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Original research

Acute neuromuscular and fatigue responses to the rest-pause method

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Abstract

Objectives: To compare muscle recruitment, maximal force, and rate of force development changes following different resistance exercise protocols with a constant volume-load.
Design: Within-subjects randomized crossover trial.
Methods: Fourteen ($n = 14$) resistance trained male participants completed three different resistance exercise protocols involving 20 squat repetitions, prescribed at 80% of 1-repetition-maximum. Protocol A consisted of 5 sets of 4 repetitions with 3 min inter-set rest intervals, protocol B was 5 sets of 4 repetitions with 20 s inter-set rest intervals, and the rest-pause method was an initial set to failure with subsequent sets performed with a 20 s inter-set rest interval. Maximal squat isometric force output and rate of force development (RFD) were measured before, immediately upon completion (IP), and 5 min (5P) following each protocol. Muscle activity from 6 different thigh and hip muscles was measured with surface electromyography (EMG) at each time point, and during every squat repetition.
Results: Participants completed the rest-pause method in 2.1 ± 0.4 sets, with a total protocol duration of 103 s compared to 140 s and 780 s for protocols B and A, respectively. All protocols elicited similar decreases ($p < 0.05$) in maximal force and RFD at IP, with full recovery at 5P. Increased motor unit recruitment was observed during the rest-pause method compared to both protocols A and B for all muscles measured ($p < 0.05$).
Conclusions: As a result of the increased EMG during exercise and no greater post-exercise fatigue, it was concluded that the rest-pause method may be an efficacious training method for resistance-trained individuals.

Keywords: Rest-pause; Training volume; Training intensity; Electromyography; Fatigue

1. Introduction

In the construction of resistance training programs a number of variables may be manipulated in attempts to achieve specific goals. One particular resistance exercise program used in the recreational training environment (particularly bodybuilding) that manipulates the use of repetitions to failure and very short inter-set rest intervals is the rest-pause method. The rest-pause method typically involves prescription of a fixed volume-load (e.g., 20-repetitions of the squat exercise, or 30-repetitions of an arm exercise) where after an initial failure set (typically 10–12 repetitions) subsequent failure sets are performed as required using short (e.g., 20 s) inter-set rest intervals. In previous research, the rest-pause method has been described as a prolonged pause between individual repetitions within a given working set.[1] A prolonged pause between individual repetitions is not a commonly observed technique in either the resistance training research or clinical practice. There is no research investigating the rest-pause method of current interest (i.e. the performance of a fixed volume-load constituted of repeated failure sets with very short rest periods).

Muscular failure and the associated metabolic and hormonal responses are considered to provide a significant stimulus for strength and neuromuscular adaptations with training.[2,3] It is thought that the extent of muscular fatigue elicited by performing repetitions to failure determines the efficacy of the training stimulus.[4] A more fatiguing resistance exercise bout is often attained by increasing the total number of failure sets, thereby increasing the total volume of exercise performed.[5] The rest-pause method is unique in that

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the prescribed volume-load is collapsed into as short a time period as possible. It is reasonable to believe the rest-pause method will be more fatiguing than protocols composed of the same volume-load but not involving repetitions to failure.

Manipulation of inter-set rest interval has been shown to significantly influence acute hormonal and metabolic responses.[6] The length of rest interval dictates the recovery that occurs between sets. At 20 s, approximately 50% of adenosine triphosphate and creatine phosphate are restored, whereas at 3 min approximately 85% are restored.[7] The American College of Sports Medicine recommends resistance trained individuals use a rest interval length of between 2 and 3 min for strength and hypertrophy.[8] However, there is equivocal evidence for whether or not short or longer rest intervals are more effective for strength and hypertrophy gains.[9,10] Typically, relative training intensity is reduced from set to set in order to allow matched volume,[11–13] forced or assisted repetitions are performed in order to ensure prescribed repetitions are achieved,[14] or low relative training intensities (<60% of a 1-RM) are used to ensure that the short duration rest periods do not cause repetition failure and/or that total volume is matched.[15,16] The rest-pause method is unique in that there is no reduction in the training intensity, or assistance provided, in the attainment of prescribed volume.

The importance of the fatiguing stimulus associated with an acute resistance training bout is associated with two physiological mechanisms for adaptation. First, it is thought that high-intensity fatiguing protocols lead to greater motor unit recruitment compared to non-fatiguing protocols.[4] This is associated with Hennemann's size principle, which describes the orderly recruitment of progressively larger motor units (and the corresponding muscle fibers) in response to increases in the intensity of the stimulus.[17] Increased motor unit recruitment is thought to be crucial for facilitating maximal strength development,[6] especially in more advanced resistance-trained individuals.[18] However, the measurement of motor unit recruitment is not often recorded during the working repetitions. Therefore insight into how different resistance exercise protocols influence recruitment is unclear. Second, more fatiguing protocols (typically associated with higher volumes of exercise) are associated with greater muscle protein signaling responses,[19,20] which may facilitate greater protein accretion in muscle over time.

The purpose of this study was to measure the acute fatigue and motor unit recruitment changes during and after 20 squat repetitions performed using the rest-pause method, and similar volume-loads performed in a non-failure manner using short (20 s) and long (3 min) inter-set rest intervals. The hypotheses of this study were that the rest-pause method would facilitate greater muscular fatigue and increased motor unit recruitment.

2. Methods

Fourteen healthy, resistance-trained males volunteered to participate in this study after providing informed written consent. Participant characteristics are as follows (mean ± SE): age, 25.0 ± 1.7 years; height, 1.80 ± 0.01 m; weight, 85.8 ± 2.3 kg; training experience, 5.5 ± 0.8 years; squat 1-RM, 179.3 ± 8.1 kg. The University Human Participants Ethics Committee approved all procedures used in this investigation. All participants had been performing regular resistance exercise at least 3 days per week for the previous 2 years. Participants reported that they were not taking performance enhancing stimulants at the time of testing and had no musculoskeletal injuries or disorders. Participants were instructed to refrain from any resistance or anaerobic exercise and were required to maintain normal dietary habits in the 24 h preceding the testing sessions. Participants were required to present to testing in a 2-h postprandial state.

Each experimental protocol involved performance of 20 squat repetitions, at an intensity of 80% of 1-RM. All squat repetitions were performed to a depth of 90° of knee flexion. This exercise model (type and intensity) has recently been used to discriminate strength gains between different volumes of prescription after as little as 3-weeks training.[5] After an initial familiarization session in which participant's squat 1-RM was measured and they were familiarized with the testing protocols, participants were randomly assigned to perform each of the three experimental protocols. Each testing session was separated by 5–7 days, and testing was always performed at the same time of day. The three experimental protocols were: protocol (A) 5 sets × 4 repetitions, with 3 min inter-set rest intervals; protocol (B) 5 sets × 4 repetitions, with 20 s inter-set rest intervals; and the rest-pause method in which repetitions were performed to failure followed by a 20 s rest interval. Subsequent sets were performed until 20 repetitions were accrued. Tow-second eccentric and one-second concentric movement phases were used for each repetition to ensure comparable time under tension between protocols. No participant failed during a squat repetition during protocol A or B.

To investigate fatigue changes, squat force output and rate of force development (RFD) were recorded via maximal voluntary isometric squat contractions (MVIC) before (PRE), immediately post (IP), and 5 min post-exercise (5P) each protocol. Electromyography (EMG) data were collected from selected muscles during the MVICs and throughout the protocols in order to examine motor unit recruitment. After careful skin preparation using disposable razors to remove excess hair, fine sandpaper and isopropyl alcohol swabs to reduce skin electrode impedance to below 5 kΩ, pairs of blue dot silver/silver-chloride electrodes (Maxensor, MediMax Global, Australia) with a 1.4 cm diameter and 2 cm center to center distance were applied to the following muscles: erector spinae (ES), gluteus maximus (GM), biceps femoris (BF), rectus femoris (RF), vastus lateralis (VL) and vastus medialis (VM).[21] Each pair of electrodes was placed according to previous recommendations for ideal anatomical placement.[21] This included measurement of relevant bony landmarks and other prominences to maintain consistency of placement among participants. Electromyo-