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ACUTE EFFECT OF DIFFERENT WEIGHT EXERCISE INTENSITIES IN MUSCULAR PERFORMANCE OF TRAINED OLDER WOMEN

ORIGINAL ARTICLE

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ABSTRACT

The aim of this study was to compare the acute response of sustainability of repetitions and the volume of resistance training sessions conducted with different intensities, in trained older women. The study included 16 older women (68.3 ± 6.0 years, 69.8 ± 10.6 kg, 157.6 ± 6.5 cm). After the determination of load related to 15 maximum repetitions (RM) in the leg press, two experimental sessions (48-72 hours apart) were conducted by performing one of two different intensities (90% or 100% of 15 RM). Crossover balanced design was used to determine the sessions order. The session with 100% of 15 RM involved the performance of three sets until muscle fatigue, while the session with 90% of 15 RM was performed in two sets with 15 repetitions and a last one until muscle fatigue. The rest interval between sets was 120 seconds. The training volume obtained with 90% of 15 RM was 22.5% higher ($P < 0.01$) than that volume obtained with the 100% of 15 RM. The sustainability of repetitions the exercise carried out at 100% of 15 RM was compromised in two final series of the session ($P < 0.01$), with differences in the protocol carried out with less intensity. The analysis of results suggests that reduction of 10% in the load corresponding to 15 RM presents a significant effect on the sustainability of number of repetitions between sets and training volume when compared to exercise performed at 100% of 15 RM in trained older women.

Keywords: aging, muscle fatigue, muscle strength, resistance exercise.

INTRODUCTION

The aging process is followed by structural and functional alterations of the neuromuscular system (NMS)[1]. The progressive reduction in muscular strength and power of older adults is an important factor which contributes to the incidence of functional limitations, reduction in independence and quality of life[2,3].

Concerning the older population, regular practice of weight training is part of the recommendations of different organizations which promote health since it is a safe and efficient strategy to increase strength and muscular mass as well as improve functionality and quality of life of this population[4]. However, in order to reach these positive effects and limit possible performance plateaus in trained individuals, different variables related to weight training prescription should be considered[5]. Among these variables, velocity of contraction, intensity, number of sets and repetitions are commonly manipulated. Although the influence of training intensity and volume has received considerable attention in the literature, there are still some gaps concerning the relative importance and specificity of each variable in order to reach different acute and/or chronic goals (e.g.: acute hormone alterations, increase of muscular power, bone mineral density or hypertrophy)[6-9].

One of the strategies for training relative intensity prescription is the method of repetition maximum zone (RM), characterized by voluntary muscular fatigue within a given amplitude of repetitions (e.g.: 12-15 RM)[5]. When the RM zone method in multiple sets, without alteration in external resistance is adopted, significant reduction in the number of repetitions of subsequent sets has been observed in young and older adults[10,11]. Considering that the volume of a training session is the sum of the total number of repetitions multiplied by the resistance used, the performance of all sets until muscular fatigue significantly reduces the number of repetitions; therefore, it is not the best strategy when the aim is to optimize the training volume.

It has been suggested that slight reduction in external resistance concerning a specific RM zone may lead to increase in training volume due to the higher sustainability of repetitions between sets, with no compromising of the post-exercise neuromuscular responses. Benson *et al.*[12] demonstrated that in young adults discreet reduction in weight exercise intensity for the elbow flexors (100% *vs.* 90% of 10 RM) enables the performance of the first sets without muscular fatigue, allowing sustainability of repetitions between sets and, consequently, increase in volume. It is important to highlight that the post-exercise neuromuscular and metabolic responses were similar between the sessions performed with different intensities. Likewise, Gurjão *et al.*[13] have not observed differences either in the acute neuromuscular responses in older women when comparing 90 and 100% of 15 RM in the elbow flexion exercise. Although these studies are important to better understand the effect of intensity manipulation on the performance of each of the sets and of the training volume, such results cannot be extrapolated for the performance of lower limbs due to differences in the aging process of the MNS between limbs[14]. Additionally, the acute responses of muscular performance in training sessions have not been systematically described in older subjects with previous experience in weight training.

In this context, the aim of the present study was to compare the acute response of the sustainability of the repetitions and total volume performed in sessions with different intensities (90 and 100% of 15 RM), in trained older women. The hypothesis of the present study is that reduction of 10% in external resistance corresponding to 15 RM will cause maintenance of the number of repetitions in all sets, as well as higher training volume.

MATERIALS AND METHODS

Subjects

16 older women trained with weight (68.3 ± 6.0 years; 69.8 ± 10.6kg; 157.6 ± 6.5cm) participated in the study. Inclusion criteria included: a) to be 60 years or older; b) to be trained with weight for a minimum previous period of eight weeks; c) not to present absolute cardiovascular, muscular, articular and bone of the lower limbs or neurological contraindications for weight training practice (WT).

All participants were participants in a supervised WT program with frequency of three weekly times, in non-consecutive days, for a minimum of eight weeks. The WT consisted of eight exercises alternated by body segments, including the leg press exercise. For each exercise, three sets with relative intensity of 15RM and recovery interval between sets and exercises of 120 seconds were performed.

After having received information about the aims and procedures to which they would be submitted, the participants signed a Free and Clarified Consent Form. The study was approved by the Ethics Committee of the State University of São Paulo, according to the guidelines of the Resolution 196/96 of the National Health Board on research involving humans (protocol number 1,961).

Experimental outlining

The leg press exercise was used to verify the acute effect of different intensities in muscular performance of lower limbs. During the experimental period of the study, each participant went five different times to the laboratory (with intervals of at least 48 hours) and was told not to perform any intense physical activity. The aim of the three first visits was to determine the loads corresponding to 15 RM (relative intensity) in the leg press exercise. After the loads were determined, two experimental sessions were performed adopting one out of two different intensities (90 or 100% of 15 RM). All the participants performed both protocols and a balanced cross over outlining was used to determine the order of the sessions. The session with 100% of 15 RM involved the performance of three sets until muscular fatigue, while the session with 90% of 15 RM was performed in two sets with 15 repetitions and one until muscular fatigue. The recovery interval between sets was of 120 seconds. In the present study, muscular fatigue was defined as the incapacity to complete the concentric phase of a given repetition. The participants were told to perform each repetition in approximately one second in the concentric phase and in two seconds in the eccentric phase. The total time of performance of the repetitions (TTPR) of each set was recorded by a manual lap watch and it was adopted as criterion of beginning of the first repetition of each set until the participant reached fatigue or in case the two first sets at 90% of 15 RM until the end of the 15^{th} repetition. The time under tension of the musculature involved in the leg press exercise was defined as the sum of the TTPR of all sets. In order to obtain the mean time of each repetition per set, the TTPR was defined by the number of repetitions performed (seconds/repetition). The total volume was calculated by multiplying the total number of repetitions in the three sets by the external resistance in kilograms. The sustainability of the repetitions between sets for the different intensities was calculated by the following equation: [(Number of repetitions of the 2nd set or 3^{rd} sets x 100) / number of repetitions of the 1^{st} set]. In order to avoid influences of the circadian variations in muscular strength, the participants performed all the test sessions at the same time.

Repetition maximum test (15 RM)

In order to determine and confirm the loads (15 RM) which were used in the experimental protocol, three sessions with minimum interval of 48 hours were performed. The participants were evaluated in a horizontal leg press machine (Righetto Fitness Equipment). Initial position in the machine was adjusted so that the knee angle was as close as possible to 90º. The legs were parallelly positioned with small lateral space and feet rested on the platform. Arms were parallel to the trunk, arms on the support bar attached to the seat Initial position of all participants was recorded and applied in all experimental sessions. One set of 10 repetitions with 50% of possible load of 15 RM was performed with previous warm-up. After 30 seconds, the participants were told to perform the higher number of repetitions possible with load being determined by the evaluator. The loads applied in the initial tests considered the training loads of each participant. In case a number of repetitions higher than 15 RM was performed, increment of one kilogram was performed at every two repetitions exceeding the target zone. During the tests, a maximum of three attempts per session, with recovery interval of 10 minutes were performed.

In order to reduce errors during the tests, the exercise performance was continuously monitored, and only the repetitions performed with total range of motion were recorded. There were no pauses between the concentric and eccentric phases of the movement or between repetitions. Additionally, verbal stimuli were given in order to maintain participants motivated.

Statistical treatment

Initially, all data were treated from descriptive procedures (mean ± mean standard deviation). Data normality distribution was verified through application of the Shapiro-Wilk test. The effects related to the manipulation of the exercise intensity on the behavior of the sustainability of repetitions and TTPR/number ratio of repetitions were examined through 2 x 3 ANOVA [Intensity (90% and 100% of 15 RM) x Sets (1^{st}, 2^{nd} and 3^{rd})] with repeated measure in the set factor. The Scheffé post hoc test for multiple comparisons was applied for identification of the specific differences in the variables in which ANOVA presented significant interaction. The total volume of the test sessions and the sum of the TTPR in the three sets obtained in the two intensities were compared using the Student's t test for dependent samples. The significance level adopted for all analyses was of $P < 0.05$. The statistical procedures were treated in the *Statistica*™ program, version 7.0.

RESULTS

The sustainability of the repetitions behavior for both intensities is presented in figure 1. ANOVA indicated the main intensity effects ($F_{(1,15)} = 111.5$; $P < 0.01$), sets ($F_{(1,15)} = 40.5$; $P < 0.01$), as well as intensity x significant sets interaction ($F_{(1,15)} = 67.0$; $P < 0.01$). The *post hoc* test presented significant differences in sustainability of repetitions between the two intensities in the second and third sets ($P < 0.01$). Only in the session performed at 100% of 15 RM significant decrease in sustainability of repetitions was observed compared to the first set (Figure 1).

The sum of the TTPR obtained in the three sets for the 100 and 90% of 15 RM intensities were significantly different, with the lower intensity presenting longer time under tension (91.9 ± 15.1s *vs.*109 ± 14.4s, respectively). In the sessions with 90 and 100% of 15 RM, the means of the TTPR/number of performed repetitions in the first, second and third sets ratio were respectively of: a) 2.3 ± 0.3, 2.3 ± 0.3 and 2.5 ± 0.3 seconds/repetition; b) 2.7 ± 0.4, 2.8 ± 0.6 and 2.7 ± 0.5, seconds/repetition. The *post hoc* test presented significant differences in the TTPR/number of repetitions ratio from the first to the third ($P = 0.02$) and from the second to the third sets ($P < 0.01$) only for the 90% of 15 RM. No difference between intensities was observed for the TTPR/number of repetitions ratio.

The total volume of each experimental session is presented in figure 2. The exercise performed with 90% of 15 RM presented training volume significantly higher (22.5%; $P < 0.01$) when compared with the training volume obtained in te session performed at 100% of 15 RM (Figure 2).

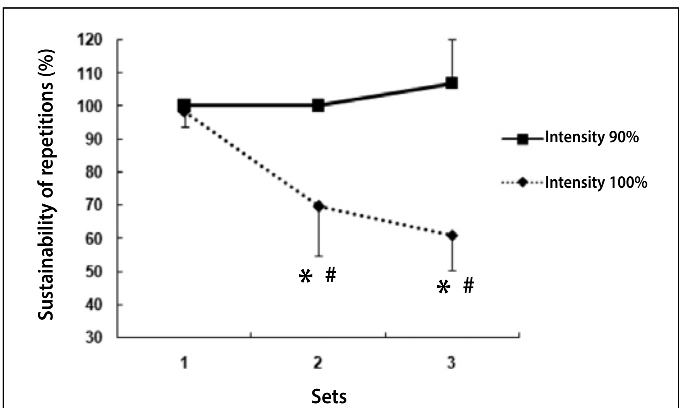

Figure 1. Sustainability of repetitions in the test sessions with different intensities (90% and 100% of 15 RM), in trained older women (n = 16). *significant differences ($P < 0.01$) concerning the first set; # significant differences ($P < 0.01$) compared with 90% of 15 RM.

DISCUSSION

The aim of the present study was to assess the behavior of the sustainability of repetitions as well as total volume in the leg press exercise performed with intensities at 100 and 90% of 15 RM. Reduction of 10% in external resistance necessary to perform 15 RM provided the sustainability of repetitions between sets and increase of 22.5% in the total volume of the sessions, corroborating the hypothesis of this investigation.

These findings agree with other results found in the literature. Some studies have suggested that sets performed with 90% of load determined in different RM zones may be a good strategy for optimization of training volume[12,13,15]. Benson *et al.*[12], for instance, demonstrated that reduction of 10% in external resistance equal to 10 RM caused increase of 14% in the training volume when compared with the volume obtained in the session at 100% of 10 RM. This volume increment was lower than the one found in the present study (22.5%). It is important to highlight the difficulty in directly comparing our findings with the study by Benson *et al.*[12] due to the different experimental outlining applied (relative intensity applied, muscular groups evaluated), gender and the alterations which occur with the aging process in the neuromuscular system and glycolytic metabolism[16,17].

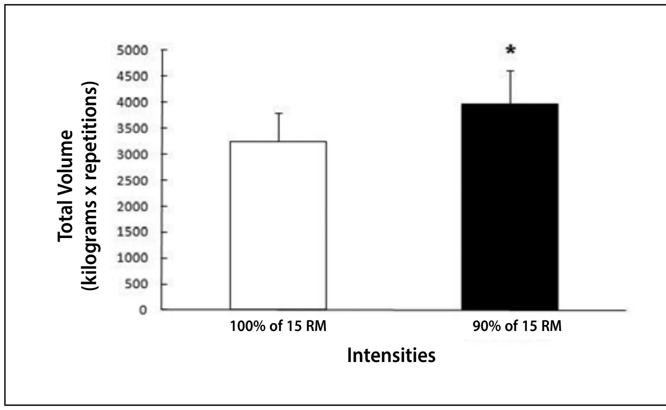

Figure 2. Total volume (kilograms x repetitions) of the test sessions with different intensities (90% and 100% of 15 RM), in trained older women (n = 16). * significant differences between intensities ($P < 0.01$).

In trained older women, Jambassi Filho *et al.*[(18)] compared muscular performance of elbow flexors using 90 and 100% of 10-12 RM, with recovery interval of 90 seconds between sets. Although the training volume has been higher when applying the lower intensity, the reduction of 10% of load corresponding to 10-12 RM was not sufficient to promote the total sustainability of the repetitions in the second and third sets (95.8 and 91.7%, respectively). Our results show that the session performed with 90% of 15 RM promoted the total sustainability of repetitions between all sets. This difference in behavior of sustainability of repetitions between studies may be related to, among other factors, the differences in exertion intensity (10-12 RM *vs.* 15 RM), in the evaluated muscular group (elbow flexors *vs.* hip flexors and knee extensors) and in the recovery interval applied between sets (90 *vs.* 120 seconds).

Brandenburg and Docherty[(7)] have suggested that the time the musculature remains under tension is an important stimulus to cause metabolic and muscular strength alterations. Although the performed session at 90% of 15 RM presents lower absolute external resistance, the possibility to perform a higher number of repetitions caused time under tension 8.6% higher than the session performed at 100% of 15 RM. Analysis of the TTPR/repetition ratio evidenced significant increase in the time needed for each repetition in the last set of the exercise performed at 90% of 15 RM. A possible explanation for this behavior may be related to the presence of muscular fatigue in the last set of the protocol. Izquierdo *et al.*[19] have demonstrated that the significant reduction of the movement velocity during a set of weight training for lower limbs (parallel squat) occurs after 63% of the total of performed repetitions. Thus, the presence of muscular fatigue in the third set may have increased the time of performance of the repetitions, especially of those which preceded fatigue. Considering that the two initial sets were performed without occurrence of muscular fatigue, it is possible that the movement velocity had not changed during all the repetitions, leading the two first sets into presenting similar TTPR/repetition ratio. Although the TTPR/repetition ratio allows the comparison of the mean time spent to perform each repetition in sets with different number of repetitions, this measurement does not allow to distinguish the moment at which the movement velocity significantly reduces.

Since the lack of muscular performance in a complete session of weight training (multiple exercises), as well as pattern of muscular activation, may be considered as potential limitations in the generalization of the results and explanation of the mechanisms, the findings observed in the present study may be of important practical application for the total volume performed during a training program or session may modulate increase in muscular strength of older adults[20-22].

The increase in the volume of WT sessions may be obtained through the manipulation of different variables, such as: intensity, recovery interval, number of sets and exercises. The reduction of 10% of external resistance corresponding to 15 RM may be one of the strategies when the aim is to increase the training volume in the leg press exercise, in trained older women. Benson *et al.*[12] have suggested that slight reduction in tension (10%) may be counterbalanced by increase in time under tension and training volume, resulting in similar post-exercise neuromuscular responses. Unfortunately, in the present study the post-exercise acute neuromuscular responses were not evaluated, which did not allow to verify whether the reduction of 10% in load of 15 RM and consequent increase in training volume provides the same stimulus in the MNS of trained older women.

CONCLUSION

The results suggest that reduction of 10% in load of 15 RM presents a significant effect in the sustainability of number of repetitions between sets, training volume and time under tension of trained older women when compared with the exercise performed at 100% of 15 RM. Thus, manipulation of intensity may be a strategy in the training volume of this population. Further studies with greater quantity of exercises, as well as analyses of the post-exercise acute neuromuscular responses are suggested.

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