited to participate in an exercise program of 10 weeks' duration to be performed 3 times per week. All participants signed a consent form agreeing to participate in the study. After satisfying the inclusion and exclusion criteria, this convenience sample were divided into 2 training groups: the isolated strengthening exercises (IS) and muscle strengthening with aerobic training (CS) groups. The allocation in the groups was not randomized. We used only the letters 'CS' and 'IS' and every individual was distributed alternating these letters. The CS group was subjected to aerobic training on a treadmill for 30 minutes at a maximum heart rate (HR max) for age of 60-70% (HR max = 220-age), followed by exercises involving 75% of the 1-repetition maximum (1RM) for the lower limbs. The IS group was subjected only to exercises involving 75% of the 1RM. All participants were subjected to pre- and post-intervention Timed Up and Go (TUG) tests to assess mobility and balance and Chair Stand Tests (CST) to assess functional capacity using the estimated lower limb muscle strength. This study was conducted between the periods of August 2010 to October 2012. The training of both groups was performed by physical therapists who were not aware of the evaluations, as well as not participated on it, only in the training groups.

Sample

The participants were women aged ≥ 65 years, regardless of race and/or social class. In addition, all participant were required to present a gait speed > 0.8 m/s and handgrip strength < 20 kg/f and were classified according to the EWGSOP as at "risk of sarcopenia" [6].

The exclusion criteria were a history of orthopedic surgery of the lower limbs and/or fracture less than 1 year earlier; inability to walk without assistance; neurological diseases or acute conditions that would interfere with testing and training; and cognitive changes as detected using the Mini Mental State Examination (according to the education level; the 1994 Brazilian version by Bertolucci et al.) [17]. A further exclusion criterion was absence for 3 consecutive sessions during the course of training.

Outcome Measures

Mobility and balance were measured using the TUG test. This test comprises the tasks of standing up from a standard seat (height, 45 cm from the floor), walking three meters, turning, returning, and sitting in the same chair. The time taken to perform the entire routine was used for the analysis [18].

The functional capacity was assessed using the estimated muscle strength of the lower limbs according to the CST. This test is intended to assess the abilities of an individual in the actions of sitting and standing and allows inferences regarding balance and leg strength. The test is performed on a standard chair (height, 45 cm from the floor). The subject rises and sits 5 consecutive times without the aid of supporting arms, which are kept crossed in front of the torso with hands resting on the shoulders. The time taken to complete the task of rising 5 consecutive times was used for the analysis [19].

Training program

Training always occurred in the afternoon under the direct supervision of research physiotherapists. Initially, blood pressure and heart rate measurements were recorded and controlled throughout the training session.

The CS group performed an aerobic workout by walking on a treadmill for 30 minutes at an intensity of 60-70% of the HRmax. The participants were monitored every 5 minutes to maintain the intensity throughout the aerobic training period. We used the first 5 minutes as a preparatory period and the last 5 minutes as a recovery period. Subsequently, the sural triceps, hamstrings, iliopsoas, and rectus femoris (4 sets of 20 seconds) muscles were stretched. Muscle strength training was accomplished through lower-limb resistance exercises; 75% of the specific 1RM for each participant was ensured. The exercises targeted the hip flexor, extensor, abductor, and adductor muscles and the knee extensor and flexor muscles. In the first 6 sessions, the load used during the knee flexion and extension exercises was equal to 50% of the 1RM (2 sets of 10 repetitions). After this period, the load was 75% of the 1RM (3 sets of 8 reps). Every 2 weeks (6 sessions), the 1RM value was recalculated to ensure a 75% load [20]. At the end of 30 sessions (10 weeks), the subjects were reassessed.

The IS group received only the muscle strength training described above. Which means: muscle strength training was accomplished through lower-limb resistance exercises; 75% of the specific 1RM for each participant was ensured, in the same way as it was done on the CS group.

The groups were trained in different days and times, under the supervision of the same group of physiotherapists.

Statistical analysis

The sample size calculation was performed after a pilot study while considering a confidence interval of 95%, α of 5%, size effect of 0.5, and margin of error of 20%, thus demonstrating the need for 13 volunteers in each group.

Comparisons between groups and between the pre- and post-intervention results were conducted with an analysis of variance (ANOVA 2x2). The statistical significance was set at an α of 5%.

Results

The study included 26 elderly women who were divided in 2 groups. During training, the training of 1 elderly woman in the CS group was interrupted because of financial difficulty; therefore,12 elderly women remained in this group for the analysis (mean age = 70.25 ± 4.78 years, mean body mass index (BMI) = 29.55 ± 4.65 kg/m^2) and 13 remained in the IS group (mean age = 73.00 ± 4.88 years, mean BMI = 29.99 ± 3.81 kg/m^2). No differences were found between the groups in terms of age (p = 0.169) and BMI (p = 0.794). All were independent in activities of daily living, gait performed without the aid of external device and had no more than two comorbidities (hypertension was the most frequent and osteoarthritis) (Table 1).

After training, the 2 groups exhibited improved mobility and balance (TUG) and despite a difference in the CS group in the beginning of training, this group exhibited a greater percentage of improvement after training (Table 2). There was a statistical post-intervention difference between the groups in the functional capacity and estimated muscle strength of the lower limbs (CST), and only the CS group exhibited improvement (p = 0.002; Table 2).

Discussion

This study aimed to compare 2 types of training, CS (aerobic associated with muscle strengthening) and IS (muscle strengthening), with regard to the functional capacity, mobility, and balance in elderly women in a community classified as at "risk of sarcopenia". The results demonstrated that both groups received benefits in mobility and balance after training and improvement in the functional capacity and estimated muscle strength of the lower limbs in the group subjected to CS.

Initially, it is important to note that the operational definition of the term sarcopenia remains difficult, although the term is widespread in the scientific community [21]. The latest definitions incorporate muscle strength, functional capacity, and muscle mass as diagnostic criteria [6,21]. In 2013, Cooper et al. reviewed the operational criteria for the definition of sarcopenia in addition to various aspects of physical function in elderly individuals evaluated in clinical trials [22]. The authors concluded that for the purposes of clinical trials, combinations of muscle mass and physical capacity measures should be used, although all currently used measures present limitations. In this context, the present study used the criteria as determined by EWGSOP in addition to assessing the functional capacity as an outcome.

Characteristics	CS group	IS group
	(n= 12)	(n=13)
Age (yrs), mean (SD)	70.25 (4.78)	73.00 (4.88)
BMI (kg/m^2), mean (SD)	29.55 (4.65)	29.99 (3.81)
MEEM, mean (SD)	23 (4.6)	23 (4.8)
White, number (%)	6 (50)	8 (61.54)
Married, number (%)	4 (33.33)	4 (30.77)
Widow, number (%)	8 (66.67)	9 (69.23)
Low education level, number (%)	8 (66.67)	10 (76.92)
SD, standard deviation; MEEM,Mini Mental State Exam		

Table 1: Characteristics of participants.

	Isolated Training		Concurrent Training		p ANOVA
	Pre-test	Post-test	Pre-test	Post-test	
TUG (s), mean (SD)	12.29 ± 0.82	11.61 ± 0.62*	10.25 ± 0.77†	8.21 ± 0.94*‡	0.003
CST (s), mean (SD)	18.39 ± 1.49	15.84 ± 1.29	16.97 ± 1.14	13.85±2.01*‡	0.002
TUG = Timed Up and Go; CST = Chair Stand Test; *p < 0.05 Pre-test vs. Post-test; †p < 0.05 Pre-test concurrent vs. isolated trainin					

Table 2: Comparison of pre- and post-intervention muscular and functional performance between the groups subjected to concurrent and isolated training.

Published studies have suggested that different durations of isolated muscular strength training interventions are effective in the elderly [23,24]. In 2014, Cadore et al. reviewed prescribed strengthening exercises and endurance for healthy and frail elderly individuals. The authors concluded that CS (muscular strength and endurance) was better for both the cardiopulmonary and neuromuscular functions. Moreover, the authors stated that training intended to gain muscle strength was more effective when performed for a period longer than 6 weeks and at a moderate to high intensity (65-80% of the 1RM) 2-3 times per week, with 3 sets per exercise [25]. The present study used parameters similar to those proposed by Cadore et al., as the sessions were conducted for 10 weeks at an intensity of 75% of the 1RM and a frequency of 3 times per week, which might partly explain the improvements obtained. In contrast, there is little information regarding the effects of these programs in elderly women with or at "risk of" sarcopenia.

Recently, Liu et al. evaluated the impacts of 2 training programs in elderly individuals with and without sarcopenia. The authors compared participants in a physical activity program containing strengthening, aerobic training, balance, and flexibility exercises with those in an educational program on healthy aging composed of educational seminars and stretching exercises for the upper limbs at 6 and 12 months after intervention. Liu and colleagues observed no significant differences between the elderly individuals with and without sarcopenia during the first 6 months when assessed them using the Short Physical Performance Battery (SPPB). However, after 12 months, there was an improvement in the gait speed, with no significant difference between elderly individuals with or without sarcopenia who followed the physical activity program. The authors concluded that elderly individuals with sarcopenia could improve their physical capacities after the intervention [26]. Although these authors used different tests than those used in the present study, the results indicate an improved functional capacity in elderly individuals at risk of sarcopenia.

Few studies have evaluated the gains achieved with muscle strength training after concurrent aerobic and strengthening exercises. Takeshima et al. observed an increase in the muscle strength and VO2max as well as a reduction in the percentage of fat and an increase in the high-density lipoprotein levels in elderly men and women after participating in a program of aerobic exercises interspersed with muscle-strengthening exercises [27]. On the other hand, Wood et al. observed increases in lower limb strength in response to different workouts—combined aerobic and muscle-strengthening, isolated aerobic, and isolated muscle strengthening programs—with no significant differences between participants subjected to each workout [23]. In addition, these authors observed gains in function and aerobic capacity after CS relative to aerobic training and isolated muscle strengthening [23]. It is important to remember that none of these studies considered elderly individuals in the context of specific conditions such as sarcopenia. Although the present study involved a shorter period than that used in the training cited above, we observed an improved functional capacity after CS, as estimated by a reduction in the time to perform the sit-up test, indicating that this type of training provided a greater benefit to elderly individuals "at risk of sarcopenia".

In contrast, in 2008 Lemos et al. reported impaired muscle strength gain after performing aerobic exercises at different intensities prior to muscle-strengthening exercises [28]. Although a direct measure of muscle strength was not used, the results presented herein challenge data presented earlier. One possible explanation lies in the greater recruitment of muscle fibers and consequent increased local metabolism and blood flow to the lower limbs provided by walking, which would allow better performance during strength training.

Although this statement is controversial, the results indicate the possibility of a differential mechanism used by the elderly, who likely differ from younger individuals in relation to fatigue and oxidative metabolism [23-25]. Nevertheless, as this study did not aim to explain the contraction mechanism, this reasoning is speculative and should be verified in future studies with appropriate methodological designs.

All of the elderly women exhibited improved mobility and balance, regardless of the type of training. These results may have been determined by the responses to the initiation of physical activity, as all participants had been sedentary. In this case, both the IS and CS contributed to a lifestyle habit modification [2] with consequent improvements in mobility and balance. In particular, participants subjected to the CS may have benefited from the selected aerobic activity, which was conducted on a treadmill at a speed determined by heart rate training and may have helped to provide increased safety and skill. Similarly, one might think that specific exercises to strengthen the lower limbs would contribute to long-term improvements in muscle strength in the long term, although these exercises would likely contribute to better functional efficiency in the short term. Under this assumption, the 2009 consensus of the American College of Sports Medicine (ACSM) indicated that an increase of 7-17% in muscle strength could lead to increased functionality in the elderly [10].

This study has some limitations. First, subject selection was not randomized and may have contributed to a type 1 error. Similarly, the groups were statistically different at the baseline with respect to mobility and balance such that even with the post-intervention improvements in both groups, no difference was detected between the types of training. Another limitation was the lack of nutritional monitoring and control in the elderly participants. Low protein and/or carbohydrate intake is known to influence gains in muscle strength [2]. Therefore, the lack of food control may have resulted in differences in energy substrate absorption and mobilization between the participants according to the type and quantity of food and the time of the last meal before training. Hence, further studies should be conducted while controlling these variables. Besides, since the sample was reduced, there is a limitation on the widespread of the results.

Conclusion

The IS program and the concurrent muscle-building and aerobic training program yielded the benefits of improved mobility and balance in elderly women from a community classified as at "risk of sarcopenia". CS was more effectively to improved the functional capacity and estimated muscle strength of the lower limbs. These results support the use of these programs in clinical practice.

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