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original article

Effect of different stretching volumes on functional capacity in elderly women

Efeito de diferentes volumes de alongamento na capacidade funcional de idosas

Luiza Herminia Gallo[1]
Raquel Gonçalves[1]
André Luiz Demantova Gurjão[1]
Alexandre Konig Garcia Prado[1]
Marilia Ceccato[1]
José Claudio Jambassi Filho[1]
Sebastião Gobbi[1]

Abstract – The study aimed to analyze the effect of two different durations of stretching exercises, 90 or 180 seconds, on the functional capacity (FC) of elderly women. Forty-three older women were assigned into three groups: inactive Control Group (CG, n. = 14), Training Group with three sets of 30 seconds (TG90, n. = 15) and Training Group with three sets of 60 seconds (TG180, n = 14). The TG90 and TG180 groups attended the university for 16 weeks, three times a week. The training protocol consisted of seven different static stretching exercises, performed in an active way. The CG attended the university only in periods of evaluations. Evaluations of the FC components and the Global Functional Fitness Index (GFFI), from the three groups, were both conducted before, and after 8 and 16 weeks of experiment, using a motor tests battery. The two-way ANOVA showed significant group x time interaction for the components flexibility, muscle strength and aerobic endurance, and for the GFFI values ($p < 0.05$). The Scheffé post hoc test pointed difference between the two training groups and the CG, with no difference between TF90 and TG180. There was also improvement in the general classification of GFFI for the TG90 and TG180, which went from "fair" to "good", while CG remained classified as "fair." It was concluded that the two durations of stretching exercises were equally effective in improving flexibility, muscle strength, aerobic endurance and levels of FC in elderly women.

Key words: Aging; Range of joint motion; Physical fitness.

Resumo – *O estudo teve como objetivo analisar o efeito de dois diferentes volumes de alongamento, 90 ou 180 segundos, na capacidade funcional (CF) de idosas. Participaram deste estudo, 43 mulheres idosas divididas em três grupos: Grupo Controle inativo (GC, n=14), Grupo Treinamento com três séries de 30 segundos (GT90, n=15) e Grupo Treinamento com três séries de 60 segundos (GT180, n=14). Os grupos GT90 e GT180 frequentaram a universidade durante 16 semanas, três vezes por semana. O protocolo de treinamento consistiu em sete diferentes exercícios de alongamento estático, realizados de forma ativa. O GC frequentou a universidade apenas nos períodos de avaliação. As avaliações dos componentes da CF e do Índice de Aptidão Funcional Geral (IAFG), dos três grupos, foram realizadas tanto no momento pré, quanto após oito e 16 semanas de experimento, por meio de uma bateria de testes motores. A ANOVA two-way apontou interação grupo x momento significante para os componentes flexibilidade, resistência de força muscular e resistência aeróbia, e para valores do IAFG ($p < 0,05$). O teste post hoc de Scheffé apontou diferença entre os grupos treinamento e o GC, sem nenhuma diferença entre GT90 e GT180. Houve, também, melhora na classificação geral do IAFG para o GT90 e GT180, que passaram de "regular" para "bom", enquanto o GC manteve-se classificado em "regular". Pode-se concluir que os dois volumes de alongamento empregados foram igualmente eficazes na melhora da flexibilidade, resistência de força muscular, resistência aeróbia e nos níveis da CF de mulheres idosas.*

Palavras-chave: *Amplitude de movimento articular; Aptidão física; Envelhecimento*

1 Universidade Estadual Paulista. Instituto de Biociências, Departamento de Educação Física. Laboratório de Atividade Física e Envelhecimento. Rio Claro, SP. Brasil.

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INTRODUCTION

Functional capacity (FC) can be defined as the ability to carry out daily tasks with vigor, alertness, and without excessive fatigue[1]. This ability is operationalized through a set of components that include: cardiorespiratory fitness, flexibility, body composition, balance, agility, reaction time and muscular strength[1]. In particular, it is known that high levels of flexibility are directly related to the efficiency in the performance of activities of daily living[2-4]. However, during the aging process, there is a decrease in levels of this component, resulting from changes in the musculoskeletal system[5]. Therefore, it is recommended that stretching routines be incorporated into physical activity programs aimed at the elderly population[6].

Although there is a relationship between decreased flexibility and difficulties in performing activities of daily living, few studies have sought to investigate the effects of stretching training in the range of motion of the elderly population[6]. Thus, there is still no consensus as to which durations and types of stretching are safer and more effective for the elderly population. Feland et al.[7] investigated the effect of three different durations of passive stretching (60, 120 and 240 seconds) on the flexibility of institutionalized elderly. The authors found improvement in flexibility for the three groups that were trained, but the group that trained with longer duration (240 seconds) presented significantly higher values when compared to the two other durations (60 and 120 seconds) and to the inactive group.

In addition, besides the development of flexibility, this type of training has further promoted improvements in other components of FC, such as muscular strength and agility[8-11], and it may positively influence FC and functionality of the individual. However, it is important to emphasize that, although there seems to be a dose-response relationship between stretching training and flexibility, no article was found in the available literature that has investigated the same phenomenon in other components of FC.

Thus, the objective of the present study was to analyze the effect of two different durations of stretching, 90 or 180 seconds, on the FC in elderly women. It is believed that both volumes of training will be effective in improving all components of FC, however, the higher volume (180 seconds) will promote significantly higher values.

METHODOLOGICAL PROCEDURES

Sample

Participants were 57 elderly women recruited from the community. They were assigned by convenience, into three groups: Inactive Control Group (CG, n. =17), Training Group, with three sets of 30 seconds (GT90, n. =20) and Training Group with three sets of 60 seconds (TG180, n. =20). It was adopted as initial inclusion criteria: a) to be female and 60 years old or more; b) to be physically inactive (not practicing physical exercise twice a week or more), not having participated in any regular physical exercise program over the last 6 months preceding the beginning of the experiment; c) not presenting musculoskeletal and/or osteoarticular contraindications that limited or impaired their performance on the training protocol and/or assessment. After receiving verbal information about the procedures to which they would be submitted, all participants who agreed to participate in the study signed a consent form. This study was approved by the Research Ethics Committee of the Institute of Biosciences - Universidade Estadual Paulista, protocol number 0749.

For health and/or personal reasons, not related to the study, three participants from CG, five participants from GT90, and six participants from TG180 discontinued participation in the study. Therefore, 43 elderly women completed the present study: 14 from CG, 15 from GT90 and 14 participants from TG180.

Experimental Design

Both training groups, TG90 and TG180, attended the university for 16 weeks, three times a week, with approximate duration of 1 hour per session. The CG did not perform any activity and attended university only in assessment periods. The evaluations of the FC components of the three groups (CG, TT90 and TG180) were performed both in the pre moment as well as 8 and 16 weeks during the experiment.

It is noteworthy to mention that the training sessions and evaluations were monitored by Physical Education professionals with previous experience in the battery of tests employed and in physical activity programs aimed at the elderly population.

Training Protocol

The training protocol consisted of seven different active stretching exercises. To perform the exercises, participants were instructed to achieve maximum range of motion slowly, without help, until the onset of pain, and remain in this position for as long as determined[12]. For each exercise they performed three sets with duration of 30 (GT90) or 60 (TG180) seconds and 30 seconds interval between sets[12]. It was adopted as the total volume of stretching the result of the multiplication of the number of sets by the duration. Verbal stimuli were provided to encourage the maintenance of the position during the determined periods.

Stretching exercises were: a) Standing, with one arm against the wall and palm facing to the side, extend elbow totally and laterally rotate the body out, performing shoulder extension (flexor muscles of the shoulder and elbow); b) Standing, bend one knee and bring the heel toward the hips (hip flexors and knee extensors); c) With one knee resting on the floor and the contralateral knee flexed forward, keeping one foot flat on the floor and hip away extended in the anteroposterior direction, firmly support one of the hands on the ground and slightly extend the upper body (hip flexor muscles); d) Sitting, with back straight and knees slightly bent forward, raise both arms and perform shoulder flexion, with the elbow also extended and palms facing inward (shoulder extensor muscles); e) Sitting, maintaining upright posture, perform shoulder flexion and elbow of one of the arms, reaching the back with the hand (extensor muscles of the shoulder and elbow); f) Sitting, with legs apart in mediolateral way and extended knees, bend your upper body toward the knee (hip extensor muscles and knee flexors); g) In supine position, keeping one of the knees bent and with a foot flat on the floor, flex the hip of the contralateral leg, keeping the knee extended, and take it towards the upper body (hip extensor muscles)[13]. Except for the exercise described in item d, all were made unilaterally, for both limbs.

Evaluation Protocol

In order to assess the components of FC (flexibility, coordination, agility and dynamic balance, muscle strength and aerobic endurance), it was used the battery of motor tests of the American Alliance for Health, Physical Education, Recreation and Dance (AAHPERD)[14]. Detailed description of the tests was previously published by Zago and Gobbi[14].

From the results found in each motor test, it was assigned a percentile score, and the sum of the scores of all components resulted in the Global Functional Fitness Index (GFFI). The GFFI allows to analyze the level of functional fitness of the individual globally and to rank it from very poor to very good according to the normative values proposed by Zago and Gobbi[14] and Benedetti et al.[15].

Statistical Analysis

Whereas the Shapiro-Wilk test did not reject the hypothesis of normal distribution of data, a descriptive analysis (mean and standard deviation) was used. The two-way ANOVA (3x3) for repeated measures was used to compare values of FC in the three groups (CG, TG90 and TG180), in the three moments of assessment (pre, after 8 weeks and after 16 weeks). The Scheffé post hoc test was used when ANOVA showed a statistically significant difference, and the level of significance adopted was $p < 0.05$.

RESULTS

The anthropometric characteristics and the age of the participants are shown in Table 1, no significant differences were found between the groups (age: $p = 0.660$; body mass: $p = 0.773$; height: $p = 0.274$; BMI: $p = 0.627$).

The component values of FC are presented in Table 2. The two-way (3x3) ANOVA showed group x moment interaction for the components: flexibility, muscular strength, and aerobic endurance ($p < 0.05$). The Scheffé post hoc test, showed significant difference between the training groups and CG, with no difference between TG90 and TG180.

Although there were no observed changes that can be attributed to stretching training for agility and coordination components (no group x moment interaction), Scheffé post-hoc tests showed main time effect ($p < 0.001$). The TG90 presented better values for coordination after 16 weeks of training, with percentage improvement of 23%. And the TG180 obtained improvement in agility of 9% and 10% after 8 and 16 weeks of training, respectively.

Table 1. Age and anthropometric characteristics of the sample. Values as mean and standard deviation.

Group	Age (years)	Body mass (kg)	Height (m)	BMI (kg/m^2)
CG (n =14)	67 ± 6.5	65.8 ± 5.9	1.57 ± 5.7	26.7 ± 5.3
TG90 (n =15)	67 ± 7.9	66.7 ± 9.3	1.55 ± 5.4	27.6 ± 3.3
TG180 (n =14)	64.9 ± 6.2	63.9 ± 10.1	1.53 ± 6.0	28.3 ± 4.9

CG = Control Group; TG90 = Training Group 30s; TG180 = Training Group 60s.

Table 2. Mean values ± standard deviation of components of Functional Capacity (FC) in the moments before, after 8 weeks, and after 16 weeks of stretching training, in the three groups (CG, TG90 and TG180).

	CG (n =14)	TG90 (n =15)	TG180 (n =14)	Effects	F	P
Flexibility (cm)				ANOVA		
Pre	56.9 ± 9.9	58.9 ± 10.9	56.7 ± 10.4	Group	1.41	0.256
After 8 Δ%	57.5 ± 10.1 1.06	64.4 ± 11.1^{a,b} 9.4	62.3 ± 9.1^{a} 9.9	Moment	25.71	<0.001
After16 Δ%	57 ± 11 0.1	66.8 ± 12.3^{a,b} 13.4	63.1 ± 7.4^{a,b} 11.3	Group x Moment	6.09	<0.001
Coordination (s)				ANOVA		
Pre	11.9 ± 3.2	13.2 ± 5.4	11.6 ± 2.6	Group	0.59	0.559
After 8 %	10.3 ± 1 -13.5	10.7 ± 2.5 -19.0	10.2 ± 2.1 - 12.1	Moment	17.42	<0.001
After16 Δ%	9.9 ± 1.6 -16.8	10.2 ± 1.3^{a} - 22.7	9.7 ± 1.1 - 16.4	Group x Moment	0.54	0.705
Agility (s)				ANOVA		
Pre	22.7 ± 3	22.2 ± 3.6	22.1± 2.3	Group	1.67	0.201
After 8 Δ%	22.2 ± 2.5 -2.2	20.7 ± 2.7 - 6.8	19.9 ± 1.8^{a} - 10.0	Moment	17.07	<0.001
After16 Δ%	22.4 ± 3.7 - 1.3	20.8 ± 2.3 - 6.3	20.1 ± 2.2^{a} - 9.1	Group x Moment	1.97	0.106
Muscle strength (repetitions)				ANOVA		
Pre	20.7 ± 5.4	22.7 ± 4	22.4 ±3.1	Group	5.23	0.01
Post 8 Δ%	22.1 ± 4 6.8	24.5 ± 2.9 7.9	27.4 ± 5.3^{a,b} 22.3	Moment	23.44	<0.001
Post 16 Δ%	22.9 ± 4 10.6	27.5 ± 2.7^{a,b} 21.2	28.1 ± 5.2^{a,b} 25.5	Group x Moment	2.56	0.045
Aerobic endurance (s)				ANOVA		
Pre	549.4 ± 79.2	531.6 ±66.8	500.8 ± 49.5^{b}	Group	2.52	0.093
After 8 Δ%	533.7 ± 87.8 - 2.9	511.7 ± 50.8 -3.7	489.8 ± 33.7^{b} - 2.2	Moment	12.25	<0.001
After16 Δ%	542.3 ± 95 - 1.3	490.1 ±43.7^{a,b} - 7.8	478.2 ± 46.8^{b} - 4.5	Group x Moment	2.63	0.041

CG = Control Group; TG90 = Training Group 30 seconds; TG180 = Training Group 60 seconds; a = significant difference regarding the pre-trial period; b = significant difference in relation to Control Group; Δ% = mean percentage variation.

Table 3 presents values for mean and standard deviation of GFFI, the respective classification of percentile variation values for Groups CG, TG90 and TG180. An improvement in ratings for the training groups and statistical analysis showed significant group x moment interaction for GFFI values ($p = 0.025$).

Table 3. Mean values ± standard deviation of the Global Fitness Index (GFFI) and its classification in the moments pre-trial, after 8 weeks, and after 16 weeks of stretching training, in the three experimental groups (CG, TG90 and TG180).

	GFFI (Percentile points)	CLASSIFICATION	Effects	F	P
CG (n =14)			ANOVA		
Pre	247.9 ± 93.5	Fair	Group	4.26	0.021
After 8 Δ%	290.9 ± 69.1 17.4	Fair	Moment	66.22	<0.001
After 16 Δ%	295.5 ± 86.3 19.2	Fair	Group x Moment	2.94	0.025
TG90 (n =15)					
Pre	272.1 ± 75.1	Fair			
After 8 Δ%	336 ± 59.8[a] 23.5	Good			
After 16 Δ%	373.6 ± 44.5[a, b] 37.3	Good			
TG180 (n =14)					
Pre	289 ± 65.8	Fair			
After 8 Δ%	366.1 ± 57[a, b] 26.7	Good			
After 16 Δ%	378.6 ± 50.4[a, b] 31.0	Good			

CG = Control Group; TG90 = Training Group 30 seconds; TG180 = Training Group 60 seconds; a = significant difference in relation to the same experimental period; b = significant difference between Control Group; Δ% = mean percentile variation; classification according to Zago and Gobbi(14) and Benedetti et al. [15].

DISCUSSION

The results showed that the two stretching durations were equally effective in improving: a) flexibility, muscle strength and aerobic endurance; b) the mean values and the ratings of participants' GFFI.

The dose-response relationship between stretching training and flexibility was investigated previously by Feland et al.[7]. Authors found that a higher volume of stretching (240 seconds) promoted greater gain in the levels of flexibility (29%) when compared to the two other volumes, 60 (8%) and 120 seconds (17%). In the present study, no significant differences were observed between the two volumes employed, 90 and 180 seconds. However, the percentage of gain is close to that found in the study of Feland et al.[7], so there was an improvement of 13% and 11%, for TG90 and TG180, respectively. Although the mechanisms involved were not evaluated, the best gains in range of motion observed in TG180 may be related to the time under tension during muscle stretching. During the aging process, there is a decrease in rigidity of the muscle-tendon unit[16]. Behm et al.[17] suggested that a less rigid muscle-tendon unit may accommodate more successfully the stress resulting from stretching. Thus, larger volumes of stretching would be needed to promote a better increase in the range of motion of elderly people[16,18].

There was no difference between the two volumes of stretching employed for values of muscle strength, both TG90 and TG180 promoted equally important improvements, 21% and 25% respectively. These results are consistent with other studies in literature[8,9]. Stanziano et al.[9] observed a significant increase in upper limbs (right arm = 45.7% and left arm = 14%) and lower limbs (17%) muscle strength resistance, and in the power of lower limb muscle strength (25.6%), after 8 weeks of stretching training. Gajdosik et al.[8] in turn, found significant increase in isometric muscle strength measured at maximum range of ankle dorsiflexion (60.8%). A series of mechanisms may be associated with the improvement in the levels of muscle strength, among them, changes in the elastic properties of the musculoskeletal system, such as viscosity of the muscle-tendon unit, which may allow a better reuse of elastic energy during the stretch-shortening muscle cycle and consequent better reuse of elastic energy, promoting greater levels of muscular strength[8,9].

However, it is important to emphasize that the response to the stretching training seems to differ according to the expression of muscle strength analyzed, once in other studies, Simão et al.[11] and Gallon et al.[10] found no significant changes in the values of maximum muscular strength (assessed by the test of 10 maximum repetitions) and torque peak (concentric and eccentric), respectively, after a period of training. Thus, the stretching training shows to be effective in increasing muscle strength, muscular power, and maximum isometric muscle strength, which is not true for the other expressions of strength.

Is it noteworthy that, the test adopted in the present study for the assessment of aerobic endurance, as well as other tests commonly used, as the 6-minute (TC6M)[3] and 10-meter[19] walking tests, are more related with the gait patterns than with the aerobic fitness of the individual. Studies have demonstrated that, besides promoting better levels of flexibility, stretching training can also be effective in improving gait parametes[20]. In addition, Geraldes et al.[3] found significant correlations between flexibility of the hip joint and tests of standing and seating on the chair, and climbing stairs (TC6M). This way, it is believed that the results obtained in both training groups are related to the increased flexibility found in the upper body and hips, and a possible change in the walking pattern.

Although no improvement was found in the levels of agility that can be attributed to training, the TG180, when compared to their initial values, showed a 9% improvement in the time required for testing. This result is consistent with other studies that have also shown improvement in this component after a period of stretching training[8,9]. Christiansen et al.[20] reported an improvement in hip, knee, and ankle flexibility and in gait speed by 0.07 m/s, after 8 weeks of stretching training. In this context, increased range of motion associated with increased levels of muscle strength of the lower limbs, have been identified as the primarily responsible for the improved performance observed in agility[3,9,20].

The improvement found for coordination in the TG90 after 16 weeks of training is an interesting result. While there are no studies in the literature that examined the relationship between stretching training and motor coordination, a possible mechanism that may explain this fact would be the best control of the movement of alternating the cans, resulting from a better muscle contraction. However, it is not possible to make direct relations due to the lack of scientific evidence, a fact that highlights the need for investigations on the topic.

Finally, the training also proved to be effective in improving participants' GFFI significantly for both training groups (TG90 = 37% and TG180 = 31%) when compared to CG (19%). The overall classification of the GFFI was also changed for both training groups, TG90 and TG180, which went from "fair" to "good", while the CG remained classified as "fair" throughout the experimental period. Although no studies that reported the effects of stretching training were found, Coelho et al.[21] found significant improvement of 3% in the values of GFFI, without changing, however, the overall rating that started and remained in "good", after 4 months of dancing activities. Once GFFI results from the sum of FC components values, it is believed that the improvement in the main values and its general classification is due to the best results obtained for the components flexibility, muscle strength and aerobic endurance.

The present study has some limitations: a) there was no direct evaluation of the neuromuscular system, which could have indicated possible structural changes such as the strength – length relationship; b) once the training was conducted involving the main joints of the body, the absence of assessments on flexibility of other joints besides the upper body and the hip limit the possible effects from the training; c) although it was recommended that the participants did not participate in other physical activities, the level of physical activity was not directly monitored.

CONCLUSION

The analysis of the results allows us to conclude that the two amounts of stretching employed, 60 and 180 seconds, were equally effective in improving the functional capacity components, in particular, flexibility, muscle strength and aerobic endurance. The training period of 16 weeks also provided positive changes in the levels of global FC of elderly women.

Thus, this study has an important practical application, since stretching training can be considered a type of exercise of easy learning and applicability, that does not require any material or specific location and that proved to be an important ally against the deleterious effects of aging, acting in the maintenance of functionality in older women.

It is suggested that further studies be conducted to manipulate other training parameters, such as different methods of stretching, and perform direct evaluations be performed, especially of muscular strength and flexibility.

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Corresponding author

Luiza Herminia Gallo.
Avenida 1 A, 1362, Vila Bela.
CEP: 13506-785 - Rio Claro, SP. Brasil.
E-mail: lu.herminia@gmail.com