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ORIGINAL ARTICLE

Effect of different manipulations of the cluster-set method on training volume and time under tension in resistance training men

Efeito de diferentes manipulações do método cluster-set *no volume de treino e tempo sob tensão em praticantes de musculação*

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KEYWORDS
Exercise
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ABSTRACT

Objective: To compare the acute effect of two training protocols until concentric failure (CF) with different intra-set interval (ISI) configurations (20 s and 40 s) on total weight, the total number of repetitions, and time under tension in trained subjects.
Methods: Ten men participated in the study (age = 25.1 ± 4.4 years; body mass = 76.5 ± 10.4 kg; height = 175.8 ± 9.3 cm). Two protocols were performed with 4 sets of bench press exercises and differentiated by the ISI: i) Protocol ISI-40 (40 s) - each set consisted of 6 repetitions followed by an ISI of 40 s and completed with repetitions up to CF; ii) Protocol ISI-20 (20 s) - each set consisted of 6 repetitions with ISI of 20 s every 3 repetitions followed by repetitions to CF. The intensity was 10 repetitions maximum, and the rest interval between sets of 80 s. A minimum interval of 48 h was adopted between protocols.
Results: There was no significant difference in the number of repetitions (p = 0.074), in the time under tension (p = 0.353) and in the total volume (p = 0.083) between the protocols.
Conclusion: The results indicate that the different ISI configurations did not distinctly influence the number of repetitions, time under tension, and total volume.

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PALAVRAS-CHAVE

Aptidão física
Exercício físico
Treinamento de força

RESUMO

Objetivo: Comparar o efeito agudo de dois protocolos de treinamento até a Falha Concêntrica (FC) com diferentes configurações do Intervalo Intra Série (IIS) (20 s e 40 s) no peso total, número total de repetições e tempo sob tensão em indivíduos treinados.
Métodos: Participaram do estudo 10 homens (idade = 25,1 ± 4,4 anos; massa corporal = 76,5 ± 10,4 kg; estatura = 175,8 ± 9,3 cm). Dois protocolos foram realizados com 4 séries no exercício supino reto e diferenciados pelo IIS: i) Protocolo IIS40 (40 s) - cada série consistiu em 6 repetições seguidas de um IIS de 40 s e completada com repetições até a FC; ii) Protocolo IIS20 (20 s) - cada série consistiu em 6 repetições com IIS de 20 s a cada 3 repetições seguido de repetições até a FC. A intensidade foi de 10 repetições máximas e a pausa entre as séries de 80 s. Respeitou-se um intervalo mínimo de 48 h entre os protocolos.
Resultados: Não houve diferença significativa no número de repetições (p = 0,074), no tempo sob tensão (p = 0,353) e no volume total (p = 0,083) entre os protocolos.
Conclusão: Os resultados apresentados indicam que as diferentes configurações do IIS não influenciaram distintamente o número de repetições, tempo sob tensão e volume total.

INTRODUCTION

The proposition of resistance training systems based on the manipulation of the rest interval[1] is driven by the fact that the training load is represented by a set of stimuli capable of promoting changes and/or adaptations to the organism[2] and because the evolution of physical performance is conditioned to its progression through the manipulation of its variables[3,4]. As the specificity of these stimuli is conditioned to the different possibilities of manipulation of the training variables, it is believed that the cluster-set system, characterized by inserting intra-set intervals (ISI), is capable of minimizing neuromuscular fatigue and, thus, maintaining movement quality, increasing time under tension, and improving strength, speed, and power[5-7].

It has been suggested that the insertion of the ISI and the consequent increase in the number of repetition blocks could increase muscle power and the recruitment of motor units[6,8-10]. This would supposedly occur due to the minimization of the effect of fatigue to the detriment of the optimization of the partial resynthesis capacity of muscle phosphocreatine, making it possible to increase the training volume, maintenance of force generation, and movement velocity for a longer time and, consequently, the increase in muscle mass[7,11,12]. However, the literature has demonstrated both the superiority[7,13-15] and the disadvantage[16,17] of the cluster-set system compared to the traditional training system, as well as similarities in their results[18]. The lack of consensus is based, among other factors, on the different configurations of the ISI used in the studies.

This has been verified in the literature studies that adopted ISI between 2.85 s[14] and 130 s[13]. However, intermediate ISI values (10 s to 40 s) seem to be more frequently used[16-19]. Most studies did not adopt clear criteria for choosing the magnitude of the ISI and only Ho et al. (2021)[18] investigated the effects of two or more protocols with different ISI. These authors did not observe differences in the rate of perceived exertion (RPE) reported by 23 physically active subjects during the execution of the bench press exercise. The volunteers performed three protocols with different ISI (ISI-0, ISI-20, and ISI-40) in a balanced way, with an interval of 72 h between the performance of each protocol. All protocols were configured with 3 sets of 6 repetitions and an intensity of 6 Maximum Repetitions (6RM). In the ISI-0 protocol, there were only rest intervals between sets (180 s). The ISI-20, in addition to intervals between sets of 160 s, a 20 s ISI was included after the third repetition. In the ISI-40, the rest interval between sets was 140 s and, after the third repetition, an ISI of 40 s was inserted. These protocols allowed the total recovery time (rest interval between sets + ISI) to be equated to 180 s. The authors identified a reduction trend in RPE after set 3 for the ISI-40 protocol and suggested that both the addition of sets and the inclusion of sets with repetitions until concentric failure could imply the detection of possible differences.

Thus, this study compares the acute effect of two resistance training protocols with different ISI (20 s and 40 s) on training volume (total weight and a total number of repetitions) and time under muscle tension in resistance-trained subjects. Based on the study by Ho et al. (2021)[18], it was hypothesized that the protocol with the 20-s ISI (ISI-20) will allow the subjects to perform greater training volume and time under tension compared to the protocol with the 40-s ISI (ISI-40).

METHODS

Subjects

Ten male subjects participated in the study (mean age 25.1 ± 4.4 years; body mass 76.5 ± 10.4 kg; height 175.8 ± 9.3 cm; 10RM = 73.4 ± 13.6 kg). The inclusion criteria required that volunteers respond negatively to pre-participation screening questions, have no history of injuries to the joints involved in the exercise and have been performing resistance training for at least 6 months[4]. All volunteers were informed of the research purposes, procedures, and risks and signed the consent form. This study was approved by the research ethics committee of the university where the research was conducted (CAAE: 09438119.4.0000.5137).

Experimental design

The volunteers attended the laboratory on three different days, separated by a minimum period of 48 h

and a maximum of 7 days. The 10RM test and the standardization of positions in the bench press exercise were performed on the first day. On the second and third days, the subjects randomly performed two resistance training protocols in the bench press exercise: i) Protocol ISI-40 - each set consisted of 6 repetitions followed by an ISI of 40 s and completed with repetitions to concentric failure; ii) Protocol ISI-20 - each set consisted of 6 repetitions with ISI of 20 s every 3 repetitions followed by repetitions until concentric failure. The volunteers were instructed not to perform activities that involved the pectoralis major, anterior deltoid, and triceps brachii muscles 48 h before each visit to the laboratory, to attend to the laboratory always at the same time as the data collection, not to use any nutritional supplement during the study period and maintain the feeding routine before data collection. In both the 10RM test and the protocols, volunteers received verbal encouragement.

10RM test

The weight used in each training protocol was determined on the first day of the laboratory visit using the 10RM test, which consisted of up to four attempts, with a 5-min interval between each attempt, following the guidelines proposed by Maia et al. (2014)[20]. The subject was instructed on the proper technique for performing the exercise before the test was applied.

Before the first attempt, the volunteer informed the weight he used to perform the bench press exercise in his training sessions.From there, an initial weight that approached the value of 10RM was used. The volunteer was asked to position himself on the bench and hold the bar at the width of the biacromial distance. Then, the subjects were instructed about the range of motion limits. The bar should be removed from the support, with the help of the researcher, until the volunteer fully extended the elbows, which was considered the upper limit. The lower limit occurred when the bar touched an EVA rubber plate (15 cm x 7 cm x 0.5 cm) positioned over the subject's sternum. Weights from 2 kg were added gradually until concentric failure occurred. Thus, the value of 10RM corresponded to the weight lifted in the previous attempt.

Experimental protocols

The weight used in both training sessions was that recorded in the 10RM test. In both protocols (ISI-40 and ISI-20), volunteers performed 4 sets separated by a rest interval of 80 s. In the ISI-40 protocol, each set consisted of performing two blocks of repetitions separated by an ISI of 40 s, so that the first block would be performed 6 repetitions, and in the second block, the volunteer would perform repetitions until concentric failure. In the ISI-20 protocol, each set consisted of three repetition blocks separated by two 20-s ISI, with the subject being instructed to perform 3 repetitions in the first and second blocks, and in the last block, he should perform repetitions until concentric failure. These settings allowed the total recovery time (inter-set interval + intra-set intervals) to be matched in both protocols (Figure 1). A digital stopwatch was used to record the time under tension for each set. The stopwatch was turned on when the volunteer started performing the first repetition of the first set and was turned off when the proposed amplitude was not reached in two consecutive repetitions or when the concentric failure occurred. The velocities of the concentric and eccentric phases were self-determined. The total training volume was calculated by multiplying the total number of repetitions by the weight recorded in the 10RM test.

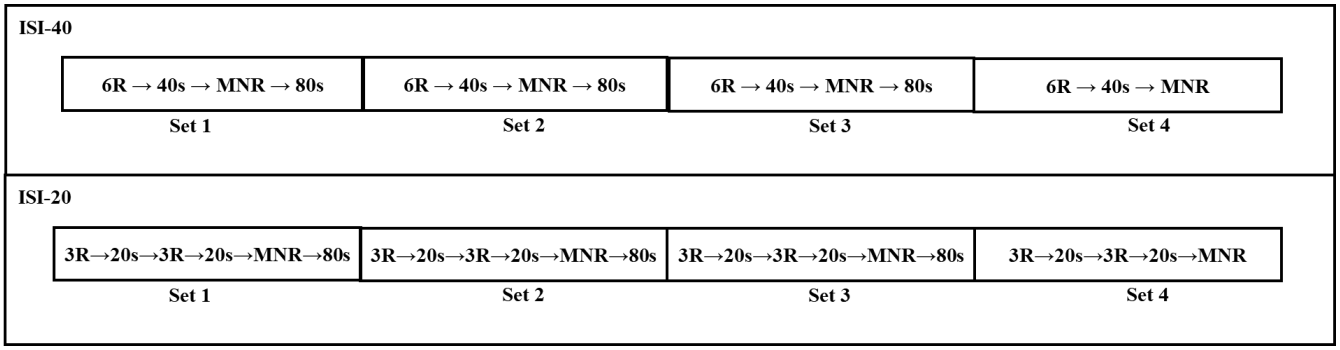

Figure 1 — Intra-set interval (ISI) training protocols with 40 s (ISI-40) and 20 s (ISI-20). R: repetitions; MNR: maximum number of repetitions to concentric failure.

Statistical analysis

Data are presented as mean and standard deviation. Data normality and variance homogeneity were confirmed by the Shapiro-Wilk and Levene tests, respectively. Comparisons of the number of repetitions and time under tension in each set were performed using two-way analysis of variance (ANOVA) (Training Protocol and Sets) with repeated measurement. When necessary, the Bonferroni post hoc was applied to identify significant differences. The comparison of the total training volume (total number of repetitions multiplied by the weight adopted in the 10RM test) between the protocols was performed using the paired t-test. A $p < 0.05$ was adopted as a significance level. In this study, the effect size was also calculated from the equation: [(mean ISI-40 – mean ISI-20) / (mean of the standard deviation of ISI-40 and ISI-20)]. The calculated values

were classified according to the parameters established by Rhea (2004)[21] for moderately trained individuals: trivial (< 0.35), small (between 0.35 and 0.80), moderate (from 0.80 to 1.50), and large (> 1.50).

RESULTS

Figure 2 presents the comparison of the number of repetitions between the protocols. Based on ANOVA, there was a main effect of the sets factor ($F3.27 = 268.1$; $p < 0.001$), but no main effect of the protocol factor ($F1.9 = 4.1$; $p = 0.074$) or interaction ($F3.27 = 1.2$; $p = 0.314$). Post hoc analysis showed a reduction in the number of repetitions over the four sets ($p < 0.05$). When comparing the effect of size in each set of ISI-40 and ISI-20 protocols, the following values were verified: Set 1 = -0.089; Set 2 = -0.276; Set 3 = -0.665; Set 4 = -0.100.

Figure 3 shows the comparison of time under tension between the protocols. From the ANOVA, there was a main effect of the sets factor ($F3.27 = 19.3$; $p < 0.01$), but there was also no main effect of the protocol factor ($F1.9 = 0.9$ $p = 0.353$) or interaction ($F3.27 = 3.2$; $p = 0.094$). The post hoc analysis showed a reduction in time under tension over the first three sets ($p < 0.05$); however, there were no differences from the 3rd to the 4th set ($p = 0.101$). When comparing the effect of size in each set of the ISI-40 and ISI-20 protocols, trivial values were found for set 1 (ES = -0.050), set 2 (ES = -0.031) and set 4 (ES = -0.082), with moderate values for set 3 (ES = -1.206).

Finally, Figure 4 presents the total weight of the training session in the ISI-40 and ISI-20 protocols. There were no differences between the experimental situations ($p = 0.083$), and the effect size value was considered small (ES = -0.297).

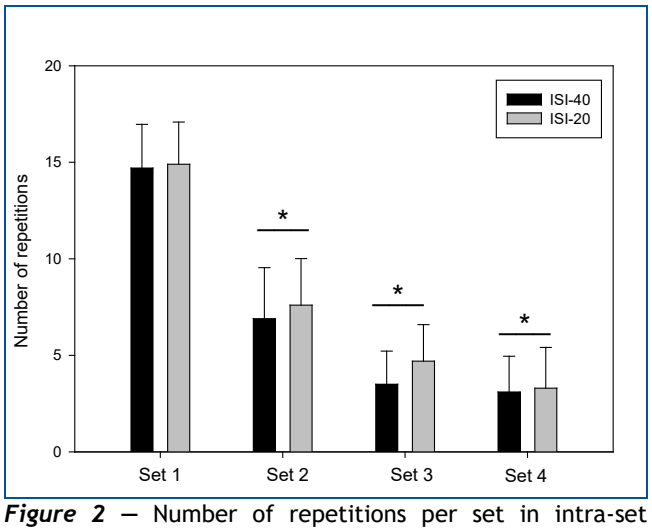

Figure 2 — Number of repetitions per set in intra-set interval (ISI) training protocols with 40 s (ISI-40) and 20 s (ISI-20). *Different from previous set.

DISCUSSION

This study compared the acute effect of two resistance training protocols performed to concentric failure with different intra-set intervals (ISI-20 and ISI-40) on training volume (total weight and number of repetitions) and on time under tension in resistance-trained subjects. The results did not indicate differences in the variables analyzed.

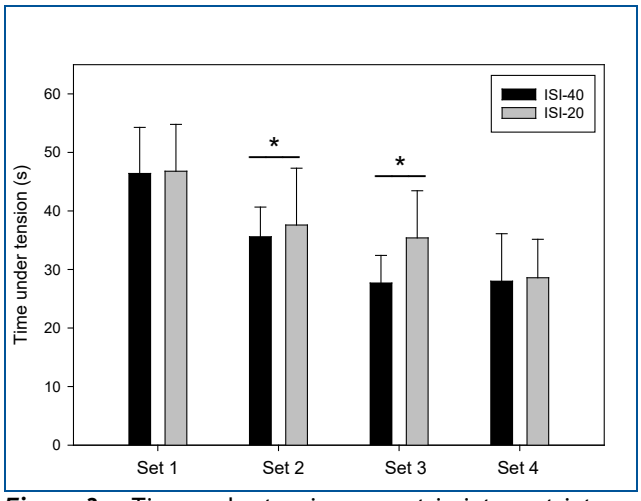

Figure 3 — Time under tension per set in intra-set interval (ISI) training protocols with 40 s (ISI-40) and 20 s (ISI-20). *Different from previous sets.

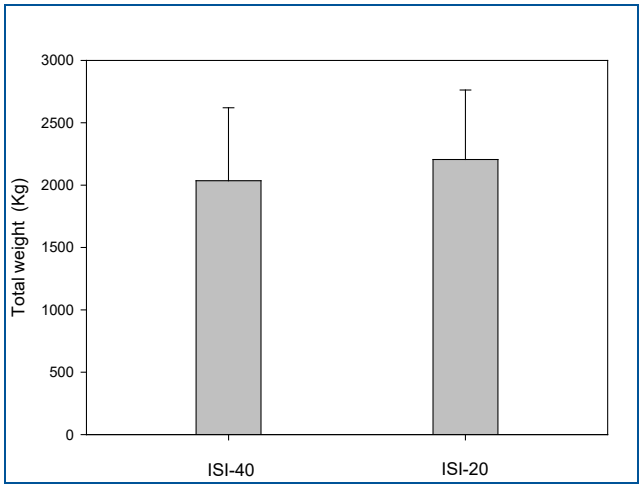

Figure 4 — Total weight of the training session in the intra-set interval (ISI) training protocols with 40 s (ISI-40) and 20 s (ISI-20).

Other authors investigated different configurations based on the cluster-set system, including ISI-20 and ISI-40 submaximal protocols[18]. Although they did not measure the training volume and time under tension, the RPE response was analyzed for both protocols. Twenty-three physically active individuals were submitted to bench press exercise in three protocols with three sets of six repetitions, but with different ISI: i) ISI-0, consisting of a single rest interval between sets (180 s); ii) ISI-20, with a rest interval between sets of 160 s, and ISI of 20 s after the third repetition; and iii) ISI-40, with a rest interval between sets of 140 s and ISI of 40 s after the third repetition. The training intensity adopted was 6RM and the total recovery time (rest interval between sets + ISI) was equated to 180 s. These authors did not observe important differences in RPE when comparing the protocols[18].Considering that the increase in RPE is

associated with the accumulation of metabolites and muscle fatigue[22], the results of Ho et al. (2021)[18] suggest that the ISI between 20 s and 40 s would promote acute metabolic responses in lower magnitude, therefore making it difficult to find differences in performance. In this study, even using a lower intensity (10RM) and adopting the execution of repetitions until concentric failure in the last block of each set did not lead the protocols to different performances.

The study by Denton and Cronin (2006)[13] also collaborates with the interpretation of our results. They demonstrated the possibility of performing greater total work (a variable associated with the volume) in response to an increase in ISI. The authors submitted trained individuals to the bench press exercise under three experimental protocols: i) traditional (TRAD), represented by 4 sets of 6 repetitions and a recovery interval between sets of 302 s; ii) cluster-set with the total volume matched (CSVM), characterized by 8 sets of 3 repetitions and ISI of 130 s every three repetitions and iii) cluster-set matched only by the rest interval (CSIM), which consisted of performing 8 sets separated by 130 s of ISI in which each set of odd order (1, 3, 5 and 7) comprised 3 repetitions and those of even order (2, 4, 6 and 8) would be performed until concentric failure. The intensity adopted was 6RM. The authors demonstrated that both the lactate concentration and the number of repetitions were higher in the CSIM compared with the TRAD and CSVM protocols. Although these results are different from those found in the present study, the researchers observed that the decrease in ISI and the consequent increase in its frequency did not influence the responses of the variables associated with the TRAD and CSVT protocols. Thus, given the level of similarity between the configurations of these protocols and those adopted in the present study, it seems that for equal total ISI, the ISI-20 and ISI-40 protocols may have represented similar mechanical stimuli on volume and time under tension. Additionally, the fact that the CSVM protocol adopted by Denton and Cronin (2006)[13], the only one characterized by repetitions to concentric failure, resulting in greater lactate accumulation and a greater number of repetitions, suggests evidence that, for similar intensities, total recovery and ISI, protocols based on the cluster-set system that presents a greater number of repetition blocks until concentric failure, can generate greater ATP depletion, greater lactate accumulation and, ultimately, a greater probability of performance improvement. In fact, it has been shown that the cluster-set leads to a greater number of repetitions and greater mechanical performance even under conditions in which concentric failure is reached[14]. However, it is possible that only the difference in a single block of set between the ISI-20 and ISI-40 protocols (adopted in the present study) was not enough to modify the demand on the ATP-CP system, lactate concentration, and, consequently, on the individuals' performance.

It is also suggested that the relationship between the number of sets, number of repetitions, and ISI may have been a limiting factor in this study due to the use of protocols containing only three and four repetition blocks per set combined with overestimated ISI. This may have contributed to the fact that the total volume (total number of repetitions and absolute total weight) and time under tension were similar between the protocols since ATP resynthesis would have been similar for the experimental conditions of the present study. Di Prampero and Margaria (1968)[23] and Meyer and Terjung (1979)[24] support this hypothesis by stating the need for a recovery interval between 20 s and 48 s so that 50% of the depleted ATP and PC are replaced, intervals that practically encompass the two ISI investigated here.

Thus, considering that fatigue is a determining factor for physiological changes to occur and that the protocols of this study were configured with only a single block with repetitions until concentric failure per set, our hypothesis that protocols with a lower ISI accompanied by a greater number of blocks would result in a greater number of repetitions could have been confirmed if we had adopted a greater number of blocks of repetitions until concentric failure. Additionally, considering that the adoption of higher movement velocities combined with a smaller number of repetition blocks impact the development of power in cluster-set systems[17], the lack of speed measurement for each muscle action becomes a limitation of the present study. Another significant limitation of our study is the absence of metabolic and/or neurophysiological variables (lactate, electromyography, etc.). We suggest that further studies be conducted using relations between stimulus (e.g., repetitions) and rest differently from those adopted in this study. We also emphasize that the present findings do not provide an insight into the effects of reducing the duration of intervals between sets.

CONCLUSION

The results of the present study indicate that the different numbers and durations of the ISI did not promote differences in the number of repetitions, time under tension, and total training volume in resistance-trained men.

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Data collection: RRD, HCMC
Writing of the manuscript: RRD, FDT, LTL, JBFJ, HCMC
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