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THE EFFECT OF DIFFERENT REST INTERVALS BETWEEN MULTIPLE BENCH PRESS BOUTS

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ABSTRACT

In order to examine the effects of different rest intervals between sets on the training volume completed during a workout, 15 male bodybuilders served as subjects (Mean SD, age=25.28±2.01; mass=73.06±8.33 kg; height=176.33±6.30 cm). All the subjects performed a minimum of three strength workouts per week for a period of two years. Data collection took place over a period of four weeks with four testing sessions. During the first session, one repetition of the maximum (1RM) for the Bench Press (BP) was tested. Each of the next three sessions included four sets of exercises performed with a 75% of 1RM load. Rest between sets was randomly assigned from: a timed three-minute rest period; a 1:3 work: rest (W/R) ratio (1:3 W/R) and achieving a post exercise heart rate (HR) of 60% age-predicted maximum (60% Post-HR). The repetitions to exhaustion from set two to set four were significantly higher in three-minute rest conditions than 1:3 W/R and a 60% Post-HR rest conditions (P<0.05), and there was no significant differences between the 60% Post-HR and 1:3 W/R conditions. Within each condition the number of repetitions to exhaustion decreased significantly for each set (P≤ 0.01). The results showed that a three-minute rest interval was the most effective method of recovery compared to 60% Post-HR and 1:3 W/R conditions during the four sets of bench press to exhaustion.

Key words: Resistance exercise; Rest interval; Work; Rest ratio; Post exercise heart rate

INTRODUCTION

Resistance training (RT) programmes are commonly used to enhance performance in many sports. Resistance training variables, originally defined by Kraemer (1983), include a number of sets and repetitions, training intensity, training volume and rest periods between sets. Manipulating any of these variables will alter the specific training stimulus, which in turn is determined by the goals of the program and the needs of the athletes. Mistakes in any of these variables in the progression of a program could, in theory, result in overtraining syndrome. Therefore, the manipulation of these variables must be done correctly (Kreider *et al.*, 1998).

Among these variables, rest periods between sets in RT have a special importance. A rest period is defined as the time period between the end of a training set and commencement of the next, or until the body condition of the individual approaches the physiological state as before the activity. It is necessary to establish suitable recovery periods between successive sets to sustain consistent repetitions.

Time, work: rest ratio (W/R) and achieving a specific recovery heart rate (HR) during the rest period are indicators as to whether the body is physiologically prepared for another work period/load. In terms of the effects of a fixed time period between sets on training volume as measured by repetitions to exhaustion, Kraemer's (1997), 3 set×10RM with 1 and 3 minutes rest, Richmond and Godard's (2004), 2 set×75% 1RM with 1, 3 and 5 minutes rest, Todd's *et al*. (2001), 3 set×60% 1RM and 90% 1RM with 1, 2, 3, 4 and 5 minutes rest, Rahimi's (2005), 4 set×85% 1RM with 1, 2 and 5 minutes rest and Willardson and Burkett's (2005), 4 set× 8RM with 1, 2 and 5 minutes rest demonstrated that when training with sub maximal loads between 50 and 90% of 1RM, long rest periods of 3-5 minutes between sets allowed for more total repetitions to be completed during a workout.

However, Larson and Potteiger (1997), in relation to W/R ratio and achieving a specific post exercise heart rate (Post-HR) as indicators of rest periods between sets, compared resistance training workout in four sets of squats with 85% of 10RM to either a 3 minute rest period, 1:3 W/R ratio and a Post-HR of 60% age-predicted maximum. They reported that three different rest conditions were equally effective methods of recovery during the four sets of parallel squats to exhaustion.

To our knowledge, the impact of a 3 minute rest, 1:3 W/R ratio and a Post-HR of 60% age-predicted maximum rest period on the bench press completed over four sets with 75% of a 1RM load has not been reported and resistance-trained athletes, such as bodybuilders or power-lifters, must perform exercises at maximal or near maximal intensities with repeated efforts in order to enhance muscular hypertrophy. Recovery between efforts for these athletes may be a critical issue for maximising performance. Therefore, the purpose of this study was to compare the effects of three different rest intervals on the bench press as measured by repetitions to exhaustions over four sets with 75% of a 1RM load.

METHODS

Experimental approach to the problem

To test the hypothesis that there is a significant difference in training volume completed during a workout involving the bench press (BP) due to different rest intervals between sets and the training volumes completed during a workout in this exercise were compared for each rest interval condition (3 minute rest, 1:3 W/R ratio and a Post-HR of 60% age-predicted maximum rest period).

Subjects

A group of 15 college-aged men volunteered for this study (age, 25.28± 2.01 years; body mass, 73.06 ± 8.33 kg; height, 176.33±6.30 cm). All the subjects were classified as experienced recreational lifters by having consistently performed a minimum of three strength workouts per week for the previous two years and none of the subjects had any experience with such training styles before the study. The subjects signed a informed consent form before participating in the study and completed a medical history questionnaire in which they were screened for any possible injury or illness. The Institutional Review Board of the University approved the research protocol.

1RM testing and exercise sessions

Data collection occurred in four sessions with 48 hours recovery between each session in a week. The subjects were required to warm up prior to each testing session, which consisted of 4 minutes of low intensity exercise on a cycle ergometer and performing upper body flexibility movements. In the first session, 1RM on the bench press was determined in accordance with Willardson and Burket (2006). Briefly, the bench press was performed with an Olympic bar through the full range of motion. Subjects descended to the point at which the Olympic bar touched the chest, before pressing the resistance back to the starting point with the elbows extended. One spotter was used during all sets to assist in racking the bar and to ensure that subjects maintained a consistent and safe technique (i.e., hyper extending the lumbar spine or bouncing the bar off the chest was not permitted). Three to five subsequent lifts were then made to determine the 1RM with 5 minutes rest between lifts. To ensure that all subjects were moving at approximately the same velocity for each repetition, each set was timed using a metronome and consisted of a one second eccentric phase followed by a one second concentric phase. The rest interval between sets was timed using a hand-held stopwatch. After the determination of the 1RM on the bench press, the 75% of 1RM load selected represented the load used in the testing sessions.

During the next three testing sessions, four sets of the bench press were performed to voluntary exhaustion at 75% of 1RM and one of the rest periods were used in each session in a counterbalance procedure (a 3 minute rest, 1:3 W/R ratio and a Post-HR of 60% age-predicted maximum rest period). Immediately following each set, the subjects sat down on chairs and remained passive during the recovery phase. Heart rates were monitored with a heart rate telemetry unit (Polar Instrument) beginning with the completion of the bench press and continuing throughout Post-HR recovery. Time was measured with a digital stopwatch for the 3 minute and the 1:3 W/R recovery periods. To calculate recovery time for the 1:3 W/R ratio, the duration of the previous work interval was multiplied by three (rest interval).

Statistical analysis

Data are expressed as Mean ± SD. Statistical evaluation was performed with SPSS 12.0 for windows and one-way ANOVA with repeated measures that were used to compare repetitions per set to exhaustion among three recover conditions. Multiple comparisons with confidence interval adjustment by the Least Significant Difference (LSD) method were used as post hoc when necessary. The significance level was set at $p<0.05$.

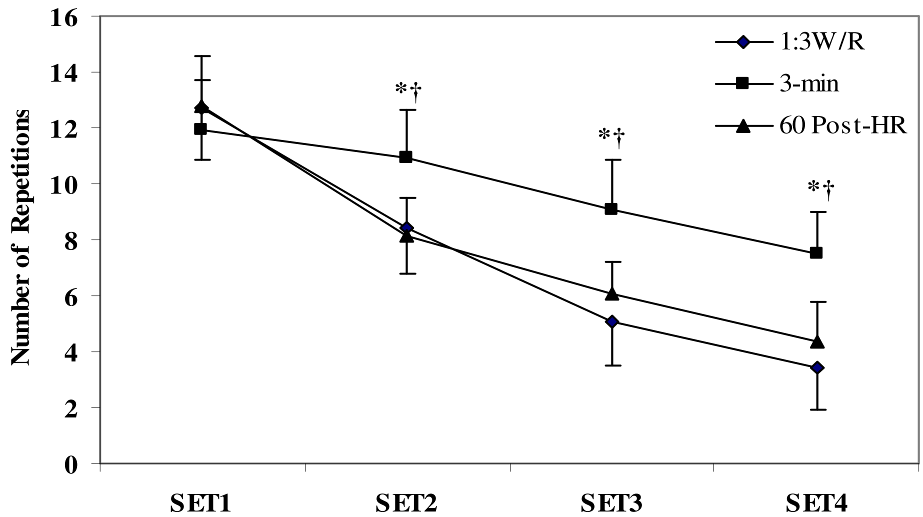
RESULTS

The repetitions to exhaustion for each set under the three recovery conditions are shown in Table 1. Significant differences were observed among the rest conditions ($p<0.05$). The repetitions to exhaustion from set two to set four were significantly higher in a 3 minute rest condition than 1:3 W/R ratio and a Post-HR of 60% age-predicted maximum rest condition ($p<0.05$, see Table 1, Figure 1) and there was no significant difference between the Post-HR and 1:3 W/R ratio conditions. Within each condition the number of repetitions to exhaustion decreased significantly for each set (p≤ 0.01).

TABLE 1: **MEAN ± SD VALUES FOR REPETITIONS COMPLETED**

Rest conditions	Set 1	Set 2	Set 3	Set 4	D	Total
60% Post-HR	12.8±1.74	8.8±1.40†	6.06±1.16†	4.33±1.49†	8.46±1.88†	31.33±4.63†
1:3 W/R	12.73±1.86	8.40±1.63†	5.60±1.54†	3.46±1.50†	9.26±1.43†	30.26±6.02†
3-min	11.93±1.79	10.93±1.70	9.06±1.83	7.53±1.45	4.40±2.19	39.46±5.57

(D: difference between set 1 and set 4; Total: repetitions completed in four sets)
† Significant difference with a 3 minute rest condition (p < 0.05).



† Significant difference with a 60% Post-HR rest condition (p<0.05).
* Significant difference with a 1:3 W/R ration rest condition (p<0.05).

FIGURE 1: **BENCH PRESS MEAN REPETITIONS PER SET IN A 3 MINUTE REST, 1:3 W/R RATIO AND A POST-HR OF 60% AGE-PREDICTED MAXIMUM REST PERIOD PROTOCOLS**

DISCUSSION

The purpose of this study was to investigate the effects of different rest intervals between sets on the training volume during multiple bench press bouts. The results demonstrated that the repetitions to exhaustion from set two to set four were significantly higher in a 3 minute rest condition than in a 1:3 W/R ratio and in a Post-HR of 60% age-predicted maximum rest condition and there was no significant differences between the 60% Post-HR and 1:3 W/R ration conditions. These results are not consistent to a study carried out by Larson and Potteiger (1997) that compared resistance training workout in four sets of squats with 85% of 10RM to either a 3 minute rest, 1:3 W/R ratio and a 60% Post-HR. They reported that the three different rest conditions were equally effective methods of recovery during the four sets of parallel squats to exhaustion. The differences in the results may be accounted for by the differences in the training status of the subjects, the resistance used and the muscles being trained (bench press versus squat).

The results of the current study are supported by Richmond and Godard's (2004), 2 set×75% 1RM with 1, 3 and 5 minutes rest, Todd's *et al.* (2001), 3 set×60% 1RM and 90% 1RM with 1, 2, 3, 4 and 5 minutes rest, Rahimi's (2005), 4 set×85% 1RM with 1, 2 and 5 minutes rest, Willardson and Burkett's (2005), 4 set× 8RM with 1, 2 and 5 minutes rest and Mirzaei's *et al.* (2008), 4 set × 60 & 90% of 1RM with 150 and 240 seconds rest intervals between sets. The results demonstrated that when training with sub maximal loads between 50 and 90% of 1RM, long rest periods of 3 to 5 minutes between sets allowed for more total repetitions to be completed during a workout. Also, results of the current study were different from those demonstrated by Kraemer *et al.* (1997) who found that when subjects rested for 3 minutes between sets, they were able to complete all 10 repetitions over three sets of the bench press with a 10RM load. In the current study, the subjects failed to complete maximum repetitions over four sets of the bench press with 75% of a 1RM load, even when resting 3 minutes between sets, the repetitions decreases from set one to set four. These differences in results may be accounted for by differences in the training status of subjects, training loads and different recovery periods.

When lifting a sub maximal amount of resistance, the slow and fast-twitch muscle fibres are recruited, but at first the slow-twitch muscle fibres exert force and when the slow-twitch muscle fibres become progressively fatigued, the fast-twitch muscle fibres continue to produce sufficient force. Finally, when all available muscle fibres are fatigued and cannot produce sufficient force, the set is ended (Zatsiorsky, 1995). When considering the rest intervals between sets, slow twitch muscle fibres would require shorter recovery due to their oxidative characteristics, whereas fast twitch muscle fibres would require longer recovery due to their glycolytic characteristics (Weiss, 1991).

Because fast-twitch muscle fibres rely heavily on anaerobic glycolysis for energy production, these fibres 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 (Jones *et al*., 1986; Taylor *et al*., 1990). However, Robergs *et al.* (2004) demonstrated that there is no biochemical support for lactate production causing acidosis. Lactate production rather retards/delay acidosis.

Similarly, there is a wealth of research evidence to show that acidosis is caused by reactions other than lactate production (Kowalchuk, 1988; Corey, 2003). Every time ATP is broken down to ADP and Pi, a proton is released. When the ATP demand of muscle contraction is met by mitochondrial respiration, there is no proton accumulation in the cell, as protons are used by the mitochondria for oxidative phosphorylation and to maintain the proton gradient in the intermembranous space. It is only when the exercise intensity increases beyond steady state that there is a need for greater reliance on ATP regeneration from glycolysis and the phosphagen system. The ATP supplied by these non-mitochondrial sources is eventually used to fuel muscle contraction increases, proton release and causes the acidosis of intense exercise. Lactate production increases under these cellular conditions to prevent pyruvate accumulation and supply the NAD^+ needed for phase two of glycolysis (Robergs *et al.,* 2004).

It is important to note that lactate production acts as both a buffering system, by consuming H^+ and as a proton remover by transporting H^+ across the sarcolemma to protect the cell against metabolic acidosis. The cause of metabolic acidosis is not merely proton release, but an imbalance between the rate of proton release and the rate of proton buffering and removal. As previously shown, proton release occurs from glycolysis (an accumulation of $NAD+H^+$ produced by the Glyceraldehyde 3-phosphatdehydrogenas reaction) and ATP hydrolysis. However, there is not an immediate decrease in cellular pH due to the capacity and multiple components of cell proton buffering and removal. The intracellular buffering system, which includes amino acids, proteins, Pi, $HCO3^-$, creatine phosphate (CrP) hydrolysis and lactate production, binds or consumes H^+ to protect the cell against intracellular proton accumulation. Protons are also removed from the cytosol via mitochondrial transport, sarcolemmal transport (lactate$^-$/H^+symporters, Na^+/ H^+ exchangers) and a bicarbonate dependent exchanger ($HCO3^-$/Cl^-). Such membrane exchange systems are crucial for the influence of the strong ion difference approach at understanding acid-base regulation during metabolic acidosis (Kowalchuk, 1988; Corey, 2003). However, when the rate of H^+ production exceeds the rate of the capacity to buffer or remove protons from skeletal muscle, or when there is not enough time to buffer or remove H^+ production, metabolic acidosis ensues and results in muscle fatigue.

Short rest intervals of one minute or less have been shown to significantly increase lactic acid levels during heavy resistance exercise (Kraemer *et al.,* 1987). The time needed for lactic acid clearance following high-intensity exercise has been shown to be four to10 minutes (Jones *et al*., 1986). Although lactate production and pH was not measured in the current study the data representing the 3 minute rest condition shows that it is likely enough time to uptake H^+ and delay fatigue, which allowed subjects to complete a higher volume of training, versus the 60% Post-HR and 1:3 W/R ratio conditions.

There are limitations in this study that warrant discussion. First, the training volume decreased from set two to set four during three rest conditions. This may have been due to H^+ production, which exceeds the rate of capacity to buffer or remove the deficiency in the intercellular buffering system. Therefore, it is recommended that future studies evaluate H^+ production, the rate of the capacity to buffer or remove H^+ and the intercellular buffering system in the muscles during the performance of RT with different rest intervals between sets. Secondly, the results related to upper body exercise (bench press) had different response to the protocols. Therefore, it is recommended that future studies evaluate the effects of the 3 minute, 60% Post-HR and 1:3 W/R ratio rest conditions on the sustainability of repetitions in different muscle groups of male and female athletes.

PRACTICAL APPLICATIONS

Bench press is a common exercise performed during workouts designed for the upper body. The results of the present investigation can be applied to bench press workouts with athletes who train in order to gain muscle hypertrophy in the upper body. Bench press repetitions sustainability during four sets with 75% of 1RM was greater in fixed 3 minute rest periods compared to 60 Post-HR and 1:3 W/R ratio conditions. It should be noted that an optimum rest period between sets depends on training goals, type of exercise, training load, number of repetitions per set and other factors. Therefore, the manipulation of these variables must be done correctly so that training goals could be attained.

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