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Influence of Different Rest Interval Lengths in Multi-Joint and Single-Joint Exercises on Repetition Performance, Perceived Exertion, and Blood Lactate

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ABSTRACT

Senna GW, Figueiredo T, Scudese E, Baffi M, Carneiro F, Moraes E, Miranda H, Simão R. Influence of Different Rest Interval Length in Multi-Joint and Single-Joint Exercises on Repetition Performance, Perceived Exertion, and Blood Lactate. **JEPonline** 2012;15(5):96-106. The purpose of this study was to compare the influence of different rest interval lengths in multi-joint and single-joint resistance exercises on repetition performance, rating of perceived exertion, and blood lactate. Twelve trained men participated in this study. First, they performed test and retest for 10 repetition maximum in a multi-joint exercise (bench press, BP) and a single-joint exercise (machine chest fly, MCF). Then, all subjects completed four different training sessions. In each session, 5 sets of one exercise were performed with 10 repetition maximum load until fatigue with 1- or 3-min rest interval between sets in a counterbalance crossover design. The 3-min rest interval promoted a greater total number of repetitions in BP and MCF when compared to 1-min rest interval. As to rating of perceived exertion, progressive elevations occurred after the 3rd set in all conditions tested. For blood lactate concentration differences between intervals occurred at the MCF with higher elevations presented at the shorter intervals. Both exercises showed similar patterns on the repetitions performance, but multi-joint exercises led to greater fatigue with longer rest interval.

Key Words: Muscle Strength, Weight Lifting, Physical Fitness.

INTRODUCTION

The length of rest interval is an acute variable that can be manipulated to approximate the responses of resistance training with different objectives. Like strength, hypertrophy, power, and muscular endurance training (2), length of the rest interval can create distinct adaptations on the endocrine (4) and neuromuscular systems (5,21). The latest position statement of the American College of Sports Medicine (2) recommends that recovery periods between sets should be from 2 to 3 min for multi-joint exercises (i.e., squats or bench press) and from 1 to 2 min for single-joint exercises (such as leg extension or machine chest fly). In a recent investigation (7), for strength and muscular power goals, longer rest periods (3 to 5 min) were recommended without taking into consideration the exercises (multi-joint and single-joint).

Numerous studies (11-13,15,16,20,22) have examined the influence of different rest intervals on the number of repetitions in multi-joint exercises or in training sessions. But until now, only one study has examined the influence of different length of rest intervals on distinct exercises (i.e., multi-joint x singe-joint exercises) (17). Senna and colleagues (17) compared the repetitions performance and ratings of perceived exertion (RPE) in different rest intervals between sets on multi- and single-joint exercise. The results indicated that in leg press, leg extension, and MCF significant differences were evident for all rest interval conditions (1 < 3 < 5 min) for the total number of repetitions completed. For all exercises, coincident declines were observed on repetition performance between sets in distinct intervals conditions, starting at the 2nd set for 1-min interval and 3rd set for 3 and 5 min, respectively. Additionally, significant increases in RPE were evident on the subsequent sets for both multi- and single-joint exercises with significant increases at the 1-min interval condition.

Even with the results of Senna et al. (17), blood lactate responses for different rest intervals between sets of exercises and multi-joint exercise and single-joint exercise have not been examined. Information about blood lactate concentrations would help demonstrate how both rest interval and different type of exercises (multi-joint and single-joint) influence the neuromuscular system. Thus, the aim of the present study was to compare the repetitions performance, rating of perceived exertion, and blood lactate with 1-min and 3-min rest interval between sets for multi- and single-joint exercises.

It was hypothesized that multi-joint exercises would produce a greater decrease at the repetition performance and, additionally, would allow for an increase in RPE followed by a higher blood lactate value. These responses should be more evidenced with the shorter rest interval conditions.

METHODS

Subjects

Twelve trained men participated in this study (age: 23.41±2.53 yrs; body mass: 77.33±8.20 kg, height: 177.08±6.17 cm, bench press relative strength: 1.53±0.25 kg/kg body mass) with the following inclusion criteria:

- Performed resistance training for at least 1 yr with a minimum frequency of three sessions per week;
- Could bench press at least 125% of their body mass;
- Did not perform any other physical activity for the duration of the current study;
- Did not present any medical conditions that could influence the training program; and
- Did not use any anabolic-androgenic steroids or other ergogenic substances that may enhance repetition performance.

Prior to data collection, all subjects answered “no” to all questions on the PAR-Q (18). After being informed of testing procedures, all subjects read and signed an informed consent in accordance with to the Declaration of Helsinki. The experimental procedures were approved by the Ethics Committee of Federal University of Rio de Janeiro.

Procedures

10RM Determination

After two familiarization sessions with the experimental procedures, the subjects performed four testing sessions with 10RM loads. At the first visit, the 10RM test was performed for the bench press (BP) exercise. During the second visit (in a non-consecutive day) the 10RM was performed for the machine chest fly (MCF). To establish reliability, two additional visits were conducted. During the 10RM tests, each subject performed a maximum of three 10RM attempts for each exercise with a 5-min rest interval between the attempts. Each testing session was separated by 48 hrs in which the subjects could not perform any exercise. The greatest load lifted over the 2-day period was considered the 10RM load. The 10RM testing protocol was described previously (19).

Standard exercise techniques were followed for each exercise (3). The following strategies were adopted to minimize errors:

- Standard instructions concerning the testing procedures were given to the subjects before the test;
- The subjects received standardized instructions on exercise technique;
- Body position was held constant (i.e., hand width during BP);
- Verbal encouragement was provided during the testing procedure; and
- The mass of all plates and bars used were determined using a precision scale.

Rate Perception Effort Scale Procedures

The OMNI Resistance Exercise Scale (9) was used to obtain the RPE. All subjects performed two familiarization sessions over a week, during which standard instructions were explained using the OMNI Scale. Subjects were asked to choose a number on a scale based on their perceived exertion or subjective intensity of effort, strain, discomfort, and/or fatigue experienced during the exercise session (9). The familiarization sessions consisted of two exercises (bench press and machine chest fly) performed for 2 sets of 15 repetitions with 2 min of rest between them. Immediately following each exercise sequence, the subjects were asked to identify their RPE.

Experimental Procedures

Forty-eight to 72 hrs after the last 10RM test, the subjects completed the first visit of four different training sessions (two sessions per week). In each session, 5 sets of 10RM loads were performed in a randomized design that was used to determine the exercise (BP or MCF) in combination with the rest interval (1 or 3 min) utilized in each session. The warm-up before each exercise consisted of two sets of 12 repetitions with a load of 40% of 10RM for that exercise. A 2-min interval was instituted between the warm-up sets and the realization of the first experimental set. Subjects were verbally encouraged to perform 5 sets until voluntary exhaustion.

Although no attempt was made to control the repetition velocity, each subject was instructed to use a smooth and controlled movement. All visits were conducted at the same time of day. The total number of repetitions and RPE Omni-Res (9) were recorded following each set. During the session, blood samples accessed from the antecubital vein for the determination of blood lactate concentrations Pre, Post, and Post 15 min from the sessions executions. The period between blood collection and verification was smaller than 30 min, in which the blood sample was placed in a specific tube with an anti-coagulant containing fluoride. Samples were collected without an arm band.

The blood sample was centrifuged and used without further modifications. It was performed a double analysis of blood lactate concentrations with BT 3000 plus equipment (Winter, Rosário, Arg).

Statistical Analyses

Statistical analysis was initially performed by Shapiro-Wilk normality test and homocedasticity test (Bartlett criterion). All variables showed normal distribution and homocedasticity. The intraclass correlation coefficient was used to determine the reliability of the loads between test and retest of 10RM for the exercises. A series of one-way ANOVAs were conducted to evaluate differences on the number of repetitions completed of each set of exercises separately for different conditions of rest interval, and also for the comparison of blood lactate in different times of examination (Pre, Post, and Post 15 min). When significant differences were indicated, a Bonferroni post-hoc test was applied for multiple comparisons. The Friedman test was used to compare differences between RPE in relation to the sets for each interval and exercise. If necessary, a Dunn post-hoc was used for multiple comparisons.

Additionally, to determine the magnitude of the findings, effect sizes (ES; the difference between the pretest score and the posttest score divided by the pretest standard deviation) were calculated for each exercise set of each rest condition, and the thresholds proposed by Cohen (6) were applied to determine the magnitude of the treatment effects. The level of significance was P=0.05. Prism software version 5.0 has been used for all statistical analysis (GraphPad, Inc).

RESULTS

Excellent test-retest reliability for each exercise was demonstrated via intra-class correlation coefficients (BP, r = 0.94, MCF, r = 0.99; P=0.001). In addition, a paired student t-test indicated no significant differences in the test-retest 10RM loads for each exercise (BP, P=0.54, MCF, P=0.18). The total number of repetitions completed in BP and MCF within the 3-min interval between sets was significantly higher than with the 1-min interval (P=0.05). For both exercises, the number of repetitions decreased between the sets for the two rest intervals conditions starting from the second set. No significant differences were observed between the 4th and 5th sets for both exercises (Table 1).

The ES were calculated using the repetition number of the 1st set as the pretest score, the repetition numbers of the 2nd through 5th sets as the posttest scores, and the standard deviation of the first set as the pretest standard deviation. The ES data demonstrated large magnitudes of repetition reductions in both exercises and all rest conditions. The magnitude of reductions increased over successive sets for all exercises in all rest interval conditions.

For all exercises, the magnitudes of reductions were higher for the 1 min rest condition across sets (see Table 1). Significant increases in RPE were evident over successive sets for both multi-joint and single-joint exercises. Significant differences for the 1st set started from the 3rd set for BP with 1-min rest interval and the MCF in both intervals conditions. Additionally, significant differences were also evident between 1- and 3-min rest intervals during the 4th and 5th set in the MCF (Table 1).

Table 1. Number of Repetitions (mean ± SD), Effect Size and RPE (median) in Each Set and the Total Number of Repetitions (mean ± SD) in Each Exercise with 1-min and 3-min Rest Intervals.

	Set 1	Set 2	Set 3	Set 4	Set 5	Total repetitions
Number of Repetitions						
BP						
1 min	10.8±0.28	6.66±1.43*	5.00±1.20*l	3.41±0.97*l §	2.83±0.57*l §	28.01±3.30
3 min	10.25±0.62	9.25±0.96*¥	8.01±0.95*l ¥	6.58±1.24*l §¥	6.25±1.54*l §¥	40.33±4.33¥
MCF						
1 min	10.67±0.98	7.17±0.94*	6.08±0.67*l	4.42±0.79*l §	3.58±0.79*l §	31.92±1.51
3 min	10.33±0.50	8.91±0.87*¥	6.75±0.78*¥	5.67±1.29*l ¥	6.00±1.40*l ¥	37.66±3.06¥
Effect Size of the Number of Repetitions						
BP						
1 min	-	11.83 (large)	17.61 (large)	23.09 (large)	25.11 (large)	-
3 min	-	1.60 (large)	3.62 (large)	5.90 (large)	6.42 (large)	-
MCF						
1 min	-	3.55 (large)	4.65 (large)	6.34 (large)	7.19 (large)	-
3 min	-	2.81 (large)	7.10 (large)	9.25 (large)	8.59 (large)	-
RPE						
BP						
1 min	6.5	7	8*	8*	9*l	-
3 min	6	7	8	8*	9*l	-
MCF						
1 min	6	7	7*	8.5*l	9*l §	-
3 min	6	6	7*	7*l ¥	8*l ¥	-

Values of the repetitions are expressed in repetitions maximum (RM); BP = bench press; MCF = machine chest fly; *Significant difference to set 1; l Significant difference to set 2; §Significant difference to set 3; ¥Significant difference to one minute rest interval (P= 0.05).

Significant elevations for blood lactate concentrations occurred in Post and Post 15 min compared with Pre verification in all exercises and intervals conditions. Significant differences between rest intervals (1 vs. 3 min) were observed in the MCF in Post and Post 15 min verification after completion of the sessions, which did not occur on the BP exercise (Figure 1 and 2).

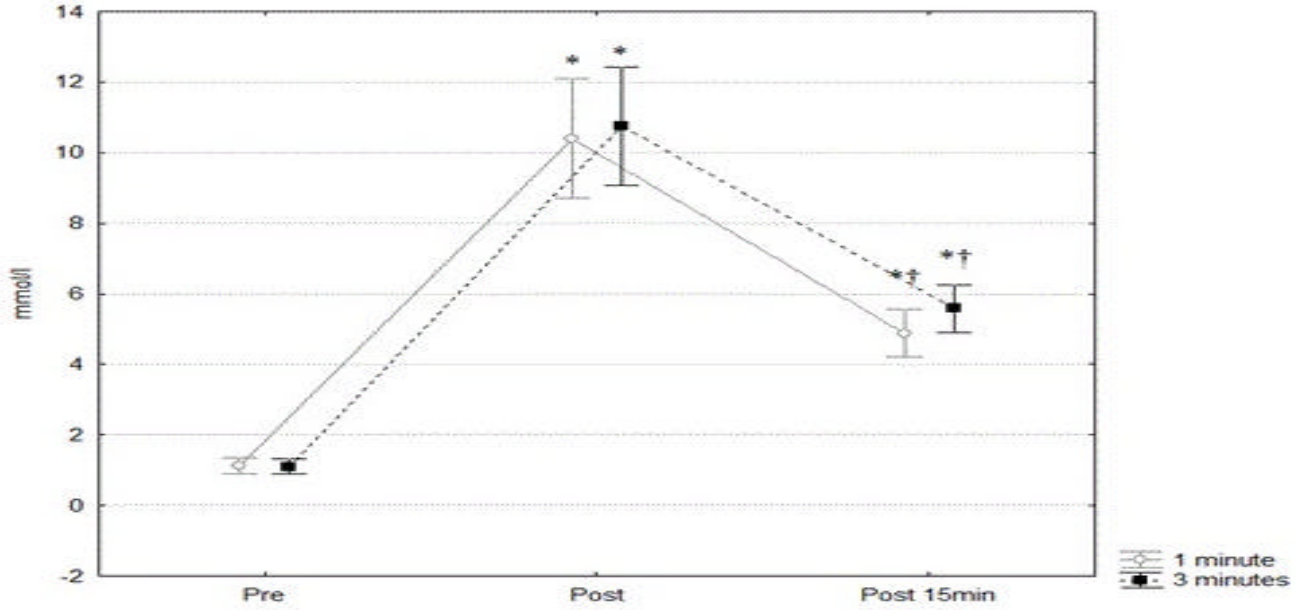

Figure 1. Blood lactate concentrations in pre, post and 15 minutes post exercise with one and three minutes rest interval for bench press. Values are expressed in mmol/1. *Significant difference to pre-test; l Significant difference to pos-test (P=0.05).

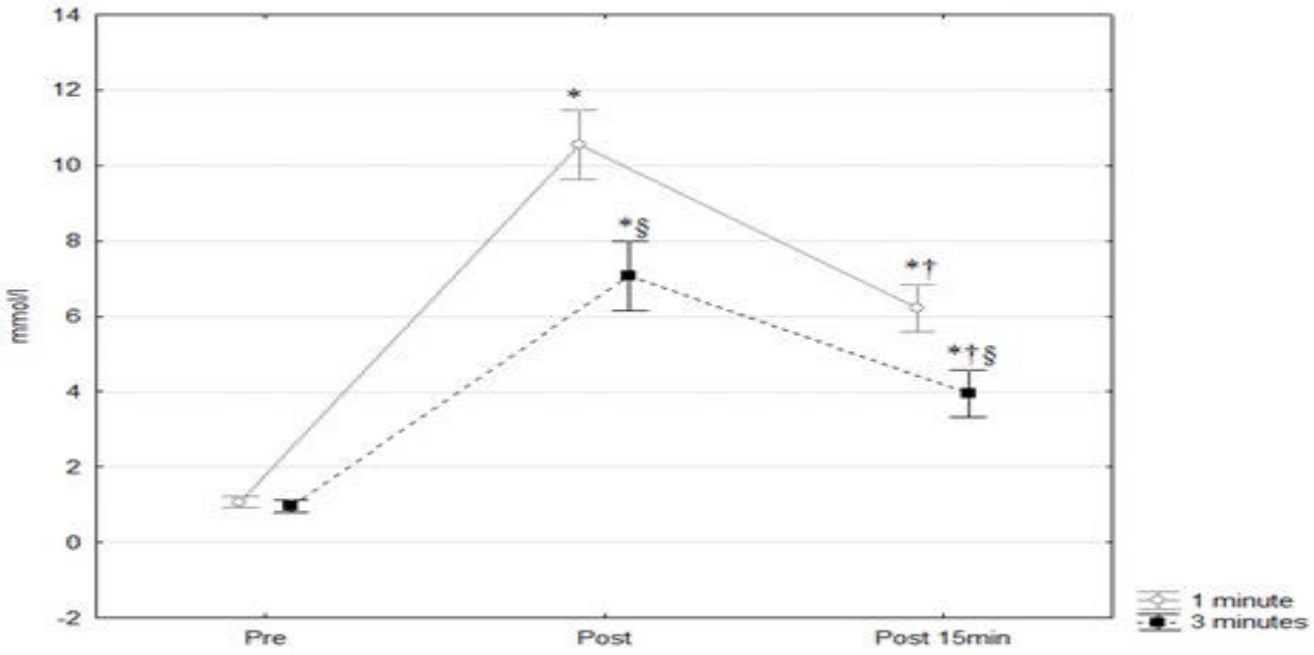

Figure 2. Blood lactate concentrations in pre, post and 15 minutes post exercise with one and three minutes rest interval for machine chest fly. Values are expressed in mmol/1. *Significant difference to pre-test; l Significant difference to pos-test (P=0.05).

DISCUSSION

The purpose of the present study was to compare the repetitions performance, rating of perceived exertion, and blood lactate with 1- and 3-min rest interval between sets for multi-joint and single-joint exercises. The key findings of this study were that both multi- and single-joint exercise (bench press, BP or machine chest fly, MCF) reduced the total number of repetitions performed when short intervals (i.e., 1-min) were utilized when compared with longer intervals (i.e., 3-min).

Number of Repetitions

Reducing the number of repetitions occurred from all sets especially at short rest intervals. The longer rest interval (i.e., 3-min) resulted in smaller decreases in the number of repetitions for each set regardless of the type of exercise (multi-joint or single-joint exercise). Our findings on repetitions performance do not corroborate with recent positions statements that recommend resting periods from 2 to 3 min for multi-joint exercises (e.g., squats, bench press) and shorter rest periods from approximately 1 to 2 min for single-joint exercises (e.g., leg extension and machine chest fly).

Investigations that have examined the length of the rest interval between sets in multi-joint exercises (15,21-23) or in training sessions (11,16) demonstrate that shorter intervals between the sets resulted in a negative effect on the number of repetitions performance in each set and, therefore, affecting the total volume, which is in agreement with our study. As to studies that looked at the influence of different rest intervals between sets in multi-joint versus single-joint exercises, they are scarce. It appears that only Senna et al. (17) directly compared the repetitions performance in multi-joint and single-joint exercises using the same prime movers (pectoral and quadriceps). Specifically, they compared repetition performance and RPE with 1-, 3-, and 5-min rest intervals between sets of multi- and single joint resistance exercises. Fifteen resistance trained men completed 12 sessions (4 exercises x 3 rest intervals). Each session consisted of 5 sets with 10RM loads for the BP, machine leg press, MCF, and machine leg extension exercises with 1-, 3-, and 5-min rest intervals between sets. The results indicated significantly greater BP repetitions with 3 and 5 min versus 1 min between sets. No significant difference was evident between the 3- and 5-min rest conditions. For the other exercises (i.e., leg press, MCF, and machine leg extension), significant differences were reported between all rest conditions (1 < 3 < 5). For all exercises, consistent declines of the repetition performance (relative to the 1st set) were observed for all rest conditions, starting with the 2nd set for the 1 min rest condition and the 3rd set for the 3- and 5-min conditions. Furthermore, significant increases in RPE were evident over successive sets for both the multi- and single joint exercises, with significantly greater values for the 1 min condition. These findings are in agreement with our data that presented significant decreases in repetitions performance for each set as well as in the total number of repetitions.

Blood Lactate Concentrations and RPE

In regards to blood lactate concentrations at different rest intervals (1 and 3 min) in distinct types of exercises (multi-joint and single-joint exercises), our study differed from the Senna et al. (17). To our knowledge, the present study is the first to elucidate these influences. Our results demonstrate significant increases in blood lactate concentrations in relation to Pre, Post, and Post 15 min for all conditions of rest interval and exercises. For the blood lactate concentrations in BP, no significant differences were found among different rest intervals (1 or 3 min) for all blood samples. However, differences for Post and Post 15 min occurred in different intervals between sets (i.e., 1 and 3 min), with greater blood lactate values found in shorter intervals. These findings suggest that shorter intervals (e.g., 1 min) provide higher muscle fatigue regardless of the exercise type. Although, for longer intervals, higher levels of muscle fatigue were found in multi-joint exercises (i.e., BP).

Rahimi and colleagues (14) examined three different rest periods (i.e., 60 sec, 90 sec, and 120 sec) on the acute hormonal response and lactate in 10 trained men. The resistance exercise session consisted of 4 sets of squat and bench press exercises to failure using 85% of 1RM load. Blood samples were collected at pre-exercise, immediately post, and 30 minutes post-exercise for the measurement of growth hormone (GH), testosterone, and lactate concentration. Serum GH concentrations were significantly higher at the 60 sec rest interval compared to the 120 sec rest interval. Testosterone serum concentrations were significantly higher immediately post the resistance exercises session when the 90 sec and the 120 sec rest intervals between sets were used. Blood lactate concentrations were significantly increased after the resistance exercise session for the 3 rest interval conditions, but no significant differences were observed between them.

These results are partially in agreement with Ahtiainen et al. (1) who researched the acute and long-term hormonal and neuromuscular adaptations to hypertrophic strength training in 13 recreationally strength trained men. Their experimental design consisted of a 6-month hypertrophic strength training period including two separate 3-month training periods with the crossover design. The design included a training protocol of short rest intervals (2 min) was compared with a longer rest interval (5 min) between the sets. The blood lactate concentrations, basal hormonal concentrations of serum total testosterone, free testosterone, and cortisol were measured at the beginning of the research, 3rd month, and 6th month. The two hypertrophic training protocols used in training for the leg extensors (leg press and squats with 10RM sets) were also examined at the beginning of the research, 3rd month, and 6th month. Before and immediately after, after 15 and 30 min after training, blood samples were collected for determination of blood lactate and hormonal concentrations. Both protocols before and after the experimental training period led to large acute increases in blood lactate concentrations, serum hormonal, as well as large acute decreases in maximal isometric force. However, no significant differences were observed between the different interval conditions.

Our study differs from these two studies in that the researchers (1,14) did not separate the conditions in the multi-joint and single-joint exercise. They analyzed only the rest interval between sets condition. However, our data partially agree with both studies in that both short and long rest intervals in multi-joint exercises that demonstrated a similar increase in blood lactate concentration. Also, our data demonstrated that for single-joint exercises (MCF) with shorter rest intervals between sets caused a higher increase in blood lactate concentrations when compared to the longer rest intervals (3 min). In support of the blood lactate results, the current study also demonstrated a significant increase in RPE with successive sets for both BP and MCF exercises (with significant increases in the RPE values for the 1 min interval conditions in the 4th and 5th sets of the MCF exercise).

The RPE is used to verify the intensity of resistance exercise sets (8-10). The 1 min condition may emphasize anaerobic glycolysis to a greater extent to compensate for the incomplete resynthesis of phosphocreatine. The greater reliance on anaerobic glycolysis is associated with the accumulation of H^+ that lowers the pH of intracellular fluid. The resulting effect is the afferent feedback from muscle chemoreceptors and nociceptors that associates with an increase in the perception of exertion. The central nervous system responds to the increase in RPE by increasing pulmonary ventilation and motor unit recruitment (10).

CONCLUSIONS

The length of the rest interval between sets is a variable that may influence other crucial variables (i.e., intensity and volume) involved in the development of specific objectives of resistance training (e.g., strength, hypertrophy, power, and muscular endurance). The findings in this study support the

body of knowledge that for multi-joint or single-joint exercises short rest intervals between sets produces significant decreases in the number of repetitions compared to long rest intervals between sets. In addition, this study showed that short rest intervals between sets produce significant increases in RPE and blood lactate concentrations regardless of the type of exercise performed. Thus, these data suggest that if the purpose of resistance training is to produce a high level of fatigue (as in muscular endurance), then, the shorter interval length seems to have great influence on the neuromuscular responses (as well as the intensity and volume) regardless of exercise type (multi-joint and single-joint exercises). On the other hand, when the training goals are related to high-volume and maintenance of the load (such as muscle strength and power), longer rest intervals may offer a higher performance of the number of repetitions. When prescribing multi-joint exercises, longer intervals between sets are an interesting option when the goal is to increase muscle fatigue.

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