

ORIGINAL INVESTIGATION (ARTIGO ORIGINAL)

COMPARISON OF 3 DIFFERENT REST INTERVALS ON SUSTAINABILITY OF SQUAT REPETITIONS WITH HEAVY VS. LIGHT LOADS

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ABSTRACT

MIRZAEI, B.; NIA, F. R.; SABERI, Y. Comparison of 3 different rest intervals on sustainability of squat repetitions with heavy vs. light loads. *Brazilian Journal of Biomotricity*, v. 2, n. 4, p. 220-229, 2008. The purpose of this research was to compare differences between 3 different rest intervals on sustainability of squat repetitions with heavy vs. light loads. Eighteen resistance trained men volunteered to participate in this study (age 22.67 ± 1.94 years; body mass 79.54 ± 15.73 kg). All subjects performed 2 testing sessions each week for 3 weeks. During the first testing session each week, 4 consecutive sets of the squat were performed with 90% of 1 repetition maximum (1RM) and with a 90-, 150-, or 240-second rest interval between sets. During the second testing session each week the same procedures were repeated with 60% of 1RM. The total repetitions completed and the sustainability of repetitions was compared between rest conditions and between loads. For each load, significant decline in repetition occurred between first and fourth set ($p = 0.000$). And the sustainability of repetitions was not significantly different between loads ($p = 0.076$). For each load a significant difference in the ability to sustain repetitions occurred between the 90-sec and 240-sec rest condition ($p = 0.000$), and between the 150-sec and 240-sec rest condition ($p = 0.002$). However, the sustainability of repetitions was not significantly different between the 90-sec and 150-sec rest condition ($p = 0.092$). These results suggest that when the training goal is development of muscular endurance, 90- sec should be taken between set and the intensity should be lowered. When the training goal is maximal strength development, 240- sec of rest should be taken between sets to avoid significant declines in repetitions. The ability to sustain repetitions while keeping the constant intensity may result in a higher training volume and consequently greater gains in muscular strength.

Key Words: Resistance training, Sets, Fatigue.

INTRODUCTION

Resistance training has been recognized as an essential component of a comprehensive fitness program for individuals with diverse fitness goals. Individuals may participate in resistance training for rehabilitative reasons or in preparation for strenuous jobs such as fire fighting, law enforcement, or military service. Several training variables must be considered when prescribing a resistance exercise program. Manipulation of training variables such as intensity, volume, frequency, repetition velocity, and rest between sets is dependent on the specific goals of the individual and the physical demands faced during daily life (BAECHLE et al., 2000; ACSM, 2002).

The manipulation of training variables as mentioned above is determined by the goals of the program and the needs of the individual. Mistakes in any of these variables in the progression of a program could theoretically result in an overtraining syndrome; therefore the manipulation of these variables must be correct done (KREIDER et al., 1998). The amount of rest between sets has been considered an important factor that can be manipulated to fit the goal of a program this factor significantly affects the metabolic (KRAEMER et al., 1987), hormonal (KRAEMER et al., 1990; KRAEMER et al., 1991; KRAEMER et al., 1993) and cardiovascular (FLECK et al., 1988) responses to an acute bout during resistance exercise, as well as performance of subsequent sets (KRAEMER et al., 1997) and training adaptations (ROBINSON et al., 1995; PINCIVERO et al., 1997).

When training for muscular endurance, the rest interval must be long enough to sustain a sufficient number of repetitions over consecutive sets, but also short enough to stimulate increased mitochondrial and capillary density and buffering capacity, all important adaptations related to muscular endurance performance (ANDERSON et al., 1982, KRAEMER et al., 1987, STONE et al., 1994). A recent meta-analysis by Rhea et al. (2002) demonstrated that when the training goal is maximal strength development, multiple sets per muscle group were superior to single sets. However, the superiority of performing multiple sets per muscle group may depend on the ability to sustain consistent repetitions over consecutive sets (ROBINSON et al., 1995). The ability to sustain consistent repetitions is largely dependent on the length of rest interval between sets (KRAEMER et al., 1987, WIER et al., 1994, TODD et al., 2001, MATUSZAK et al., 2003, RICHMOND et al., 2004, WILLARDSON et al., 2005, WILLARDSON et al., 2006c). The length of rest interval must be sufficient to recover energy sources (i.e., adenosine triphosphate [ATP] and phosphocreatine), clear fatigue-producing substances (i.e., hydrogen ions), and restore force production (HARRIS et al., 1976, WEISS et al., 1991).

No research has been conducted to determine the relationship between rest interval length and the sustainability of repetitions when training with different loads designed to muscular strength and develop muscular endurance. Therefore, the present study was designed to test the hypothesis that sustainability of squat repetitions with 60 and 90 percent of 1RM is related to duration of rest intervals between sets.

METHODS

Subjects

Eighteen resistance trained men (age 22.67 ± 1.94 years; body mass 79.54 ± 15.73 kg) were required for this investigation. All subjects were classified as experienced recreational lifters by having consistently performed a minimum of 3 resistance training session per week with a moderate to high intensity level for the previous 3 years.

Upon arriving for the initial testing, subjects were informed of the scope of the study and then asked to complete a medical history questionnaire, an exercise history questionnaire, and an informed consent as approved by the university's human subjects committee.

Procedures

Data collection occurred over a period of 4 weeks. During week 1, maximal strength for the squat exercise was determined for each subject on 2 different days using standardized procedures (SEWALL et al., 1991, KRAEMER et al., 1995). The highest value of the two 1 repetition maximum (1RM) measurements was used to determine the load assignments for the other testing sessions. During weeks 2, 3, and 4, subjects performed 2 testing sessions each week, the sessions being separated by 72 hours, the first with a load of 90% of 1RM and the second with a load of 60% of 1RM.

The intensities and rest intervals were randomized between subjects. During each testing session, all subject performed 4 consecutive sets to the point of voluntary exhaustion with 90-, 150- or 240 second rest intervals between sets.

Subjects were allowed to continue with their normal workouts throughout the duration of the study with the following exceptions: (a) subjects were instructed not to perform the squat, leg press and any other leg exercises in their personal workouts, and (b) subjects were instructed not to work out on the day of their scheduled testing sessions. Prior to testing, all subjects wear weight-lifting belts and performed warm-up sets for each load of squat. For the 60% test condition, subjects performed 1 warm-up set at 60% of the goal resistance for 10 repetitions. For the 90% test condition, subjects performed 2 warm-up sets; the first with 50% of the goal resistance and the second with 75% of the goal resistance, for 10 repetitions each (LARSON et al., 1997, WILLARDSON et al., 2005). After the warm-up sets, all subjects were performed 4 concocive sets to voluntary exhaustion. The rest interval between sets was timed using a hand-held stopwatch.

To ensure that all subjects were moving at approximately the same velocity for each repetition, each set was timed using a hand-held stopwatch. The spotter called out a cadence for the eccentric and concentric phases of each repetition. The repetition velocity consisted of a 3-second eccentric phase followed by a 1-second concentric phase. However, repetitions still were counted if the cadence slowed due to the effects of fatigue. For example, during the final portion of each set, the concentric portion of each repetition was typically performed in 1–3 seconds. The same spotter was utilized for all sets to reduce the potential for error.

The squat was performed with an Olympic bar through the full range of motion in a power cage. The pins in the power cage were adjusted to allow the subject to descend to the point where the tops of the thighs were parallel to the floor. If the participant was unable to complete a repetition, he was instructed to set the weight on the pins. One spotter was utilized during all sets of the squat to assist in racking the resistance and to ensure that subjects maintained proper technique.

The sustainability of repetitions was evaluated separately for each load of squat. The number of repetitions completed on each consecutive set was divided by the repetitions completed on the first set.

Statistical analysis

The resulting percentages were used in a 2 (loads) by 3 (rest intervals) by 4 (sets) repeated ANOVA with LSD post-hoc to compare of the sustainability of repetition between sets, rest condition and between loads. Linear and quadratic contrasts were calculated to assess the performance patterns associated with repeated sets to exhaustion. An alpha level of 0.05 was used to determine significance for all comparisons.

RESULTS

The results indicated that the sustainability of repetitions was significantly different between sets ($p=0.000$) and between rest conditions ($p=0.000$) but was not significantly different between loads ($p=0.076$). *Post-hocs* was then conducted using the LSD adjustment to determine specific differences between sets and between rest conditions (see Table 1).

Table1. Post-hoc sets and rest intervals

Set	significance	Rest (second)	Significance 60%	Significance 90%
1 vs. 2	0.000	90 vs. 150	0.092	0.092
1 vs. 3	0.000	90 vs. 240	0.000	0.000
1 vs. 4	0.000	150 vs. 240	0.002	0.002
2 vs. 3	0.000			
2 vs. 4	0.000			
3 vs. 4	0.000			

Significant linear ($p = 0.000$) and quadratic ($p = 0.000$) contrasts indicated that a large decline in repetitions occurred between the first set and the forth set (Figure 1).

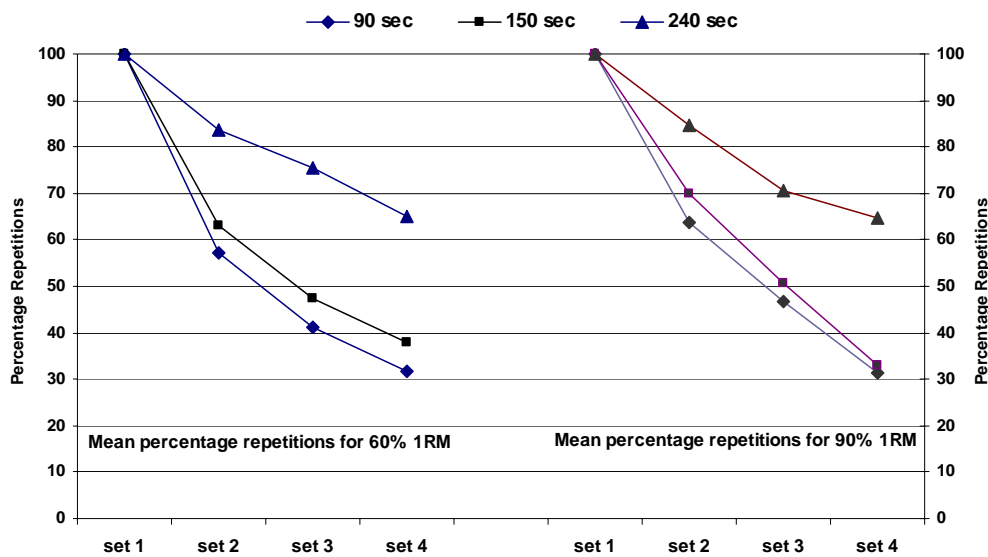


Figure 1 - Mean percentage repetitions for 60% and 90% 1RM

Post-hocs for sets indicated significant differences in the percentage of repetitions completed between the first set and each subsequent set thereafter (see Table 2 and figure 1).

Table2 - Repetition 4 consecutive sets (Mean ± SD)

Rest second	Load %	Set 1 Mean ± SD	Set 2 Mean ± SD	Set 3 Mean ± SD	Set 4 Mean ± SD
90	60	21.08 ±1.17	11.42 ±2.08	8.67 ± 2.59	6.86 ± 3.13
150		20.95 ±2.81	13.19 ±3.12	9.94 ±2.42	7.94 ±2.64
240		21.06 ±2.01	17.65 ±3.04	15.87 ±2.92	13.69 ±3.43
90	90	6.1 ± 0.42	3.89 ± 0.74	2.85 ± 0.49	1.91 ± 0.47
150		6.09 ± 0.54	4.26 ± 0.91	3.08 ± 0.97	2.01 ± 0.94
240		6.07 ± 0.94	5.12 ± 0.43	4.72 ± 0.65	3.93 ± 0.36

Post-hocs for rest indicated a significant difference in the ability to sustain repetitions between the 90-sec and 240-sec rest conditions (p = 0.000), and between the 150-sec and 240-sec rest condition (p = 0.002). However, the ability to sustain repetitions was not significantly different between the 90-sec and 150- sec rest condition (p = 0.092).

DISCUSSION

The results of the current study demonstrated that the sustainability of repetitions over 4 consecutive sets was similar for the 60% and the 90% of 1RM loads and repetitions were not sustainable over 4 consecutive sets performed with neither a 60% nor 90% 1RM; irrespective of the rest conditions (see Table 2 and figure 1). A significant difference in sustainability of repetition occurred between the 90- sec and 240- sec and between 150- sec and 240 sec rest conditions. Also, 240- sec resting between set resulted in greater sustainability of repetitions vs. 150- sec and 90- sec resting between sets. However, the sustainability of repetitions was not significantly different between the 90-sec and 150-sec rest condition and between loads.

Other studies, which examined the effect of different rest intervals on the sustainability of muscular performance, have demonstrated mixed results. Weir et al. (1994) and Matuszak et al. (2003) demonstrated that a maximal squat and bench press were repeatable following a 1-, 3-, 5-, or 10-minute rest interval. However, a limitation of these studies was the performance of only two 1RM sets. Therefore, the results of these studies might be applicable to strength testing, but not to actual resistance training workouts, which involve a higher volume of training. In contrast, Kraemer et al. (1997), Todd et al. (2001), Richmond and Godard (2004), and Willardson and Burket (2005, 2006b) demonstrated that when training with submaximal loads between 50% and 90% of 1RM, longer rest intervals of 3-5 minutes between set allowed for more total repetitions to be completed during a workout.

According to the Henneman's size principles, when lifting a submaximal amount of resistance, the slow and fast-twitch muscle fibers are recruited but at first the slow-twitch muscle fibers exert force and when the slow-twitch muscle fibers become progressively fatigued, the fast-twitch muscle fibers continue to produce sufficient force. Finally, when all available muscle fibers are fatigued and cannot produce sufficient force, the set is ended (Sale et al., 1987). When considering the rest interval between sets, slow-twitch muscle fibers would require shorter recovery due to their oxidative characteristics, whereas fast-twitch muscle fibers would require longer recovery due to their glycolytic characteristics (WEISS et al., 1991). In contrast, Robergs et al. (2004) demonstrated that there is no biochemical support for lactate production causing acidosis, Lactate production retards, not causes, acidosis. Similarly, there is a wealth of research evidence to show that acidosis is caused by reactions other than lactate production (KOWALCHUK et al., 1988; TAFALLETI et al., 1991; COREY et al., 2003).

When training for muscular strength, longer rest intervals are generally prescribed to allow for greater recovery and maintenance of training intensity. However, the length of the rest interval can vary, depending on the magnitude of the loads. Studies that have examined strength increases have provided support for longer rest intervals between sets. Pincivero et al. (1997) concluded that longer rest intervals allowed for the maintenance of training intensity, which led to greater strength increases.

Robinson et al. (1995) demonstrated that a 3-minute rest interval was superior

to 90- second and 30-second rest intervals for producing strength increases in the free-weight squat exercise.

When training for muscular endurance, the extremely short rest intervals between sets necessitate lowering the training intensity over consecutive sets to sustain repetitions within the range conducive to this training goal (WILLARDSON et al., 2006a).

In the present study, it was shown that repetitions were most sustainable when resting 240-second between sets. This leads to an apparent paradox in results of previous reports which showed that training with shorter rest intervals may result in adaptations favoring greater muscular endurance (ANDERSON et al., 1982; KRAEMER et al., 1987; STONE et al., 1994).

Mirzaei et al. (2008) compared the sustainability of bench press repetitions with different rest intervals. Subjects performed 7 testing sessions with 48 hours recovery period between sessions. During each session, 4 consecutive sets of the bench press were performed with a 60% or 90% of 1RM and with a 90-150- or 240 sec rest intervals between sets. The results demonstrated that for each load, significant decline in repetition occurred between first and fourth set and the sustainability of repetitions was significantly different between loads (MIRZAEI et al., 2008).

The duration of rest intervals during resistance exercise appears to affect muscular endurance. It has been shown that bodybuilders (who typically train with high volume and short rest periods) demonstrate a significantly lower fatigue rate in comparison with power lifters (who typically train with moderate volume and longer rest periods). These data demonstrate the benefit of high-volume, short-rest-period workouts for improving local muscular endurance (ACSM, 2002).

Willardson and Burkett compared the sustainability of squat and bench press repetition with different rest intervals between sets. Five consecutive sets were performed with a 15 RM load and a 30- second, 1- minute, or 2- minute rest intervals between sets. The load was kept constant over all 5 sets and the percentage decline in repetitions was compare between rest conditions. The results demonstrated that all rest conditions, significant decline in repetitions occurred between the first set and the fifth set for both exercises. However, the 2- minute rest condition afforded greater sustainability of repetitions, with more total repetitions completed vs. the other rest condition. The author concluded that muscular endurance training programs that involve 30 second rest between sets should lower the training intensity over consecutive sets in order to sustain repetitions within the range conducive to this training goal (WILLARDSON et al., 2006c).

CONCLUSIONS

The squat is a common exercise prescribed in resistance training programs. When designing resistance training programs, the amount of rest prescribed between sets is likely dependent on the goal, the training status of the individual, and the load being lifted.

The results of the current study can be applied to weekly squat workouts that undulate between heavy (i.e., 90% 1RM) and moderate (i.e., 60% 1RM) intensities. It should be noted that findings of the current study are applicable only to the squat.

When the training goal is maximal strength development, 240-sec rest should be taken between sets to avoid significant declines in repetitions. The ability to sustain repetitions while keeping the intensity constant may result in a higher training volume and, consequently, greater gains in muscular strength (ROBINSON et al., 1995), and when training to increase muscular endurance, resting 90- sec might be appropriate between consecutive sets.

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