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original article

Impact of 12 weeks of resistance training on physical and functional fitness in elderly women

Impacto de 12 semanas de treinamento com pesos sobre a aptidão físico-funcional de mulheres idosas

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Abstract – The objective of the study was to analyze the impact of 12 weeks of resistance training (RT) on physical functional fitness in elderly women. Fifty-one elderly women (66.1±4.4 years), apparently healthy, insufficiently active, and without prior experience in RT were randomly assigned into two groups: Training Group (TG = 24) and Control Group (CG = 27). The TG was submitted to a standardized RT program composed of eight exercises, performed in two sets of 10 to 15 repetitions, three times a week, and the CG was submitted to a 12 week stretching exercise program composed by two sessions per week of 30 minutes each. Their physical and functional fitness level was analyzed before and after the intervention period by motor testing to assess Right and Left Upper Limb Endurance (RULE, LULE), Lower Limb Endurance (LLE), Flexibility (FLEX), Manual Skills (MS), Ability to Put on Socks (APS), and Coordination (COORD). The TG had improved performance in LLE (+13.8%), RULE (+24.3%), LULE (+22.9%), and MS (- 0.9 s), whereas the CG improved performance in RULE (+13.9%) and LULE (+14.1%), but had increased time in COORD by (+1.5 s), and these were the only tests showing significant interactions of group vs. time ($p<0.05$). The results suggest that 12 weeks of RT seem to be sufficient to induce positive changes on physical and functional fitness of healthy and previously untrained elderly women.

Key words: Aging; Functional capacity; Resistance training.

Resumo – *O objetivo do estudo foi analisar o impacto de 12 semanas de treinamento com pesos (TP) sobre a aptidão físico-funcional de mulheres idosas. Para tanto, 51 mulheres idosas (66,1±4,4 anos), aparentemente saudáveis, insuficientemente ativas e sem experiência prévia em TP foram separadas aleatoriamente em dois grupos: grupo treinamento (GT = 24) e grupo controle (GC = 27). O GT foi submetido a um programa de TP estruturado com oito exercícios, executados em duas séries de 10 a 15 repetições, três vezes por semana, a partir de uma montagem alternada por segmento, ao passo que o GC foi submetido a 30 minutos de alongamento, duas vezes por semana, durante 12 semanas de intervenção. A aptidão físico-funcional foi analisada antes e após o período de intervenção, por meio de testes motores para avaliação da resistência muscular de membros inferiores (RMMI) e superiores direito (RMMSD) e esquerdo (RMMSE), flexibilidade (FLEX), habilidades manuais (HM), capacidade de calçar meias (CCM) e coordenação (COORD). O GT apresentou melhoria de desempenho nos testes de RMMI (+13,8%), RMMSD (+24,3%) RMMSE (+22,9%) e HM (-0,9 s), ao passo que o GC melhorou o desempenho nos testes RMMSD (+13,9%) e RMMSE (+14,1%) e piorou o tempo no teste de COORD (+1,5 s), com interações significantes grupo x tempo sendo identificadas apenas nesses testes (p<0,05). Os resultados sugerem que 12 semanas de TP parecem ser suficientes para induzir benefícios na aptidão físico-funcional de idosas saudáveis e previamente não treinadas.*

Palavras-chave: *Capacidade funcional; Envelhecimento; Treinamento resistido.*

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INTRODUCTION

Since the early 60s there has been a sharp increase in the elderly population as well as demographic movements and epidemiological transition characterized by lower number of live births and change in high death rate from infectious diseases, which characterize deaths by chronic diseases[1,2].

Brazilian data indicate that from 1970 to 1990 the elderly population grew from 5.1 to 7.2% of the country's total population[3]. Based on this data, it is estimated that in 2025 Brazil will have the sixth largest elderly population in the world with approximately 32 million people over 60 years old[3]. Because of this projection, health professionals have become interested in investigating strategies that can promote health during the aging process and better quality of life by caring for changes in structural, morphological, functional, biochemical, and psychological areas which make the elderly more vulnerable to disease processes[4].

One of the main changes observed in aging is the decrease in muscle mass and strength, a process called sarcopenia[5]. Sarcopenia causes increased fragility and decreased physical and functional fitness, bringing negative repercussions to perform basic activities of daily living[6]. Because of the aging process, relatively simple activities such as eating, bathing and dressing, or even little tasks such as shopping, answering the phone, or using means of transportation can become extremely difficult for many elderly people[7]. These limitations are directly associated with the gradual loss of autonomy and, consequently, decrease of this population's quality of life[8].

Considering that adopting a physically active lifestyle can minimize many losses observed in advancing age and thus positively contribute to a healthier aging process[9,10], researchers have recommended that the elderly regularly participate in resistance training (RT) since the practice of this type of exercise with weights increases and helps to preserve muscle mass and strength[11,12], thus improving physical and functional fitness[9]. Some researchers demonstrate the existence of an inverse relationship between the practice of RT and the incidence of falls as well as development of, or worsening condition of many chronic degenerative disorders[12,13].

However, the benefits associated with RT for the elderly depend on careful control of the training program's variables which includes the following: number, sets, and reps of exercises; exercise order; speed of execution; rest intervals between exercises and sets; weight used; and weekly frequency[9]. Results from several studies available in literature on RT for elderly are often difficult to interpret because of the lack of methodological rigor in controlling some of these variables[14-16]. Also, some studies with the elderly did not use a control group[17], control of initial levels of habitual physical activity[18], or eating habits[15,19], which are factors that can interfere greatly on the results during different periods of intervention. Therefore, the aim of this study was to analyze the impact of 12 weeks of RT, prescribed according to current recommendations for elderly[9,20,21] on the physical and functional fitness of previously untrained elderly women.

METHODOLOGICAL PROCEDURES

Subjects

After an initial recruitment of approximately 200 women using means of advertisements in newspapers and radio, as well as handing out leaflets in the central area of the city Londrina, Paraná state, 54 elderly women (>60 years), untrained but apparently healthy, were selected to participate in this study through individual interviews and assessing the subject's clinical history. The sample size was based on an alpha value of 95%, statistical power of 80%, and a sample loss estimated at 20%. Criteria for inclusion included: clinically healthy participants, nonsmokers, as well as preceding the beginning of this study were not involved in the regular practice of systematic physical activity more than one day per week over the last six months. All participants who were considered as eligible for participation in exercise programs were previously evaluated by a cardiologist performing a stress test on a treadmill.

The sample was divided randomly into two balanced groups: Training Group (TG) which was subjected to a standardized RT program, and Control Group (CG), which was subjected to a standardized stretching exercise program. All participants were instructed to maintain their usual level of physical activity and not to get involved with any other physical exercise program during the course of the study. Three participants of the TG did not finish the study and therefore were excluded from the analysis. The reason for two dropouts was not attending sufficient training sessions (<85% of total program), and the third dropout was due to a motor vehicle accident.

All participants signed the terms of informed consent after they had received information about the study's purpose and procedures to which participants would be submitted. This study was approved by the local Ethics Committee in accordance with regulations of Resolution 196/96 of the National Health Regulatory Council on research involving human subjects (case no. 048/2012).

Anthropometry

Anthropometric measurements of weight and height were obtained before (initial time - T1) and after (end time - T2) 12 weeks of intervention. Body mass was measured on a Filizola digital scale, model ID 110 (São Paulo, Brazil) with a scale of 0.1 kg, and height was determined using a wooden stadiometer (0.1 cm scale), according to conventional procedures reported in literature[22]. Based on the measurements obtained body mass index (BMI) was calculated by body weight (kg) divided by height (m) squared.

Dietary habit control

Participants were instructed by a previously trained nutritionist on how to fill-out dietary records during the first and last week of intervention and also were instructed on how to identify portion size of food consumed, including beverages, using standardized home measurements. The nutritional assessment program used to determine the total energy value as well as macronutrient amounts and proportions was Avanutri, version 3.1.4. Instructions were given to the elderly women to keep these eating habits during the entire study.

Physical functional fitness

Physical functional fitness was determined by motor testing proposed in quantities of available literature[23-25]. To analyze physical abilities, upper limb muscle endurance, lower limb muscle endurance, and flexibility, the following tests were used respectively: unilateral elbow flexion tests for 30 seconds (right and left sides), sit and rise from a chair in 30 seconds, and reach for back, according to recommendations of Rikli and Jones[23]. To evaluate the ability to put on socks and perform manual skills, a series of tasks proposed by Andreotti and Okuma[24] was used. A specific test was used to evaluate motor coordination proposed by AAHPERD[25]. Testing of both T1 and T2 were done on the same day by one trained evaluator and it had a technical error of measurement of less than 5% in each test.

Training protocols

- Weight training

Elderly women of the TG were submitted initially to six sessions to become familiar with the exercise equipment to be used, and subsequently to 12 weeks of RT. The training sessions were only held in the mornings and the single RT program was carried out three times per week on alternate days. Participants were individually supervised during each RT session by experienced instructors.

The RT program was structured based on current recommendations of the practice of RT for the elderly[9,20,21], using a sequence of alternating assembly segment and consisting of eight exercises performed in the following order: vertical bench press, leg extension, front pull with high pulley, leg curl, barbell curls on *Scott* bench, seated calf, triceps pulley, and crunch. Each exercise was performed in two sets of 10 to 15 repetitions until moderate fatigue[20]. The only exceptions were the calf muscle exercises (15 to 20 repetitions) and crunch (20 to 30 repetitions, with no additional weight applied). During the execution of movements, participants were instructed to breathe in during the eccentric phase and breathe out during the concentric phase using execution movement speed of a ratio 1:2 concentric/eccentric phases, respectively. Rest intervals established between sets were 60 to 90 seconds, and between exercises two to three minutes.

The weight used was compatible with stipulated intervals of repetitions for each exercise and determined after the performance of each elderly woman during the familiarization sessions and adjusted individually throughout these sessions when the upper limit of predetermined repetitions for each exercise was achieved in both sets. The incremental increase established was 2 to 5% for upper limb exercises and 5 to 10% for lower extremity exercises[21] so that the initial training intensity was preserved during the 12-week intervention. At the end of each session, approximately five minutes were allotted to perform stretching exercises for the muscle groups worked out in the RT session.

- Stretching exercises

The participants of the GC underwent, as a group, a static stretching exercise program for 12 weeks with a frequency of two sessions weekly. All training sessions were held in the morning and lasted approximately 30 minutes each. The training program was structured according to recommendations of the American College of Sports Medicine[21]and consisted of three stretching exercises for each major muscle groups of the upper and lower limbs (chest, back, biceps, triceps, lower back, gluteus, quadriceps, hamstrings, and calf). Each exercise was performed by active stretching (without assistance) in two sets, each lasting 20 seconds, and an interval of 15 seconds between sets and at least 30 seconds between exercises.

Data analysis

The normality of the data was verified by the Shapiro-Wilk test. Thus, all variables were expressed using mean values and standard deviation, and evaluated using parametric procedures. The Student's *t* test for independent samples was used for comparisons between groups at T1 (baseline). Two-way analysis of variance (ANOVA) to evaluate repeated variables was used for comparisons within and between groups, at T1 and T2, when the assumption of sphericity (Mauchly test) was confirmed. In the variables where assumption of sphericity was not met, the Greenhouse-Geisser correction was applied. The Scheffé *post hoc* test was used to identify specific differences in variables in which the F values were found below the established criterion for statistical significance ($p<0.05$). The magnitude of the differences was calculated using Effect Size (ES), being considered small ($0.2< ES \leq 0.5$), moderate ($0.5< ES \leq 0.8$), or large ($ES >0.8$)[26]. The data were processed using the statistical package SPSS, version 17.0.

RESULTS

The general characteristics of the study participants before and after 12 weeks of RT are presented in Table 1. No statistically significant difference ($p>0.05$) was found when comparing between or within the groups either in morphological variables or in eating habits which remained relatively constant throughout the study.

Table 1. General characteristics of the groups before (T1) and after (T2) 12 weeks of intervention. Results are expressed as mean values ± standard deviation

	TG (n = 24)		CG (n = 27)	
	T1	T2	T1	T2
Age (years)	65.9±4.8	66.0±4.8	66.3±4.1	66.6±4.1
Body mass (kg)	60.2±9.2	60.5±8.9	63.4±9.4	64.2±10.4
Height (cm)	156.1±5.9	156.1±5.9	156.7±5.9	156.7±6.0
BMI (kg/m^2)	24.7±3.5	24.8±3.1	25.8±3.2	26.1±3.5
TEC (Kcal/day)	1392.6±209.3	1376.9±195.8	1379.3±154.2	1409.8±153.4
Carbohydrates %	57.2±8.7	56.6±6.8	53.4±5.7	55.8±4.5
Proteins %	17.2±4.0	16.4±4.3	16.1±1.9	16.6±2.5
Lipids %	13.0±6.4	11.7±2.4	12.8±1.9	12.5±1.4

Note. No intragroup differences or significant interaction (group vs. time) (p>0.05).

Table 2 shows physical functional fitness behavior throughout the study in the TG and CG. Significant interactions of group vs. time (p<0.05) were identified in all the variables analyzed except in flexibility and ability to put on socks (p>0.05). There was a moderate increase in the number of repetitions performed only in the TG (+2.2 rep; ES = 0.78; p<0.001) in motor testing in lower limb muscular endurance. As for the motor testing of muscular endurance in upper limbs, both groups increased greatly in relation to repetitions on the right side (TG = +5.3 rep; ES = 1.59; p<0.001; CG = +3.1 rep; ES = 0.87; p<0.001) as well as the left side (TG = +5.1 rep; ES = 1.89; p<0.001; CG = +3.1 rep; ES = 0.87; p<0.001). A moderate reduction in time in the testing series of manual skills was detected in TG (- 0.9 s; ES = 0.58; p=0.006). No significant change in flexibility (p>0.05) could be attributed to training. As to the variable of ability to put on socks, ANOVA identified isolated effect of time. A moderate reduction in time to complete the task was observed only in the CG (-0.5 s; ES = 0.52; p=0.01). In contrast, the test of motor coordination only in the CG group demonstrated a moderate increase in time to complete the task (+1.5 s; ES = 0.70; p=0.002).

Table 2. Physical functional fitness before (T1) and after (T2) 12 weeks of intervention in the Training Group (TG) and Control Group (CG). Results are expressed as mean values ± standard deviation

	TG (n=24)	CG (n=27)	Effects	F	p
LLE (rep)			ANOVA		
T1	16.0±2.1	15.6±2.5	Group	2.88	0.10
T2	18.2±3.4*	16.2±2.6	Time	31.99	< 0.001
ES	0.78	0.24	Interaction	12.29	0.001
RULE (rep)			ANOVA		
T1	21.8±2.9	22.2±3.5	Group	0.70	0.40
T2	27.1±3.0*	25.3±3.6*	Time	109.4	< 0.001
ES	1.59	0.87	Interaction	7.50	0.009
LULE (rep)			ANOVA		
T1	22.3±2.6	22.0±3.5	Group	2.70	0.11
T2	27.4±2.8*	25.1±3.6*	Time	121.6	< 0.001
ES	1.89	0.87	Interaction	7.30	0.01
FLEX (cm)			ANOVA		
T1	-2.2±6.2	-5.4±7.9	Group	3.50	0.07
T2	-0.9±5.3	-5.0±8.3	Time	4.00	0.05
ES	0.22	0.05	Interaction	1.40	0.24
MS (sec.)			ANOVA		
T1	8.9±1.6	8.6±1.3	Group	0.04	0.83
T2	8.0±1.5*	8.5±1.4	Time	8.10	0.006
ES	0.58	0.07	Interaction	6.53	0.01
APS (sec.)			ANOVA		
T1	3.7±0.9	4.0±1.1	Group	0.85	0.36
T2	3.5±0.7	3.5±0.8*	Time	5.69	0.02
ES	0.25	0.52	Interaction	1.31	0.26
COORD (sec.)			ANOVA		
T1	13.0±2.0	11.0±2.1	Group	2.29	0.14
T2	12.0±2.5	12.5±2.2*	Time	0.64	0.43
ES	0.44	0.70	Interaction	23.29	< 0.001

Note. rep = repetitions, ES = Effect Size; LLE = Lower Limb Endurance; RULE = Right Upper Limb Endurance; LULE = Left Upper Limb Endurance; FLEX = Flexibility, MS = Manual Skills, APS = Ability to Put on Socks; COORD = Coordination *p<0.05 x T1.

DISCUSSION

The main findings of this study were that RT in previously untrained elderly women was effective for improving upper and lower limb endurance and carrying out manual skills. As to the other in variables investigated, there were no significant changes that could be attributed to RT. These results confirm information that regular practice of RT can be beneficial for physical functional fitness in elderly women, providing them greater protection against various harmful effects caused by the aging process[27].

In this study, improvement performance in lower limb endurance test was 13.8% and in upper right and left limbs was 24.3 and 22.9%, respectively. Although other studies have reported improved motor performance in elderly women practicing RT for six[14], 10[15] and 20 weeks[28], the different ways used of handling the volume and intensity of training programs greatly complicates the interpretation of the magnitude of variables encountered throughout the intervention period. The study of Marin et al.[15] for example, used fixed weights of 1 kg during the entire experiment and manipulated only frequency of repetitions over time (eight initially, then 10, 15, and finally 20), so that intensity was reduced at the expense of increased training volume, prioritizing metabolic overload, while Galvão and Taaffe[28] kept the volume constant (8-RM) and increased the intensity (exercise weight), prioritizing tension overload. Accordingly, the apparent advantage of this study compared to previous ones is that this RT program structure adopted recent ACSM[9,20,21] recommendations using progressive overload (variation in weight and frequency as training progressed), which provides longer lasting adaptations to training, slows the plateau effect quite common in programs with small variations of stimuli, and allows comparisons with new studies that adopt similar methodology recommended by specialists in this area[21].

Moreover, the fact that the selected sample was composed exclusively of elderly women who were insufficiently active and their eating habits were monitored throughout the study, and being that these variables can strongly influence the body's responses to training, strengthens the findings of this study. In fact, monitoring the eating habits of those submitted to the RT program may be a determining factor in the interpretation of the information produced. If, on the one hand, the high intake of macronutrients, particularly proteins, can help produce results to this type of training in elderly people[29], on the other hand, a high dietary intake can increase body weight and adiposity[30], hindering the performance of daily living activities.

As for the results found related to the variable flexibility, one of the factors that may explain at least in part the absence of change in the groups investigated, was the lack of sensitivity of the test used to discriminate the different specific requirements of each training used in this study. This hypothesis is based on the results reported by Gonçalves et al.[19], which showed statistically significant increases in extension movements of left shoulder and hip extension of both the right and the left sides when evaluating flexibility using a fleximeter in older men and women submitted to eight weeks of

RT. Therefore, it is possible that other non-evaluated joints have presented a behavior different than those involved in the test applied in this study.

Additionally, some researchers[16] report that the flexibility of different joints after a few weeks of RT depends on the intensity of the training, and that programs using moderate/high intensity are more effective in improving flexibility. The results of this study, however, did not confirm this hypothesis as the RT program used was established using a moderate intensity base.

Because of some important limitations of this study, it should be pointed out that the results of this study should be viewed with some caution. It is believed that the factors that explain the changes observed in the physical functional fitness of the elderly women are linked to increased muscle mass and strength from RT, which, in turn, can be mainly attributed to neural adaptations such as greater muscle activation, improved recruitment of muscle fibers, increased firing rate of motor units, and decreased co-activation of the muscle pairs antagonistic to movement[31]. These assumptions, however, could not be confirmed because of the lack of specific measurements of these variables in this study. Therefore, research devoted to this area could substantially contribute to the analysis of the changes found in some variables in this study. Additionally, for ethical reasons, we chose to not maintain a pure control group, which in itself limits the analysis of the isolated effect of RT, although the behavior of the group undergoing stretching exercises did not compromise the interpretation of most of the information produced, indicating that this group can be considered a good control group for this study.

CONCLUSION

The results of this study suggest that 12 weeks of RT, prescribed according to current recommendations for elderly people[9,20,21], seem to be sufficient to cause significant changes in physical functional fitness of previously untrained healthy elderly women who are physically independent. Considering that RT programs can also provide important improvements in the functional capacity of elderly women who are more fragile and/or older[18], the results found in this study appear promising to prevent and treat functional disability. This is especially important when considering the exponential growth of an aging population in most countries of the world, reinforcing the need of preventive measures to improve quality of life and health of this population group.

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REFERENCES

1. Carvalho JAM, Garcia RA. O Envelhecimento da população Brasileira: um enfoque demográfico. Cad Saúde Pública 2003;19(3):725-33.
2. Omram AR. The epidemiologic transition: a theory of the epidemiology of population change. Bulletin of the World Health Organization. 2001;79(2):161-70.
3. Chaimowicz F. A saúde dos idosos brasileiros às vésperas do século XXI: problemas, projeções e alternativas. Rev Saúde Pública 1997;31(2):184-200.
4. Brasil. Ministério da Saúde. Secretaria de Ação à Saúde. Departamento de Ação Básica. Envelhecimento e saúde da pessoa idosa. Brasília, 2006.
5. Orsatti FL, Dalanesi RC, Maestrá N, Nahas EAP, Burini RC. Redução da força muscular está relacionada à perda muscular em mulheres acima de 40 anos. Rev Bras Cineantropom Desempenho Hum 2011;13(1):36-42.
6. Aijänseppä S, Notkola IL, Tijhuis M, van Staveren W, Kromhout D, Nissinen A. Physical functioning in elderly Europeans: 10 year changes in the north and south: the HALE project. J Epidemiol Community Health 2005;59(5):413-9.
7. Kuwano VG, Silveira AM. A influência da atividade física sistematizada na auto percepção do idoso em relação às atividades da vida diária. Rev Educ Fís/UEM 2002;13(2):35-9.
8. Janssen I, Heymsfeld S, Ross R. Low relative skeletal muscle mass (sarcopenia) in older persons is associated with functional impairment and physical disability. J Am Geriatr Soc 2002;50(5):889-96.
9. American College of Sports Medicine. Exercise and physical activity for older adults. Med Sci Sports Exerc 2009;41(7):1510-30.
10. Mummery WK, Kolt G, Schofield G, McLean G. Associations between physical activity and other lifestyle behaviors in older New Zealanders. J Phys Act Health 2007;4(4):411-22.
11. Bea JW, Cussler EC, Going SB, Blew RM, Metcalfe LL, Lohman TG. Resistance training predicts 6-yr body composition change in postmenopausal women. Med Sci Sports Exerc 2010;42(7):1286-95.
12. Kryger AI, Andersen JL. Resistance training in the oldest old: consequences for muscle strength, fiber types, fiber size and MHC isoforms. Scand J Med Sci Sports 2007;17(4):422-30.
13. Korpelainem R, Kiukaanniemi SK, Keikkinen J, Väänänen K, Korpelainem J. Effect of impact exercise on bone mineral density in elderly women with low BMD: a population-based randomized controlled 30-month intervention. Osteoporos Int 2006;17(1):109-18.
14. Cavani V, Mier CM, Musto AA, Tummers N. Effects of a 6-week resistance training on functional fitness of older adults. J Aging Phys Act 2002;10(4):443-52.
15. Marin RV, Matsudo S, Matsudo V, Andrade E, Braggion G. Acréscimo de 1kg aos exercícios praticados por mulheres acima de 50 anos: impacto na aptidão física e aptidão física funcional. Rev Bras Ciên Mov 2003;11(1):53-8.
16. Fatouros IG, Kambas A, Katrabasas I, Leontsini D, Chatzinikolaou A, Jamurtas AZ, et al. Resistance training and detraining effects on flexibility performance in the elderly are intensity-dependent. J Strength Cond Res 2006;20(3):634-42.
17. Ueno DT, Gobbi S, Teixeira CVL, Sebastião E, Prado AKG, Costa JLR et al. Efeitos de três modalidades de atividade física na capacidade funcional de idosos. Rev Bras Educ Fís Esporte 2012;26(2):273-81.
18. Serra-Rexach JA, Bustamante-Ara N, Villará MH, Gil PG, Ibáñez MJS, Sanz NB, et al. Short-term, light- to moderate-intensity exercise training improves leg muscle strength in the oldest old: a randomized controlled trial. J Am Geriatr Soc 2011;59(4):594-602.

19. Gonçalves R, Gurjão ALD, Gobbi S. Efeitos de oito semanas do treinamento de força na flexibilidade de idosos. Rev Bras Cineantropom Desempenho Hum 2007;9(2):145-53.
20. Nelson ME, Rejeski WJ, Blair SN, Duncan PW, Judge JO, King AC, et al. Physical activity and public health in older adults. Recommendation from the American College of Sports Medicine and the American Heart Association. Med Sci Sports Exerc 2007;39(8):1435-45.
21. American College of Sports Medicine. Position stands: quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. Med Sci Sports Exerc 2011;43(7):1334-59.
22. Gordon CC, Chumlea WC, Roche AF. Stature, recumbent length, and weight. In: Lohman TG, Roche AF, Martorell R, editors. Anthropometric standardizing reference manual. Champaign: Human Kinetics Books, 1988; p. 3-8.
23. Rikli RE, Jones CJ. Development and validation of a functional fitness test for community-residing older adults. J Aging Phys Activity 1999;7:129-61.
24. Andreotti RA, Okuma SS. Validação de uma bateria de testes de atividades da vida diária para idosos fisicamente independentes. Rev Paul Educ Fís 1999;13(1):46-6.
25. Osness WH, Adrian M, Clark B, Hoeger W, Raab D, Wiswel IR. Functional fitness assessment for adults over 60 years (A field based assessment). AAHPERD 1990:1-36.
26. Cohen, J. Statistical power analysis for the behavioral sciences. 2nd ed. Hillsdale (NJ): Lawrence Erlbaum Associates; 1988.
27. Lucena NM, Guerra RO, Lucena AB, Silva CF, Nascimento RQ. Análise da capacidade funcional em uma população geriátrica institucionalizada em João Pessoa. Fisioterapia Brasil 2002;3(3):164-9.
28. Galvão DA, Taaffe DR. Resistance exercise dosage in older adults: single- versus multiset effects on physical performance and body composition. J Am Geriatr Soc 2005;53(12):2090-7.
29. Iglay HB, Thyfault JP, Apolzan JW, Campbell WW. Resistance training and dietary protein: effects on glucose tolerance and contents of skeletal muscle insulin signaling proteins in older persons. Am J Clin Nutr 2007;85(4):1005-13.
30. Campbell WW, Leidy HJ. Dietary protein and resistance training effects on muscle and body composition in older persons. J Am Coll Nutr 2007;26(6):696S-703S.

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