

Effect of two different weekly resistance training frequencies on muscle strength and blood pressure in normotensive older women

Efeito de duas diferentes frequências semanais de treinamento com pesos sobre a força muscular e pressão arterial em mulheres idosas normotensas

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Abstract – The aim of this study was to analyze the effect of two different weekly resistance training (RT) frequencies on muscle strength and blood pressure (BP) in normotensive older women. Thirty normotensive and physically independent older women participated in the study, which were divided into two groups: RT performed in two weekly sessions (G2X, n = 17; 67.6 ± 4.6 years; 69.7 ± 13.4 kg; 156.6 ± 5.8 cm) and three weekly sessions (G3X, n = 13; 68.7 ± 5.0 years; 69.8 ± 16.1 kg, 155.2 ± 7.8 cm). The RT program was composed by eight exercises for different muscle groups (upper limbs, trunk and lower limbs), lasting 24 weeks (two phases of 12 weeks each). In the first phase, exercises were performed in one set of 10–15 maximum repetitions per exercise, while in the second phase, two sets were performed. BP and muscle strength (1RM) measures were performed at pre-training and after 12 and 24 weeks of RT. Increases in total muscle strength (P < 0.05) were observed in both groups (G2X = 16.8% and G3X = 18.9%), with no difference between groups. On the other hand, no significant changes (P > 0.05) in systolic BP and diastolic BP were found in both groups. The results suggest that 24 weeks of a supervised RT program improve muscle strength without affecting BP in normotensive older women, regardless of frequency of two or three weekly sessions.

Key words: Aging; Hemodynamics; Resistance training.

Resumo – O objetivo do presente estudo foi analisar o efeito de duas diferentes frequências semanais ao treinamento com pesos (TP) sobre a força muscular e pressão arterial (PA) em mulheres idosas normotensas. Trinta mulheres normotensas e fisicamente independentes foram divididas em dois grupos: TP realizado em duas sessões semanais (G2X; n = 17; 67,6 ± 4,6 anos; 69,7 ± 13,4 kg; 156,6 ± 5,8 cm) e em três sessões semanais (G3X; n = 13; 68,7 ± 5,0 anos; 69,8 ± 16,1 kg; 155,2 ± 7,8 cm). O programa de TP foi composto por oito exercícios para os diferentes segmentos corporais (membros superiores, tronco e membros inferiores) e teve a duração de 24 semanas (duas etapas com duração de 12 semanas cada). Na primeira etapa todos os exercícios foram executados em uma única série de 10–15 repetições máximas, ao passo que na segunda etapa houve a progressão para duas séries por exercício. Medidas de pressão arterial (PA) e força muscular (testes de 1RM) foram realizadas nos momentos pré-treinamento, após 12 e 24 semanas de TP. Aumentos significantes na força muscular (P < 0,05) foram encontrados em ambos os grupos (G2X = +16,8% vs. G3X = +18,9%), sem diferenças entre eles. Por outro lado, nenhuma alteração significativa foi identificada na PA sistólica e diastólica ao longo do tempo em nenhum dos grupos (P > 0,05). Os resultados do presente estudo sugerem que 24 semanas de um programa de TP supervisionado melhoram a força muscular, sem acarretar modificações na PA, em mulheres idosas normotensas, independente da frequência de duas ou três sessões semanais.

Palavras-chave: Envelhecimento; Hemodinâmica; Treinamento de resistência.

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INTRODUCTION

The aging process is characterized by important changes that negatively affect various health indicators and quality of life¹, resulting in reduced muscle strength and increased blood pressure (BP)². If the reduction of muscle strength compromises functionality and hinders the performance of relatively simple tasks of the daily living, high BP is associated with increased cardiovascular risk and higher incidence of death due to ischemic heart disease, stroke, and renal complications³. Thus, it is important to develop strategies for the preservation of muscle strength and prevention of hypertension with advancing age.

The regular practice of physical exercises has been indicated both for the improvement of muscle strength and for the primary prevention of arterial hypertension². Although aerobic training produces important modifications in rest BP in older women⁴, the regular practice of resistance training (RT) has been more recommended for this population⁵, since in addition to assisting in controlling BP, can provide numerous additional health benefits in the elderly, with emphasis on muscle strength, muscle power, metabolic behavior, balance, muscle mass, bone mineral content and density^{1,5}.

However, the magnitude of responses induced by regular practice of RT seems to be influenced by the manipulation of variables that compose training programs, and that determine the relationship between volume and intensity⁶⁻⁸. In this sense, the training volume can be modified by simply manipulating the number of exercises, sets and / or repetitions, as well as by increasing the weekly frequency. Although literature indicates that there is an important dose-response relationship between adaptations caused by RT and training volume⁹⁻¹², to our knowledge, there are no studies to date comparing the effect of different RT frequencies on BP in elderly women.

Therefore, the aim of the present study was to analyze the effect of two different weekly RT frequencies on muscle strength and BP of normotensive older women. Our hypothesis was that a higher RT frequency by producing a greater training volume could lead to changes in muscle strength and better adaptations in BP based on a higher dose-response effect.

METHODOLOGICAL PROCEDURES

Experimental Design

The present study was developed from a database produced by the “Impact of different weekly resistance training frequencies in older women” project, partially funded by the National Council for Scientific and Technological Development (CNPq) (Protocol No. 486371 / 2011-5). The study had total duration of 30 weeks, of which weeks 1 and 2, 15 and 16, and 29 and 30 were intended for measurements and evaluations. The first stage of RT was performed between weeks 3 and 14, while the second stage was conducted between weeks 17 and 28.

Participants

Thirty physically independent older women aged ≥ 60 years who had at least 12 weeks of RT practice, and were detrained for at least three months were voluntarily selected to participate in the study. The recruitment of participants took place through announcements in local radios and newspapers, posters in the university community and in the central region of the city. The sample was selected through interviews and clinical anamnesis. The following inclusion criteria were adopted for this study: 1) absence of musculoskeletal dysfunctions that could interfere with the performance of training sessions and tests to be applied; 2) not being hypertensive; and 3) not having restrictions for the practice of physical exercises attested by a cardiologist after specific examinations.

After being properly informed about the study proposal and the procedures to which they would be submitted, all participants signed the free and informed consent form. The project was approved by the Ethics Research Committee involving human beings of the Londrina State University (CEP protocol No. 048/2012).

Anthropometry

Body mass was measured on a digital platform scale (Balmak, model Class III, Santa Bárbara D'Oeste, SP, Brazil) with accuracy of 0.1 kg and height was measured in a wooden stadiometer with accuracy of 0.1 cm, according to procedures described in literature¹³. Body mass index (BMI) was determined by the relationship between body mass (kg) and squared height (m²).

Blood pressure

Resting BP was determined by means of OMRON HEM-742 automatic device (Omron Healthcare, Lake Forest, IL, USA). Prior to BP measurements, participants were instructed not to perform any type of vigorous physical activity, not to drink alcohol or caffeine in the 24 h preceding the days of data collection, and not to be on urinary continence at the time of BP measurement.

Measurements were performed at three evaluation moments (pre-training, after 12 and 24 weeks). At each of these moments, BP was measured three times a day at rest, for three consecutive days, at similar times, and the mean value was recorded. The average of the three days was adopted as the reference value. To measure BP, the following procedures were adopted: 1) measurements were always performed in the morning; 2) participants were instructed to remain seated in a chair at rest for 10 min before measurements; 3) an interval of five minutes was established between measures; and 4) the cuff was placed on the right arm, which was supported on a table and raised to the height of the midpoint of the sternum.

Muscle strength

Muscle strength was determined by the maximal repetition test (1RM) in three exercises involving trunk, lower limb and upper limb segments.

The exercises chosen were tested in the following order: chest press, leg extension and biceps curl. The methodological procedures followed recommendations of literature¹⁴, including three previous familiarization sessions in 1RM tests, in each exercise, with intraclass coefficient being greater than 0.96 in the three exercises. For the determination of total muscle strength, the sum of loads obtained in the 1RM tests for the three exercises (chest press machine, leg extension and biceps curl) in each participant was used.

Resistance Training Program

The RT program was performed in two stages, each one lasting 12 weeks (totaling 24 weeks of training), which was structured for muscle strengthening¹⁴. The training sessions were performed on non-consecutive days, that is, on Tuesdays and Thursdays for G2X, or on Mondays, Wednesdays and Fridays for G3X, always in the morning period. In order to standardize the execution of movements and guarantee safety, all participants were monitored and individually guided by professors and undergraduate and graduate students in Physical Education at the local University.

The RT program was structured with exercises for the different body segments (lower limbs, trunk and upper limbs). In both training stages, participants performed the same eight exercises in the following order: chest press, horizontal leg press, seated row, leg extension, biceps curl, leg curl, lat pull down, and seated calf rise. The first 12 weeks consisted of a single set of 10 to 15 maximum repetitions in each exercise, while in the last 12 weeks, participants performed two sets with the same number of repetitions as in the previous phase. During the performance of exercises, participants were instructed to: 1) inhale during eccentric muscular action and exhale during concentric muscular action; 2) try to maintain the performance speed at the 1: 2 ratio (concentric and eccentric muscular action, respectively); and 3) maintain the recovery interval between exercises and / or sets of one to two minutes.

Loads were individually readjusted in each exercise, whenever the maximum number of repetitions (15 repetitions) was reached in one set (first stage of the study) or in two sets (second stage of the study) by two consecutive training sessions in an attempt to preserve intensity throughout the experimental period. Thus, whenever necessary, loads were increased by 2 - 5% for upper limbs and 5 - 10% for lower limbs¹⁵. All participants were instructed to maintain their lifestyle habits and did not initiate new exercise programs or diets during the intervention period. It is noteworthy that participants had frequency of 91% (G2X: 22 ± 1 sessions per stage) and 92% (G3X: 33 ± 2 sessions per stage) at RT sessions.

Statistical analysis

The Shapiro-Wilk test was used to verify data distribution. The homogeneity of variances was analyzed by the Levene test. Sphericity was verified by the Mauchly test and, in case of violation of this assumption, the Greenhouse-Geisser correction was adopted. The Student t test for independent

samples was used to analyze the scores of the general characteristics of groups at the pre-training. Analysis of variance (ANOVA) 2x3 for repeated measurements was used for intra and inter-group comparisons over time. The Bonferroni *post hoc* test was used for the identification of differences. The effect size was calculated to analyze the magnitude of differences. Effect size of 0.20-0.49 was considered small, 0.50-0.79 moderate and ≥ 0.80 large¹⁶. Data were processed in the SPSS statistical software version 17 and the significance level adopted was $P < 0.05$.

RESULTS

Table 1 presents the general characteristics of groups (G2X and G3X) at the beginning of the study. No statistically significant differences were identified between groups ($P > 0.05$).

Table 1. Initial characteristics of participants.

	G2X (n = 17)	G3X (n = 13)	P
Age (years)	67.6 ± 4.6	68.7 ± 5.0	0.88
Body weight (kg)	69.7 ± 13.4	69.8 ± 16.1	0.49
Height (cm)	156.6 ± 5.8	155.2 ± 7.8	0.17
BMI (kg/m ²)	28.4 ± 5.0	28.9 ± 5.4	0.70

BMI = body mass index, G2X = group that performed the RT program twice a week, G3X = group that performed the RT program three times a week. Values expressed as mean and standard deviation.

The muscle strength, systolic BP (SBP) and diastolic BP (DBP) values at different moments of the study are presented in Table 2. No group vs. time interaction or main effect of time was found for SBP and DBP measures ($P > 0.05$). The effect size for this variable was considered small (variation from -0.20 to 0.09). In contrast, a main time effect was found for muscle strength, indicating significant increases ($P < 0.01$) in both groups (G2X = + 16.8% vs. G3X = + 18.9%), with no statistically significant difference between groups ($P > 0.05$). The effect size for muscle strength was considered small for G3X after 12 weeks of training and moderate after 24 weeks, whereas for G2X, the effect size was moderate throughout the experimental period.

Table 2. Rest systolic (SBP) and diastolic blood pressure (DBP) and muscle strength at the different time points of the study in older women trained for 24 weeks in different resistance training frequencies (RT).

	G2X (n = 17)	G3X (n = 13)	ANOVA	F	P
SBP (mmHg)					
Pre-training	116.8 ± 7.9	114.0 ± 9.5	Group	0.25	0.62
After 12 weeks	115.2 ± 12.2	114.5 ± 10.3	Time	0.11	0.89
After 24 weeks	116.3 ± 11.8	114.9 ± 10.9	Interaction	0.19	0.82
ES 1	-0.20	+0.05			
ES 2	+0.09	+0.04			
DBP (mmHg)					
Pre-training	67.2 ± 5.3	66.1 ± 6.9	Group	0.10	0.75
After 12 weeks	66.4 ± 5.8	65.8 ± 6.5	Time	0.31	0.72

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After 24 weeks	66.0 ± 7.7	65.6 ± 5.6	Interaction	0.13	0.87
ES 1	-0.15	-0.04			
ES 2	-0.07	-0.03			
Muscle strength (kg)					
Pre-training	100.6 ± 13.4	110.9 ± 18.0	Group	3.0	0.09
After 12 weeks	109.1 ± 18.7	118.6 ± 18.7	Time	64.0	<0.01
After 24 weeks	117.4 ± 17.6	129.8 ± 19.5	Interaction	0.44	0.64
ES 1	+0.63	+0.43			
ES 2	+0.62	+0.60			

G2X = group that performed the RT program twice a week, G3X = group that performed the RT program three times a week, ES = effect size, ES 1 = pre-training after 12 weeks, ES 2 = after 12 and 24 weeks. Values expressed as mean and standard deviation.

DISCUSSION

The main finding of the present study was that 24 weeks of a supervised and progressive RT program increased muscle strength, but did not promote changes in rest BP in normotensive older women regardless of weekly frequency (two vs. three). Our hypothesis was refuted, since RT in different weekly frequencies produced similar results for both muscle strength and for SBP and DBP.

The literature presents conflicting results regarding the effect of RT on BP. Previous studies have reported increases¹⁷, decreases¹⁸⁻²³ or did not find²⁴⁻²⁷ changes in rest BP in different training protocols and populations. Divergences of results seem to be related to the characteristics of samples studied, mainly in relation to pre-experiment BP values. Higher reduction magnitudes appear to occur in individuals with higher BP values and untrained individuals²⁸⁻²⁹. Gerage et al.¹⁹ submitted 29 normotensive and untrained older women to 12 weeks of RT in three weekly sessions and observed reductions in SBP (-5 mmHg). Disagreement regarding the present study can be explained by the level of physical conditioning of participants (untrained vs. detrained), which leads us to believe that untrained participants are more susceptible to changes in BP when compared to detrained ones³⁰. Despite using lower intervention period (eight weeks of training) when compared to our study, Gurjão et al.²⁰ observed an even more significant change in SBP (-13 mmHg); however, higher pre-experiment BP values may explain, at least in part, the higher magnitude reduction observed².

The chronic responses induced by RT are dependent of the volume and intensity manipulation⁶⁻⁸. Brito et al.⁸ verified larger-scale reductions in post-exercise BP in trained hypertensive older subjects submitted to higher volume RT protocol (simple sets vs multiple sets). The present study did not reveal significant differences in chronic BP when G2X and G3X groups were submitted to either single sets (3-14 weeks) or multiple sets of exercises (17-28 weeks). However, the results do not allow for comparison mainly due to the fact that the present study did not evaluate BP in an acute way. Chronic studies with total training volume (sets + frequency

+ duration + number of exercises + number of repetitions + load) found responses similar to those of the present study regarding BP²⁶⁻²⁷.

In general, protocols of previous studies did not compare different RT frequencies, but adopted training protocols with frequency of two or three weekly sessions. Thus, comparing our findings with studies that used the same frequency of weekly RT (two or three sessions), it is observed that they are in agreement, once previous studies also did not find changes in BP at frequency of two²⁴⁻²⁵ or three weekly RT sessions²⁶⁻²⁷. On the other hand, Nascimento et al.²² showed significant reductions in SBP (-18.1 mmHg) and mean blood pressure (MBP) (-12.8 mmHg) in hypertensive older women submitted to 12 weeks of RT performed in two weekly sessions. It is worth mentioning that the existing hypertensive condition and the use of antihypertensive drugs are factors that may have contributed to the greater reduction of pressure levels. At the same weekly training frequency, similar results were found in normotensive and hypertensive older men and women².

The results found in previous studies do not allow generalization for the present study because they adopted treatments that used independent training protocols, with no standardization of RT variables and the evaluation methods adopted in this study. In addition, the differences found among studies may have been influenced, at least in part, by gender (men vs. women), physical fitness level (untrained vs. detrained vs. trained), BP conditions (normotensive vs. hypertensive) and diet.

The results of this study indicated significant increases in muscle strength in similar magnitudes for both RT frequencies analyzed. Farinatti et al.⁷ submitted 48 physically active older women to 16 weeks of RT at three different weekly frequencies (1, 2 and 3 times / week), and observed that in two exercises (chest press and leg extension) increases occurred with more frequent training. However, in two other exercises (bench press and seated calf), increases in muscle strength occurred regardless of weekly frequency. Although Farinatti et al.⁷ reported that the participants were physically active, none were engaged in a supervised RT program. Thus, it is possible that at least part of the differences found in our study is due to the different levels of previous RT experience of samples from both studies, since Murlasits et al.⁶ also observed increases in muscle strength in untrained elderly women after eight weeks of a RT program; however, with no differences between weekly frequencies analyzed (2X vs 3X).

To our knowledge, this is the first study to analyze the effect of different RT frequencies on BP in detrained and non-hypertensive older women. The similarity between groups at the beginning of the study, the control of BP measurements that were performed at the same time (morning) in order to avoid variations in the circadian rhythm, the intervention period (24 weeks of RT) and the adoption of a training protocol following current recommendations for RT in the elderly¹⁵ are strengths of the present investigation.

On the other hand, our study presents some limitations that should not be overlooked. The absence of a control group does not allow evaluating

the real effect of RT in isolation. Therefore, considering the modifications induced by the aging process, it is possible that the modifications found in our study would be even more significant if the results were contrasted with their peers without receiving intervention. In addition, although participants received guidelines for maintenance of eating habits and usual physical activities, these variables were not objectively controlled. With regard to eating habits, in particular, the control of dietary sodium intake would be a valuable contribution. As practical application, our results indicate that the practice of RT at a frequency of at least two weekly sessions with low volume (one or two sets per exercise) is enough and should be encouraged to increase muscle strength gains in detrained older women, since this variable is fundamental for health, quality of life and longevity. However, such a strategy does not appear to provide changes in BP in normotensive women.

CONCLUSION

The results of the present study suggest that a supervised RT program with one or two sets, regardless of frequency of two or three weekly sessions, appears to be sufficient for improving muscle strength but not for reducing BP in detrained normotensive older women.

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