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A Comparison of 3 Different Rest Intervals on the Exercise Volume Completed During a Workout

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Abstract. Willardson, J.M., and L.N. Burkett. A comparison of 3 different rest intervals on the exercise volume completed during a workout. *J. Strength Cond. Res. 19(1):23–26. 2005.*—The purpose of this research was to compare differences between 3 different rest intervals on the squat and bench press volume completed during a workout. Fifteen college-aged men volunteered to participate in this study (age 20.73 ± 2.60 years; body mass 80.73 ± 10.80 kg). All subjects performed 3 testing sessions, during which 4 sets of the squat and bench press were performed with an 8 repetition maximum (8RM) load. During each testing session, the squat and bench press were performed with a 1, 2, or 5-minute rest interval between sets. Volume was defined as the total number of repetitions completed over 4 sets for each rest condition. Statistical analysis was conducted separately for the squat and bench press. One-way repeated analyses of variance with Bonferroni post hocs demonstrated significant differences between each rest condition for both exercises tested ($p < 0.05$). The 5-minute rest condition resulted in the highest volume completed, followed in descending order by the 2- and 1-minute rest conditions. The ability to perform a higher volume of training with a given load may stimulate greater strength adaptations.

Key Words. recovery, squat, bench, corridor, recruitment

Introduction

When designing strength training programs, many variables must be considered. The manipulation of training variables is determined by the goals of the program and the needs of the individual. Strength training programs can be structured to emphasize muscular power, strength, hypertrophy, or endurance. Variables that are commonly manipulated to accomplish these goals include intensity, volume, frequency, repetition velocity, and rest between sets (1, 2).

The amount of rest between sets has been considered an important factor that can be manipulated to fit the goal of a program. When training for increased strength, longer rest periods of 2–5 minutes have been recommended to allow for greater recovery and maintenance of training intensity (1, 2, 13). Previous studies have shown that the amount of rest between sets has a significant effect on the total volume completed during a workout, which may affect subsequent strength adaptations (10).

Kraemer (6) utilized a sample of National Collegiate Athletic Association Division I football players to determine the effect of a 3-minute rest interval versus a 1-minute rest interval on the total number of repetitions completed over 3 sets of bench press and leg press with a fixed 10 repetition maximum (10RM) load. When resting 3 minutes between sets, each player was able to complete 10 repetitions for all 3 sets. However, when resting 1 minute between sets, a significant reduction in the total number of repetitions was observed ($p < 0.05$).

A similar study by Larson et al. (9) utilized a sample of recreationally trained men to determine the effect of 3 different rest intervals on the total number of repetitions completed over 4 sets of squats with 85% of a 10RM load. The 3 rest intervals included (a) a postexercise heart rate (HR) equal to 60% of age-predicted maximum HR, (b) a timed 3-minute interval, and (c) a work:rest ratio of 1:3. No significant differences were observed between each rest condition for the total number of repetitions completed. However, within each condition, the number of repetitions performed for each set declined significantly between the first and the fourth set ($p < 0.05$).

Finally, a study by Weir et al. (12) utilized a sample of college-aged men to determine the effect of 4 different rest intervals on a repeated maximal bench press. Each subject performed 2 maximal bench presses, separated by a 1-, 3-, 5-, or 10-minute rest between sets. Results demonstrated no significant differences between rest intervals in the ability to perform a repeated maximal bench press ($p < 0.05$).

The results of these studies suggest that the repeatability of performance over multiple sets is dependent on the amount of rest between sets and the load being lifted. However, no prior studies have examined the effect of interset rest intervals on exercise volume when training with loads between 1RM and 10RM. Loads within this range are often used by athletes and recreational lifters to maintain or increase strength (1, 2). Therefore, the purpose of this study was to compare the effects of 3 different rest intervals on the squat and bench press volume completed over 4 sets with an 8RM load.

Methods

Experimental Approach to the Problem

A group of 15 college-aged men volunteered for this research study (age, 20.73 ± 2.60 years; body mass, 80.73 ± 10.80 kg). All subjects were classified as experienced recreational lifters by having consistently performed a minimum of 3 strength workouts per week for the previous 3 years. All subjects were required to sign a consent form, in accordance with human subject regulations.

Data collection occurred over a period of 4 weeks with 1 testing session each week. During the first testing session, an 8RM was determined for each subject using standardized procedures for submaximal strength testing (7). During the next 3 testing sessions, 4 sets of the squat and

TABLE 1. Mean ± *SD* values for repetitions completed.

	Set 1	Set 2	Set 3	Set 4	Total
Bench					
1 min	7.47 ± 1.06	4.40 ± 1.64	2.87 ± 1.30	2.40 ± 1.18	17.13 ± 4.42
2 min	7.73 ± 0.46	5.73 ± 1.39	4.20 ± 1.47	3.93 ± 1.58	21.60 ± 4.52
5 min	7.60 ± 0.91	6.53 ± 1.55	6.00 ± 1.41	5.60 ± 1.24	25.73 ± 4.23
Squat					
1 min	7.87 ± 0.52	5.93 ± 1.90	4.47 ± 1.85	4.20 ± 1.94	22.47 ± 4.79
2 min	8.00 ± 0.00	6.67 ± 1.45	6.07 ± 1.53	4.80 ± 1.82	25.53 ± 4.29
5 min	8.00 ± 0.00	7.80 ± 0.56	7.00 ± 1.65	6.00 ± 1.77	28.80 ± 3.08

bench press were performed with a 1-, 2-, or 5-minute rest interval between sets. A counterbalance procedure was used to determine the order of exercises and the rest interval between sets for each testing session. 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 or bench press in their personal workouts, and (b) subjects were instructed not to work out on the day of their scheduled testing sessions.

Prior to testing, subjects performed warm-up sets for each exercise. The first warm-up set was performed at 50% of 8RM for 10 repetitions, while the second warm-up set was performed at 75% of 8RM for 5 repetitions. On the third set, the resistance was raised to 8RM, and 4 sets were performed to voluntary exhaustion. After the 4 sets were completed, participants were given 5 minutes of rest prior to beginning warm-up sets for the next exercise. If a subject was able to exceed 8 repetitions on the first set of an exercise, the resistance was raised 5 pounds for the bench press and 10 pounds for the squat.

To ensure that all subjects were moving at approximately the same velocity for each repetition, each set was timed using a handheld 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. The same spotter was utilized for all sets to reduce the potential for error.

The squat and bench press were each performed with an Olympic bar through the full range of motion. The squat was performed 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. The bench press was performed on a traditional flat bench. Subjects lowered the weight to the point where the resistance touched the chest before pressing the resistance back to the starting point above the shoulder joints. One spotter was utilized during all sets of the squat and bench press to assist in racking the resistance and to ensure that subjects maintained proper technique.

Statistical Analyses

Statistical analysis was conducted separately for the squat and bench press. Rest conditions for both exercises were compared using 1-way repeated analyses of variance with Bonferroni post hocs. The alpha level was set at 0.05 in order for a difference to be considered significant. Intraclass reliability was assessed between the last 3 testing sessions. Volume was defined as the total number of repetitions completed over 4 sets for each rest condition.

RESULTS

The volume completed for the squat was significantly different between the 1- and 5-minute rest conditions and between the 2- and 5-minute rest conditions ($p < 0.05$; see Table 1). However, the volume completed was not significantly different between the 1- and 2-minute rest conditions ($p = .056$). Intraclass reliability for the squat was 0.99.

The results for the bench press were similar to that reported for the squat. The volume completed for the bench press was significantly different between all rest conditions ($p < 0.05$; see Table 1). The 5-minute rest condition allowed for the highest volume, followed in descending order by the 2- and 1-minute rest conditions. The intra-class reliability for the bench press was 0.99.

DISCUSSION

The results for both exercises demonstrated that, as the rest interval between sets increased, the total number of repetitions completed also increased. There was not a significant difference in the squat volume completed between the 1- and 2-minute rest conditions ($p = 0.056$). This indicates that subjects exhibited a greater degree of endurance when performing the squat versus performing the bench press.

Perhaps because the muscles of the lower body are used to a greater extent on a daily basis compared to the muscles of the upper body, a higher level of endurance was exhibited when performing the squat. In contrast to the squat, the volume completed for the bench press was significantly different between all rest conditions ($p < 0.05$). These results can be explained by the corridor theory, which was proposed to explain the recruitment of muscle fibers during a submaximal set of resistance exercise (11, 14).

When lifting a submaximal amount of resistance, the slow-twitch muscle fibers are recruited first. As the slow-twitch muscle fibers become progressively fatigued, the fast-twitch muscle fibers are recruited and continue to produce sufficient force. Finally, when all available muscle fibers are fatigued and cannot produce sufficient force, the set is ended (11, 14). 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 (13).

Because fast-twitch muscle fibers rely heavily on anaerobic glycolysis for energy production, these fibers

would accumulate higher levels of lactic acid during high intensity exercise. The accumulation of lactic acid has been shown to lower intracellular pH through the dissociation of hydrogen ions (H^+), which results in muscle fatigue (4, 5). Short rest intervals of 1 minute or less have been shown to significantly increase lactic acid levels during heavy strength training exercise (8). The time needed for lactic acid clearance following high-intensity exercise has been shown to be 4–10 minutes (4). In the current study, the 5-minute rest condition likely afforded the fast-twitch muscle fibers greater clearance of lactic acid, which allowed subjects to complete a higher volume of training, versus the 1- and 2-minute rest conditions.

The results of the current study were different from those demonstrated by Kraemer (6), who found that when subjects rested 3 minutes between sets, they were able to complete all 10 repetitions over 3 sets of bench press with a 10-RM load. In the current study, subjects failed to complete all 8 repetitions over 4 sets of bench press and squat with an 8RM load, even when resting 5 minutes between sets (see Table 1). These differences in results may be accounted for by differences in the training status of subjects.

The subjects utilized by Kraemer (6) were Division I football players accustomed to training with maximal exertion over multiple sets. These subjects possibly had adapted to the point that more repetitions were possible with shorter rest intervals between sets. By contrast, the subjects in the current study lifted recreationally and rarely trained with maximal exertion over multiple sets. Larson et al. (9) utilized a sample of recreationally trained men and demonstrated results that were consistent with the current study, with a significant decline in the number of repetitions completed over 4 sets of squats with 85% of a 10RM load.

The higher training load utilized in the current study may have been another factor accounting for results that differed from those of Kraemer (6). For example, as training load increases, there is greater reliance on intramuscular adenosine triphosphate (ATP) and phosphocreatine (PCr) to supply the energy necessary for muscle contraction (13). Recovery of ATP requires 3–5 minutes, while PCr recovery requires 8 minutes, thus creating the need for longer rest intervals in order to maintain training volume with a higher load (3).

Weir et al. (12), however, showed no differences in the ability to repeat a maximal bench press following 1-, 3-, 5-, or 10-minute rest interval between sets. A limitation of this study was that subjects only performed 2 1RM sets. Had more than 2 sets been attempted, longer rest intervals may have resulted in superior performance. In the current study, subjects were able to maintain training volume to the greatest extent when resting 5 minutes between sets for both the squat and bench press.

Although longer rest intervals appear to result in a higher training volume, few studies have examined the effect of interset rest intervals on strength gains. Robinson et al. (10) divided 33 trained men into 3 groups based on a 3-minute, 90-second, or 30-second rest interval between sets. Volume lifted was compared between groups and was defined as the repetitions performed multiplied by the weight lifted. At the conclusion of the study, the 3-minute group demonstrated significantly greater strength gains in the squat ($p < 0.05$). The authors concluded that the 3-minute rest interval led to greater strength gains due to the ability to maintain a higher training volume.

Although Robinson et al. (10) demonstrated that a 3-minute rest interval resulted in a higher training volume, a longer rest interval may have produced an even higher training volume and, consequently, greater strength gains. The current study demonstrated a dose-response relationship between the amount of rest between sets and the volume of training completed. However, the practicality of longer rest intervals must also be considered, and there may be a point of diminishing returns, yet to be determined, where a longer rest interval yields no additional volume.

PRACTICAL APPLICATIONS

The squat and bench press are common exercises prescribed in strength training programs. When designing strength 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. This study demonstrated that a 5-minute rest interval between sets allowed for the highest volume to be completed when training with an 8RM load. The ability to perform a higher volume of training with a given load may stimulate greater strength adaptations, as demonstrated by Robinson et al. (10). A limitation of the current study was that gains in strength were not measured and subjects were not separated into groups designated by different rest intervals. Future research should continue to examine changes in muscular strength, dependent on differences in the rest interval between sets.

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