EFFECTS OF DIFFERENT REST INTERVALS BETWEEN SETS ON MUSCLE PERFORMANCE IN THE LEG PRESS EXERCISE IN UNTRAINED ELDERLY WOMEN

EXERCISE AND SPORTS MEDICINE CLINIC

ORIGINAL ARTICLE

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ABSTRACT

Objective: To assess the influence of two different rest intervals (RI) between sets in the leg-press exercise on the number and sustainability of repetitions and total volume in untrained elderly women. Methods: Eleven untrained elderly women (66.5 ± 5.0 years; 59.2 ± 9.1 kg; 146.4 ± 34.9 cm) were submitted to two experimental sessions of resistance exercise with intensity of 15 maximum repetitions. Each experimental session consisted of three sets performed until muscle fatigue with an RI of one (RI-1) or 3 minutes (RI-3). The experimental sessions were separated by at least 48 hours. All participants performed both protocols and a balanced cross-over outlining was used to determine the experimental sessions order. Results: For both RI between sets, significant reduction ($P < 0.05$) in the number and sustainability of repetitions was observed from the first to the second and third sets, and the second to the third sets. Significant differences ($P < 0.05$) between the RI were observed in the two final sets. The total volume of the session with RI-3 was statistically higher (20.4%, $P < 0.05$) when compared with RI-1 session. Conclusion: The number and sustainability of repetitions and the total volume of training in untrained elderly women are influenced by the RI employed between sets. Longer RI should be used when the training goal is to increase training volume through the sustainability of repetitions. Conversely, a shorter RI should be used when the goal is to obtain higher levels of muscle fatigue.

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

INTRODUCTION

Performance of resistance exercises (RE) is a safe and efficient strategy for maintenance and development of different expressions of muscle strength of elderly adults, as well as an important contribution to improvement and of functionality and maintenance of independence[1,2]. In order to reach these positive results, different variables should be considered in the prescription of RE, such as: intensity, volume, weekly frequency, contraction velocity, exercise order and duration of the rest interval (RI) between sets and exercises[3].

Different studies have demonstrated that the duration of the RI between sets significantly affects the metabolic, hormone and of muscle strength responses[4-7]. Moreover, when multiple sets are performed until muscle fatigue, with no alterations of absolute intensity, duration of RI between sets has significant influence on the number of repetitions (NR) of the subsequent sets[8-11]. Considering the NR performed in each set is one of the components of the total training volume, the RI manipulation may be one of the strategies when training with higher volume through the NR is a priority.

In elderly adults, different studies have applied isokinetic exercises in an attempt to comprehend the effect of different RI in the muscular performance of the subsequent set[12-14]. Although the results of these studies present important information concerning the alterations in muscular strength and power in multiple sets, these findings cannot be applied to isoinertial exercises, which are widely described with different aims to elderly adults.

In isoinertial exercises, Jambassi Filho et al.[15] investigated the effect of two different RI (90 *versus* 180 seconds) between sets in the muscular performance (NR and total volume) of the elbow flexors in trained elderly women. The findings showed that none of the RI adopted was sufficient to promote the sustainability of the repetitions in the subsequent set. However, similarly to what has been verified in young adults, the longer RI provided total volume significantly higher in comparison to the shorter RI. Although this study helps to understand the effect of different RI between sets in muscular performance of elderly women, such results cannot be extrapolated to performance of lower limbs due to possible differences in the aging process of the neuromuscular system between limbs[16]. Additionally, Willardson and Burkett[17] have demonstrated different responses in sustainability of repetitions of upper and lower limbs in young adults when applying the same RI between sets.

Moreover, other factors can also influence muscular performance through the manipulation of the RI between sets, such as: composition of the muscle fibers, magnitude of the load lifted, active or passive rest, exercise order, training history and status[18]. In that sense, it is necessary to evaluate the correlation between the RI and muscular performance of lower limbs of elderly women when loads designed for the development of muscular endurance are used.

Thus, the aim of the present study was to verify the influence of two RI (one and three minutes) between sets, on the number and sustainability of repetitions and on the total volume in the leg press exercise in untrained elderly women.

MATERIAL AND METHODS

Experimental outlining

During the experimental period of the study, each participant went to the laboratory in five different occasions (with a minimum interval of 48 hours) and was instructed not to perform any intense physical activity. The aim of the three first visits was to determine the absolute loads concerning 15 repetitions maximum (RM). In the two subsequent visits, the experimental sessions were conducted adopting a RI of one minute (RI-1) or RI of three minutes (RI-3). All participants performed both protocols and the balanced cross-over outlining was used for determination of the order of the experimental sessions. In order to minimize the influences of the circadian variations in the muscular strength, the participants performed all the sessions at the same time.

Subjects

The participants of the local community were recruited through invitation in public places, release on written newspapers, radio and personal recommendation of elderly subjects from a RE program. Initially, 12 elderly women answered to the invitation. One participant did not complete the evaluation protocol for reasons not related to the intervention. Thus, the present study was concluded with 11 elderly women (66.5 ± 5.0 years; 59.2 ± 9.1kg; 46.4 ± 34.9cm). Inclusion criteria were: a) age equal or older than 60 years; b) absence of absolute cardiovascular, muscular, articular or bone contraindications of lower limbs or neurological contraindication for performance of RE; c) no regular participation in any weight training program during the last six months preceding the beginning of the experiment.

After having received information about the aims of the study and the procedures to which they would be submitted, agreed in participating in the study, 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 norms of the 196/96 resolution of the National Health Committee on research involving humans (protocol number 7090).

Tests of repetition maximum (15 RM)

Previously to the beginning of the loads determination, all participants performed two weeks of familiarization to the RM test. The participants were evaluated in a horizontal leg press machine (Righetto Fitness Equipment). The knee angle was adjusted in 90º and the hip angle in 110º. Legs were parallelaly positioned with slight lateral space and feet rested on the platform. Arms were parallel to trunk, and hands gripping to the support bar from the seat. Initial position of all participants was recorded and applied in the experimental sessions. Initially, a set of 10 repetitions with 50% of load expected for 15 RM was used as previous warm-up. After 30 seconds, the participants were told to perform the highest NR as possible with load determined by the evaluator. Had a NR lower or higher 15 RM been performed, alterations of one kilogram were performed at every two repetitions outside the target zone. During the tests, maximum of three attempts per session were performed, with RI of 10 minutes.

The exercise performance was monitored by the researchers of the study with the aim to reduce errors during the tests. Additionally, only the repetitions performed with total range of motion were recorded. Pauses between the concentric and eccentric phases of the movement or between the repetitions were not allowed. Moreover, verbal stimuli were given so that the participants remained motivated.

Experimental sessions

Previously to the performance of both experimental sessions, all participants performed warm-up which consisted of a set of 10 repetitions with 50% of 15 RM. After 30 seconds, the first set of exercise was initiated. In each experimental session, three sets until concentric muscle fatigue were performed with absolute load of 15 RM. The NR performed in each set was recorded. The following equation was applied to verify the percentage variation of the NR of the first set compared with the first set in relation to the target zone (15 RM): $\Delta\% = [(\text{NR of the } 1^{st} \text{ set} \times 100) / 15]$. The following formula was applied with the purpose to calculate the percentage of maintenance of the NR concerning the first set: sustainability of repetitions (%) = [(NR of the 2^{nd} set or 3^{rd} set x 100) / NR of 1^{st} set]. The total volume of each experimental session was calculated by the sum of the NR of the three sets, multiplied by the absolute load in kilograms (Σ repetitions x load).

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, defined with the beginning of the first repetition until the muscle fatigue moment, was manually recorded by a digital lap watch[19]. The time under tension of the involved musculatures in the leg press exercise was defined as the sum of the TTPR of the three sets. In order to obtain the mean time of each repetition per set, the TTPR of each set was divided by the NR performed of the respective set ($s.R^{-1}$).

Statistical procedures

Subsequently to the confirmation of the normal distribution (Shapiro Wilk test) and homogeneity (Levene test) of the data, descriptive procedures (mean ± standard deviation of the mean) were used. Two-way ANOVA for repeated measures on the second factor was applied for the comparisons between the different conditions (RI-1 and RI-3) and moments (first, second and third set – for the NR, sustainability of repetitions, TTPR of each set and TTPR/NR). The Fischer post hoc test for multiple comparisons was applied for identification of the specific differences in the variables in which ANOVA presented significant difference. The size of the effect (h_p^2) for the main effects (conditions x moments) and interactions (conditions x moments) was also calculated. The Student's *t* test for dependent samples was used to compare the NR of the test-retest sessions, total volume, and sum of the three sets for NR, TTPR and TTPR/NR between the experimental sessions (RI-1 and RI-3). In addition to that, the intraclass correlation coefficient (ICC) was used to evaluate the reliability in the test-retest of 15 RM. The significance level adopted for all analyses was of $P < 0.05$. The statistical procedures were performed in the Statistica™ program, version 7.0.

RESULTS

The ICC (R) for the 15 RM test was of 0.89 (CI 95%; 0.67 – 0.97). Moreover, significant differences have not been observed (P = 0.6) between the NR performed in the test-retest sessions.

The results for the NR, TTPR, TTPR/NR per set as well as the total of each variable for the different RI are presented in table 1. Significant interactions condition x moment ($P < 0.05$) have been observed for the NR ($F_{(1.10)} = 11.8$; $h_p^2 = 0.37$) and TTPR ($F_{(1.10)} = 8.13$; $h_p^2 = 0.29$). Concerning the TTPR/NR, only the main effect of significant moment ($F_{(1.10)} = 3.73$; $h_p^2 = 0.16$) was observed. The NR significantly reduced ($P < 0.05$) from the first to the second and the third sets for both RI when compared with the first. The RI-1 and RI-3 also demonstrated significant reduction ($P < 0.05$) in the NR from the second to the third sets. Significant differences ($P < 0.05$) between the RI were observed in the two final sets, providing a significantly higher total NR (19.9%; $P < 0.05$) for the RI-3 in comparison to the RI-1. Similar behavior was verified for the TTPR for the two subsequent sets; however, significant differences ($P < 0.05$) between the RI have been observed only in the second set. The total time under tension was significantly higher for the RI-3 (17.8%; $P < 0.05$) in comparison with the RI-1. Only the RI-1 presented significant increase ($P < 0.05$) for the mean time of the repetitions (TTPR/NR) on the third and second sets in comparison with first one, without significant differences (P > 0.05) between the RIs.

Significant main effects of the condition ($F_{(1,10)} = 20.43$; $h_p^2 = 0.50$), moment ($F_{(1,10)} = 204.04$; $h_p^2 = 0.91$) and condition x moment interaction ($F_{(1,10)} = 9.27$; $h_p^2 = 0.32$) ($P < 0.05$) were verified for the sustainability of the repetitions (figure 1). Both the RI presented significant reduction ($P < 0.05$) in the sustainability of repetitions from the first to the second and third sets and from the second to the third set.

Table 1. Responses of the number of repetitions (NR), total time of repetitions performance (TTRP), mean time per repetition (TTRP/NR) and the total of each variable for the recovery intervals of one (RI-1) and three minutes (RI-3), in untrained elderly women (n = 11). Values expressed in mean ± SD.

	1st set	2nd set	3rd set	Total
NR				
RI-1	15.1 ± 0.8	8.5 ± 2.0[a,c]	7.1 ± 1.3[a,b,c]	30.6 ± 3.4[c]
RI-3	15.3 ± 0.9	11.6 ± 1.8[a]	9.8 ± 1.8[a,b]	36.7 ± 3.8
TTRP (s)				
RI-1	40.4 ± 6.6	23.9 ± 4.8[a,c]	20.5 ± 4.3[a,b]	84.7 ± 14.0[c]
RI-3	40.5 ± 6.8	32.1 ± 7.3[a]	27.2 ± 5.8[a,b]	99.8 ± 17.5
TTRP/NR s.reps-[1])				
RI-1	2.7 ± 0.3	2.9 ± 0.6[a]	2.9 ± 0.4[a]	8.4 ± 1.2
RI-3	2.7 ± 0.4	2.8 ± 0.4	2.8 ± 0.4	8.2 ± 1.1

[a]Statistically significant differences in comparison with the first set (P < 0.05);
[b]Statistically significant differences in comparison with the second set (P < 0.05);
[c]Statistically significant differences in comparison with the RI-3 (P < 0.05).

Nonetheless, significantly higher sustainability of repetitions ($P < 0.05$) was observed in the second and third sets when the experimental sessions was performed with RI-3.

The total volume of each experimental session is presented in figure 2. The experimental session performed with the RI-3 presented significantly higher total volume (20.4%; $P < 0.01$) in comparison to the RI-1.

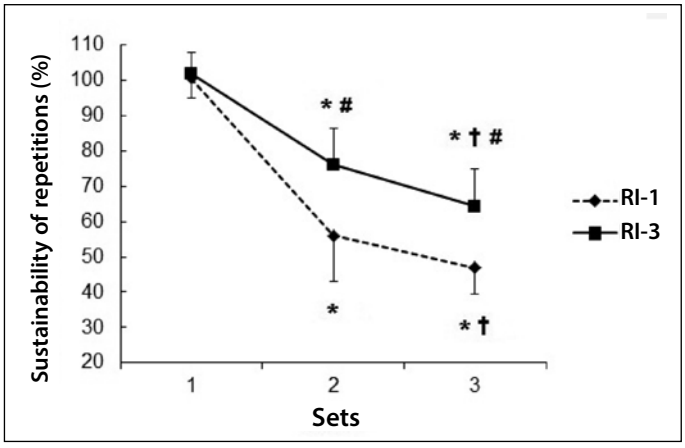

Figure 1. Sustainability of the repetitions in the experimental sessions performed with recovery intervals of one (RI-1) and three (RI-3) minutes, in untrained elderly women (n = 11). *Indicates significant differences (P < 0.05) in comparison with the first set; †Indicates significant differences (P <0.05) in comparison with the second set; #Indicates significant differences (P < 0.05) compared with the RI-1.

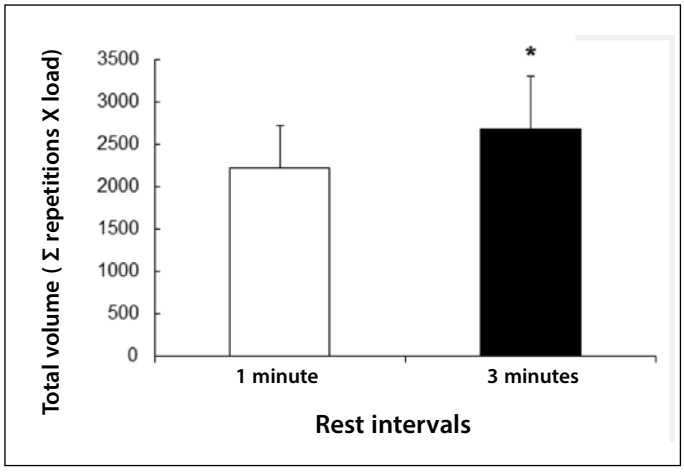

Figure 2. Total volume of the experimental sessions performed with rest interval of one (RI-1) and three (RI-3) minutes, in untrained elderly women (n = 11). * Indicates significant differences (P < 0.05) in comparison with the RI-1.

DISCUSSION

The aim of the present study was to assess the behavior of the number and sustainability of repetitions as well as the total volume in the *leg-press* exercise in sessions performed using different RI between sets (one and three minutes). Regardless of the RI adopted, the participants were not able to keep the number of repetitions and the sustainability of the repetitions concerning the first set (table 1 and figure 1, respectively). However, the session performed with RI-3 presented higher total NR (table 1), sustainability of repetitions (figure 1) and total volume (figure 2) when compared with the session performed with RI-1. The mean time of the repetitions significantly increased in the subsequent sets when the RI-1 was applied.

These findings are similar to the ones described by other studies performed with young adults. Willardson and Burkett[20] demonstrated that the application of longer RI leads to longer sustainability in the NR compared with shorter RI. Longer sustainability of repetitions between sets led to the significant increase of the training volume. This behavior was also observed in the untrained elderly women of the present study. The results indicate that, similarly to the young adults, the application of longer RI may be a strategy for promotion of increase in training volume with no need of alterations in the absolute intensity or number of sets.

In isokinetic exercises, some studies performed with older adults have verified differences in muscular performance in the subsequent sets when different RI are used[12-14]. Bottaro et al.[12], for example, compared different RI (one and two minutes) on the peak of torque (PT) and total work (TW) in untrained elderly men. Three sets of 10 repetitions were performed with angle velocity of 60°·s^{-1} in knee extension. Significant decline (10.6%) in PT occurred between the first and third sets only when the RI-1 was used. In the third set, the TW was significantly lower for the RI-1 when compared with the RI-2. Corroborating these findings, Theou et al.[14] verified the effect of different RI (15, 30 and 60 seconds) in the PT in trained elderly women. Three sets of eight RM with angle velocity of 60°·s^{-1} in knee extension and flexion were performed. In the knee extension, significant decrease in the PT mean between the first and third sets occurred only for the 15s (15%) and 30s (3.2%) RI. In the knee flexion, only the 15s RI caused reduction in the PT between sets. Regardless of the type of exercise applied (isokinetic or isoinertial), sample characteristic (gender and training status), NR, evaluated muscular group or RI, higher compromise of the muscular performance occurs when shorter RI are applied.

In isoinertial contractions, Jambassi Filho et al.[15] compared the effect of RI with 90s (RI-90) and 180s (RI-180) in the muscular performance of the elbow flexors in the *Scott* curl exercise, in trained elderly women. Similar to the findings of the present investigation, both RI were insufficient to keep the NR of the subsequent set within the pre-set target zone (10-12 RM). Regarding the RI-90 and RI-180, the decrease percentage of the NR from the first to the third sets was of 49.5% and 29.7%, respectively. Moreover, the total volume of the experimental session performed with the RI-90 was statistically lower than in the session with the RI-180. In the present investigation, when the RI-3 was used, lower percentage decrease (36%) was observed in the NR from the first to the third set concerning the RI-1 (53%). The collective analysis of these results indicates that, in untrained elderly women, the RI is an important variable to be considered when the aim is the training volume manipulation.

It is well-established in the literature that the performance of an intense activity of short duration, which is the case of RE, implies in the muscular fatigue process, generally characterized as acute reduction in production of muscular strength[21]. Different factors are associated with the reduction in muscular performance during performance of RE, such as metabolic and mechanical ones, besides movement velocity[21-25].

Different studies have tried to investigate the effect of movement velocity in the NR performed until muscular fatigue. The performance of movements with faster velocities may allow higher NR in comparison to the movements performed with lower velocity for the same absolute intensity[23,25]. In addition to that, it is possible that the movement velocity had caused greater effect in the NR performed with lower intensities in comparison to higher ones[25]. Thus, the control of the movement velocity plays an important role in the interpretation of the results of the experimental protocol.

In the present study, there were not significant differences in the TTPR/NR ratio obtained in the first set between the RI. However, significant increase was observed in the TTPR/NR of the subsequent sets when the RI-1 between sets was applied (table 1), indicating reduction in the performance velocity when compared with the first set. This decrease in velocity may be associated with higher compromising of the muscular recovery promoted by the RI-1 compared with the RI-3, leading to reduction in the NR. The RI-3 allowed longer total time under tension (17.8%) in consequence of higher NR performed in the subsequent sets. Additionally, lower sustainability of repetitions when the IR-1 was applied provided lower total volume (20.4%) in comparison with the session performed with the RI-3 (figure 2). Although the TTPR/NR ratio allows the comparison between the mean time spent for performance of each repetition in sets with different NR, this measure does not allow distinguishing the moment in which the movement velocity significantly decreases in each set.

Therefore, the observation of muscular performance in the *leg-press* exercise applying different RI between sets presents important practical applications for professionals involved in the designing of different training, especially due to the fact that this exercise is frequently prescribed in RE programs for elderly women. The choice of the RI should be carefully performed according to the training goal. Longer RI should be used when the goal is to optimize the sustainability of repetitions, reflecting on the training volume. Conversely, shorter RI should be used when the goal is to obtain higher levels of muscular fatigue. A limitation of the present study was the lack of evaluation of metabolic and neuromuscular indicators associated with the decrease in muscular performance using different RI.

CONCLUSION

The results of this study suggest that the sustainability of the repetitions and the training total volume of untrained eldest women are significantly influenced by the RI between sets. Both RI were not able to maintain the sustainability of repetitions in the subsequent sets. However, the session performed with RI-3 presented higher maintenance of muscular performance and higher total volume. Further studies using other exercises, different intensities and populations should be carried out. Additional studies are also necessary to determine the explanation mechanisms for the decrease in muscular performance using different RI between sets in elderly women.

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