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Rest Period Length Manipulation on Repetition Consistency for Distinct Single-Joint Exercises

Gilmar Senna[1,2], Estevão Scudese[1,2], Cássio Luiz Martins[3], Fabiana Rodrigues Scartoni[3], Felipe Carneiro[2], Júlio César Camargo Alves[1], Camilla Zarlotti[1], Estélio Henrique Martin Dantas[1,2]

[1]Nursing and Biosciences Post-Graduation Program, Doctorate of Federal University of State of Rio de Janeiro, Brazil, [2]Biosciences Laboratory of Human Movement, Tiradentes University, Brazil, [3]Center Science, Catholic of Petrópolis University, Brazil

ABSTRACT

Senna G, Scudese E, Martins CL, Scartoni FR, Carneiro F, Camargo JC, Zarlotti C, Dantas EHM. Rest Period Length Manipulation on Repetition Consistency for Distinct Single-Joint Exercises. **JEPonline** 2016;19(5):93-101. The purpose of this study was to verify the influence of different rest periods between sets for single-joint exercises. Ten trained men (24.3 ± 2.8 yrs; 75.8 ± 9.1 kg; 174.4 ± 7.0 cm) performed 3 sets of 10RM for the machine chest fly and the biceps curl. Each exercise was performed with a different rest period (1, 2, and 4-min) using a random cross-over design. There were reduced total number of repetitions for the machine chest fly with 1-min compared to 2-min and 4-min (Δ% = - 17.29; - 34.3). As for the biceps curl exercise, the shorter 1-min also decreased the performance when compared with rest periods of 2-min and 4-min (Δ% = - 13.3; - 31.7). In addition, there were also important differences between the 2-min and the 4-min rest for both exercises (machine chest fly, Δ% = - 21.3; biceps curl, Δ% = - 21.1). We concluded that short rest periods resulted in early reductions in repetition performance and training volume over multiple sets for both single-joint exercises.

Key Words: Muscle Strength, Weight Lifting, Physical Fitness

INTRODUCTION

Over the last decades, strength training has been established as an effective strategy to improve muscle endurance, strength, and power (1). In order to maximize the results, it is important that exercise physiologists properly manipulate a diverse range of training variables regarding individual goals. Among these variables, the rest period between sets, has been shown to be an important variable that might trigger acute and chronic adaptations (6,17). In fact, it is well established that different rest interval lengths will promote distinct outcomes in performance on multiple sets for multi-joint exercises and also over the course of an entire training session (5,7-12,14-16), resulting in endocrine (6) and neuromuscular responses (17). The latest American College of Sports Medicine (ACSM) position stand on strength training (1) recommends 2 to 3-min of rest for multi-joint exercises (such as the squat and bench press), and shorter rests periods (1 to 2-min) for single-joint exercises (i.e., machine chest fly and biceps curl).

For multi-joint exercises, a series of experiments demonstrated that distinct rest lengths result in a different number of repetitions performed (5-12,14-16). These results highlighted that short rest periods of less than 2-min are not sufficient to sustain repetition consistency over multiple sets. In addition, it seems to be a consensus that longer recoveries between sets (such as 3 to 5-min) may lead to greater number of repetitions completed during multiple sets for multi-joint exercises. Interestingly, by comparison, there only a few studies (9,12) that have investigated different rest periods on the performance of multiple sets for single-joint exercises.

For instance, Senna et al. (9,12) observed a similar performance pattern for multi and single-joint exercises. In both studies, the authors found a significant decrease in the number of repetitions with a shorter rest period (1-min) for all exercises. In addition, Senna et al. (9) also observed that the single-joint exercises presented lower blood lactate elevations with a longer rest period (e.g., 3-min) when compared to the multi-joint exercises. Conversely, Senna et al. (12) observed that 2-min of rest was sufficient for single-joint exercises with near maximum loads.

Although there seems to be an established recommendation by ACSM (1), without question there is a very limited body of knowledge regarding single joint-exercises and its relationship with distinct rest periods. Therefore, the purpose of this study was to investigate the influence of different rest periods of 1-min, 2-min, and 4-min between sets on the performance of repetitions in different single-joint exercises.

METHODS

Subjects

Ten trained men participated in this study (24.3 ± 2.8 yrs; 75.7 ± 5.5 kg; 175.2 ± 8.4 cm; 24.7 ± 1.8 $kg \cdot m^{-2}$). All subjects followed a specific inclusion criteria: (a) they must have at least 1 yr of experience in strength training with a minimum frequency of 3 $times \cdot wk^{-1}$; (b) avoid performing any type of regular physical activity during the data collection period; (c) not present any medical condition that might influence the training protocol; and (d) not use any anabolic-androgenic steroids and/or other ergogenic substance. Each subject signed a consent form acknowledging the benefits and risks of participation. The study was approved

by the ethics committee of the Catholic University of Petrópolis, under protocol number 0012.0.395.000-08. On the first visit, the subjects underwent anthropometric measurements and answered the PAR-Q questionnaire (13). All procedures followed the recommendations of the International Society for the Advancement of Kinanthropometry (4).

Determination of Ten Repetition Maximum

After two familiarization sessions with the machine chest fly and the biceps curl exercises, the subjects performed the first load test session with a 10 repetition maximum load (10RM) for each exercise. The initial load was reported by each subject for each exercise using the daily workouts as a reference for the 10 repetitions. With this load, subjects were encouraged to perform the maximum number of repetitions until they reached the concentric failure. If less than 9 or >10 repetitions were completed, a new attempt was made adjusting the load with a maximum of three attempts for exercise with 5-min of rest between each attempt. A minimum of 10-min of rest was required between different exercises for tests purposes. The following strategies were adopted in order to reduce error on the 10RM tests: (a) standardized instructions were provided before the load tests; (b) each subject was informed of the correct technique for each exercise; and (c) instructors standardized the subjects positioning for each exercise (2). Seventy-two hours after the initial load test, a retest of 10RM was conducted with the same procedures of the previous visit. The ICC showed high reliability between loads by test-retest (machine chest fly, $r = 0.97$; biceps curl, $r = 0.98$; $P<0.0001$). The test and re-test were performed on the same time of day for each subject.

Procedure

Seventy-two hours after the final testing session, the subjects underwent three sessions for the machine chest fly exercise and the biceps curl exercise with 3 sets for each exercise with a 1-, 2-, or 4-min rest period. The rest protocol order was determined by a random cross-over design. For all training sessions, subjects performed a warm-up consisting of 12 repetitions with 40% of a self-estimated 8RM load (5). After 2-min, subjects were verbally encouraged to perform 3 sets until volitional exhaustion. No attempt was made to control repetition velocity, although, the subjects were instructed to use a controlled movement. All the visits were conducted at the same time of the day in order to avoid any accumulated carry-over effects from the circadian cycle.

Statistical Analysis

The data are presented according to their means ± SD. One-way ANOVA was used to verify the total number of repetitions for different rest condition for both exercises and for analysis of repetitions for each individual set for each rest condition. The level of significance adopted was $P<0.05$. The Tukey *post hoc* test was used for multiple comparisons. Additionally, to determine the magnitude of the results, the effect size (the difference between the number of repetitions of the first set, i.e., the pre-test and the number of repetitions of each subsequent set, divided by the standard deviation of the pre-test) was calculated for each set. Limits proposed by Cohen (3) were applied to determine the magnitude of the treatment effect. Analysis was made by Statistica 7.0 software (StatSoft, USA).

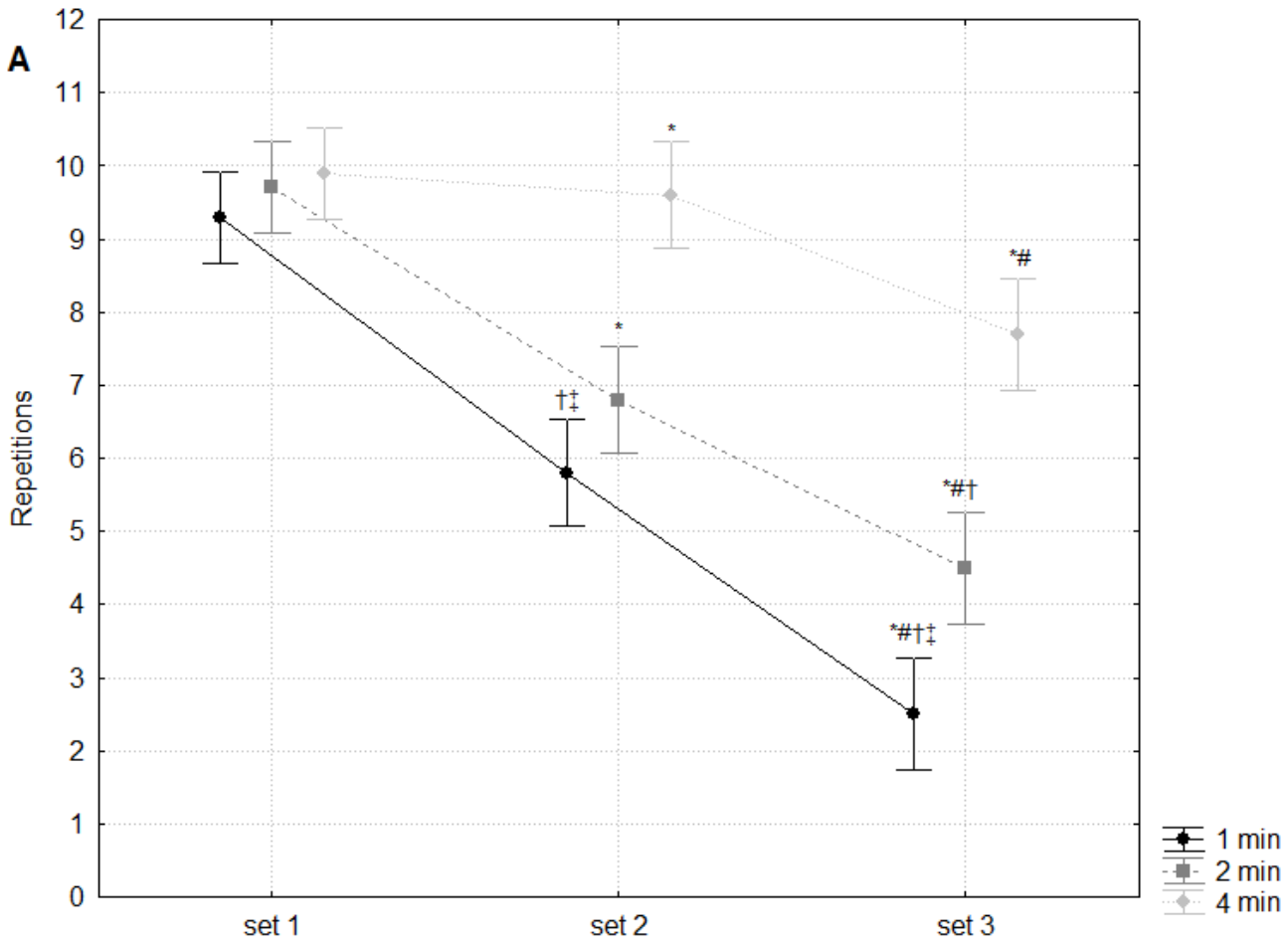
RESULTS

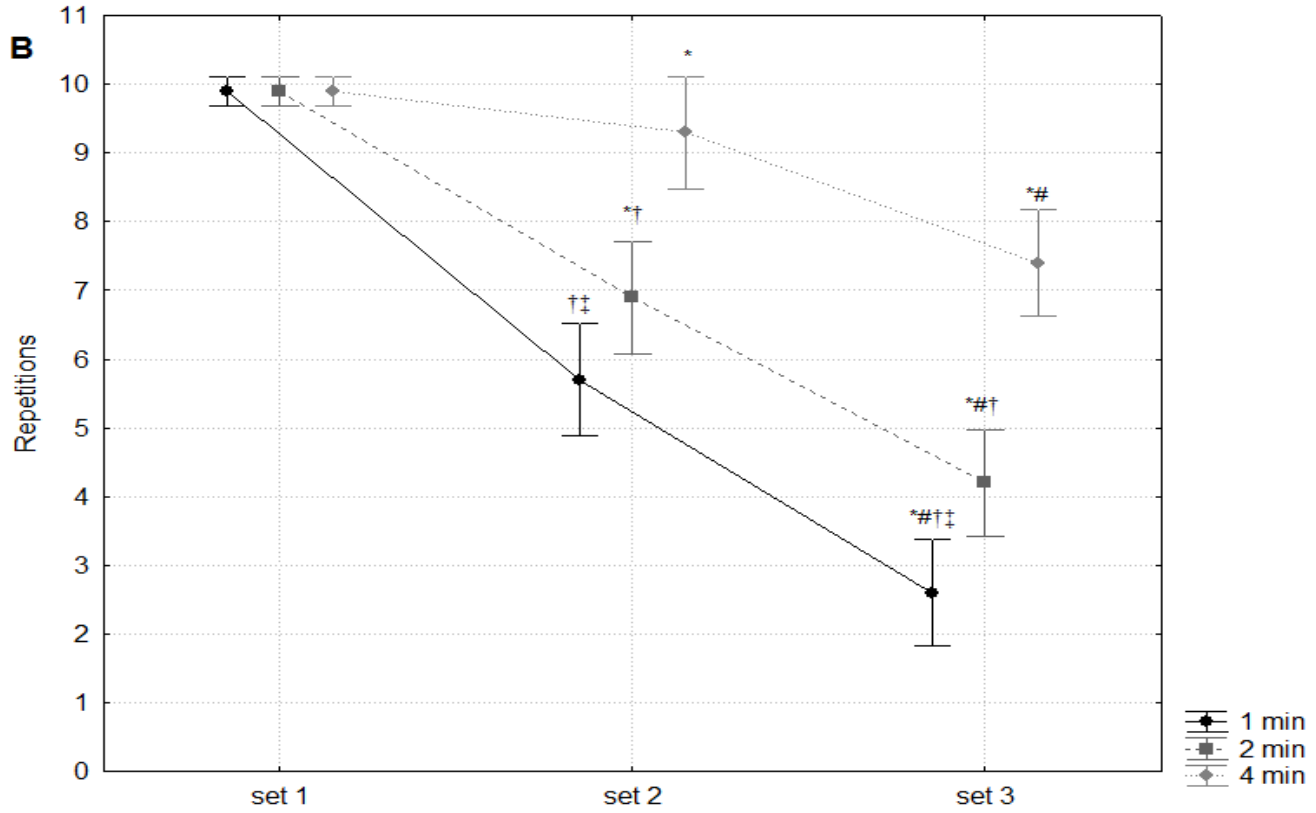
The total number of repetitions for the machine chest fly with the 1-min rest (17.7 ± 3.05 repetitions) was significantly lower than the 2-min rest (21.4 ± 3.65 repetitions). In contrast,

compared to the shorter rest periods, the 4-min condition presented a significantly greater number of repetitions (27.2 ± 1.93 repetitions). A similar pattern of repetition distribution was observed for the biceps curl exercise. For instance, the 1-min rest condition presented lower total repetition values (18.1 ± 2.18 repetitions) when compared to the 2-min rest period (20.9 ± 2.46 repetitions) and both rest conditions were significantly reduced when compared to the 4-min rest period (26.5 ± 2.36 repetitions).

For both exercises, total repetition number was related to rest period length. The greater the rest period length, a higher number of repetitions was performed. Additionally, the longer rest periods resulted in a smaller reduction in second (for machine chest fly; 4-min > 1-min) (for biceps curl; 2 and 4-min > 1-min) and third set (for machine chest fly and biceps curl; 2 and 4-min > 1-min), compared to shorter rest lengths. Finally, progressive reductions occurred for each rest period strategy over the course of consecutive sets for both exercises. The repetitions behavior for each set and exercise are represented on Figure 1.

Figure 1. Number of Repetitions in Each Set with 1-, 2-, 4-Min Rest Interval for Machine Chest Fly and Biceps Curl.





Repetitions maximum values for Machine Chest Fly (A) and Biceps Curl (B). *Significant difference to set 1; #Significant difference to set 2; †Significant difference to 1-min rest interval (P≤0.05). ‡Significant difference to 4-min rest interval (P≤0.05)

The effect size demonstrated dramatic reductions for shorter intervals (1 and 2-min) in both the 2nd and 3rd sets. For the 4-min rest condition, a large reduction was observed only for the biceps curl exercise for the 3rd set. Table 1 represents the magnitudes of the effects for each rest condition and exercise.

Table 1. Effect Size of Number of Repetitions Reductions in Second and Third Set.

Rest Conditions	Set 2	Set 3
Machine Chest Fly		
1-min	3.66 (large)	6.77 (large)
2-min	2.08 (large)	3.50 (large)
4-min	0.09 (small)	0.66 (moderate)
Biceps Curl		
1-min	1.30 (large)	2.29 (large)
2-min	0.93 (large)	1.77 (large)
4-min	0.40 (moderate)	1.67 (large)

DISCUSSION

The findings in the present study indicate that shorter rest periods (specifically, the 1-min and 2-min rest periods) vs. the longer rest period (4-min) resulted in lower values in repetition performance and training volume over multiple sets for both single-joint exercises. Moreover, we demonstrated that for both single-joint exercises none of the rest periods (1-min, 2-min, and 4-min) allowed maintenance of repetition consistency over the 3 consecutive sets, which resulted in a decrease in the expected total number of repetitions. Additionally, the effect size was classified as large for repetition reduction on shorter rest periods. Our data analysis demonstrated that the 1-min rest period and the 2-min rest period demonstrated significant reductions. This indicates that an important decrease in performance resulted from the shorter intervals of rest (1-min to 2-min), which is in opposition with the ACSM rest interval guidelines for single-joint exercises (1) for the maintenance of the capacity to perform subsequent sets of single-joint exercises without compromising the total work volume.

Investigations that focus on different rest intervals between sets for single-joint exercises are scarce. In a recent investigation, Senna et al. (11) observed repetition performance and perceived exertion with a 1-min, a 3-min, and a 5-min rest interval between sets on multi-joint exercises and single-joint exercises for the upper limbs and the lower limbs. Fifteen trained men underwent 12 sessions (4 exercises x 3 rest conditions) of one exercise per visit for the bench press, leg press machine, leg extension, and machine chest fly with 5 sets of a 10RM load. The results for bench press demonstrated a greater number of repetitions performed vs. the shorter 1-min condition. For the leg press, leg extension, and machine chest fly exercises, significant differences were found between all conditions for a number of repetitions performed (1-min < 2-min < 5-min). In addition, there were significant increases in perceived exertion during subsequent sets for both the multi-joint exercises and the single-joint exercises with significantly higher values in the 1-min rest interval period. Thus, the multi-joint exercise and the single-joint exercise exhibited similar patterns of performance on consecutive sets for both repetitions performance and perceived exertion independent of the duration of the rest interval between sets.

In addition, Senna et al. (9) compared the influence of different rest intervals on multi and single-joint exercises for repetitions performance, perceived exertion, and blood lactate. Twelve trained men performed load tests for 10RM on the bench press and machine chest fly. All subjects completed four different experimental sessions with one exercise for five consecutive sets with a 10RM load to failure with either a 1-min or a 3-min recovery period between sets. The authors found that the 1-min rest period promoted a higher total number of repetitions on both the bench press and machine chest fly compared to the 1-min protocol. Regarding perceived exertion, progressive elevations occurred after the 3rd set for both conditions tested. Also, for blood lactate concentrations, both the bench press and the machine chest fly exercises demonstrated significant elevations immediately after the exercises and the 15-min post session when compared to the pre-condition for both rest conditions (1-min to 3-min). For the single-joint exercise (machine chest fly), there was a higher blood lactate concentration with the 1-min rest period compared to the 3-min interval. As for the multi-joint exercise (bench press), the blood lactate curve remained similar between the different intervals (1-min to 3-min).

The present study confirmed the hypothesis that short rests periods are not sufficient to allow for full recovery of repetitions performance over consecutive sets. Our investigation helped to clarify that isolating the primary muscles (pectoral major and biceps brachii) by distinct single-joint exercises (machine chest fly and biceps curl), the similar pattern of reduction observed with repetition number over multiple sets would be directly dependent on the duration of the rest interval (1-min, 2-min, and 4-min). The shorter the rest interval, lower the total number of repetitions obtained compared to the longer rest periods. The differences in the present study and the Senna et al. study (9,11) adds to the current body of knowledge showing that even with minor differences in rest duration between rest protocols (such as 1-min to 2-min), important differences occur in repetition performance with single-joint exercises for different primary muscles of the upper limbs. However, both shorter rest conditions were not sufficient to maintain the subjects' repetition performance regardless of the single-joint exercise.

Conversely, in a recent study by Senna et al. (12), it was reported that a 2-min rest interval between sets was sufficient for single-joint exercise (machine chest fly). In this case, the trained subjects underwent 8 different training sessions with 48 hrs between each session. The sessions were performed in random order with a specific combination of exercises (machine chest fly or biceps curl) and rest intervals (1-min, 2-min, 3-min, or a 5-min rest). Five sets were performed for maximal repetitions with the predetermined 3RM load. The results indicate that for maintenance on the consistency in repetition performance, the rest interval of 2-min between sets was sufficient for the machine chest fly while 3 to 5-min was sufficient for the bench press exercise with the 3RM load zones. The fundamental difference for the present study was the specificity in maintaining the repetitions performance for distinct load zones (3 vs. 10RM). In the present study with lower loads, the 2-min rest condition was not sufficient to maintain the repetitions performance.

Other studies (14-16) have also investigated the influence of different rest periods on multi-joint exercises in distinct conditions. Specifically, Willardson and Burkett (15) compared the effects of three different interval lengths for bench press with heavy (80% of 1RM) vs. light (50% of 1RM) percentage of 1RM. The subjects were 16 trained men who performed two testing sessions each week for 3 wks. During the first testing session each week, 5 consecutive sets of the bench press were performed with 80% of 1RM with a 1-min, 2-min, or 3-min rest condition between sets. During the second testing session each week, the same procedures were repeated with 50% of 1RM. Regardless of load intensity, resting 3-min between sets resulted in a significantly greater total repetitions compared with the 2-min or 1-min rest condition. These results are in agreement with the findings in the present study, in which the shorter rest period presented dramatic reductions in the total number of repetitions when compared to the longer rest conditions specifically for the upper limbs.

CONCLUSIONS

For training goals with the objective to achieve a high volume and intensity, the rest interval between sets is an important variable to comprehend in order to be properly design and prescribe an individualized strength training program. We found that short rest periods resulted in significant reductions in both total number of repetitions performed at the end of the session and the number of repetitions for each consecutive set of single-joint exercises for the primary pectoralis major and biceps brachii muscles. It should be emphasized that our data do not support the current ACSM recommendations (1) for increasing strength, power,

and hypertrophy. This is due to the fact that the rest periods of 1-min and 2-min were not able to sustain repetition consistency of the 10RM load range. However, it should be noted that the present study did not examine the subjects' blood lactate or electromyography data to elucidate the physiologic phenomena reported. Additional research is needed to elucidate these considerations as well as the analysis of a different combination of rest periods and the influence on anthropometric measures in order to increase the body of knowledge regarding the strength training prescription.

Address for correspondence: Gilmar Senna, Federal University of State of Rio de Janeiro, Xavier Sigaud, 290/401, Praia Vermelha, Rio de Janeiro, RJ, Brazil, 22290-180. Email: sennagw@gmail.com.

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