Available online at www.sciencedirect.com

ScienceDirect

Journal of Exercise Science & Fitness 13 (2015) 104–110

www.elsevier.com/locate/jesf

Original article

Maximal repetition performance, rating of perceived exertion, and muscle fatigue during paired set training performed with different rest intervals

Marianna de Freitas Maia [a], Gabriel Andrade Paz [a,*], Humberto Miranda [a], Vicente Lima [b], Claudio Melibeu Bentes [c], Jefferson da Silva Novaes [a], Patrícia dos Santos Vigário [d], Jeffrey Michael Willardson [e]

[a] *Federal University of Rio de Janeiro, Rio de Janeiro, RJ, Brazil*
[b] *Biodynamic Laboratory of Exercise, Health and Performance, Castelo Branco University, Rio de Janeiro, RJ, Brazil*
[c] *Oswaldo Cruz Foundation–Fernandes Figueira Institute, Graduate Program in Applied Clinical Research On Women's Health, Rio de Janeiro, RJ, Brazil*
[d] *Rehabilitation Sciences Master's Program; Augusto Motta University Center (UNISUAM), Rio de Janeiro, Brazil*
[e] *Kinesiology and Sports Studies Department, Eastern Illinois University, Charleston, IL, USA*

Received 18 October 2014; revised 7 August 2015; accepted 11 August 2015
Available online 3 November 2015

Abstract

Background/Objective: The purpose of this study was to examine rest interval length between agonist–antagonist paired set training (PS) on maximal repetition performance, rating of perceived exertion, and neuromuscular fatigue.
Methods: Fourteen trained men (age, 24.2 ± 1.1 years; height, 175 ± 5.5 cm; body mass, 76.6 ± 7.0 kg) performed two experimental protocols in random order with 2 minutes (P2) or 4 minutes (P4) between agonist–antagonist PS, which consisted of a bench press set followed immediately by a seated row set with 8-repetition maximum loads, respectively. A total of three PS were performed for each rest interval protocol. The total repetitions performed and the rating of perceived exertion were recorded for each exercise set within each rest interval protocol. Electromyography signals were recorded for the posterior deltoid, biceps brachii, pectoralis major, and triceps brachii muscles during the SR exercise. The electromyography signals were then used to calculate a fatigue index for each rest interval protocol.
Results: No significant differences were identified in the total repetitions completed between rest interval protocols for the bench press (P2 = 22.9 ± 1.3 and P4 = 22.6 ± 0.8) and seated row (P2 = 25.4 ± 1.7 and P4 = 25.1 ± 1.3). However, a significantly higher fatigue index was found for all muscles under the P2 versus the P4 protocol.
Conclusion: When performing agonist–antagonist PS, prescribing a shorter rest interval between PS may induce higher levels of fatigue, albeit with similar total repetitions versus a longer rest interval.

Keywords: Electromyography; Exercise; Recovery; Resistance training

Introduction

Several methodological variables are manipulated during the prescription of resistance training programs, such as the volume, exercise order, load intensity, training frequency, and the rest interval between sets.[1] Researchers have found that different rest intervals between sets can affect repetition performance and training volume (load × sets × repetitions).[2,3] Miranda et al[4] observed a significant reduction in the total number of repetitions completed over three consecutive sets with a 1-minute versus a 3-minute rest interval between sets for a total body resistance exercise circuit in trained men.

* Corresponding author. Federal University of Rio de Janeiro, Avenida Pau Brasil 540, Ilha do Fundão, Cep: 21941-590 Rio de Janeiro, RJ, Brazil.
E-mail address: gabriel.andrade.paz@gmail.com (G.A. Paz).

http://dx.doi.org/10.1016/j.jesf.2015.08.002

A higher training volume is directly related to long-term strength adaptations.[5] Several training methods are adopted by coaches and practitioners in order to increase training volume, but in a time-efficient manner.[6] One such method is to perform agonist–antagonist paired sets (PS), which are characterized by complementary exercises performed for agonist and antagonist muscles, with or without an intervening rest interval (e.g., superset).[7] This method has been shown to increase training volume and reduce training session duration in a time-efficient manner (training volume/time), when compared to the traditional training method, in which rest intervals are adopted between all sets of each exercise.[7,8] Decreases in training time are realized as the agonist muscles are resting while the antagonist muscles are working.[7] That is, the time efficiency associated with PS training is based on the theory that exercise sets for the antagonist muscles (e.g., antagonist preloading) performed between exercise sets for the agonist muscles may be done so with relatively short rest intervals, without compromising the adaptive stimulus,[7–11] and may also increase agonist muscle strength performance in an acute manner.[12–15]

Agonist–antagonist training methods differ from traditionally structured training in which all sets of the same exercise are typically performed in succession, prior to the execution of all sets for the next exercise and so on.[16] Robbins et al[10] found no significant differences in the total repetitions completed and muscle activation for an agonist–antagonist PS protocol that alternated sets of bench pull and bench press (BP), compared to a traditional approach; adopting 4-minute rest intervals between exercises and sets, respectively. A subsequent investigation by Robbins et al[7] involving similar exercises (e.g., bench pull and BP) found that over three sets, bench pull and BP (e.g., with 4 repetition maximum loads) volume load decreased significantly from Set 1 to Set 2 and from Set 2 to Set 3 under both the PS (e.g., 4-minute rest between like sets) and traditional method (e.g., 2-minute rest between like sets) protocols. However, bench pull and BP volume load per set were significantly less for the traditional approach versus the PS protocol over all sets, with the exception of the first set (bench pull Set 1). Recently, Maia et al[15] found significant increases in repetition performance and muscle activity of the knee extensors for an agonist–antagonist PS protocol using 10-repetition maximum (RM) loads for the lying leg curl and leg extension exercises with or without a shorter rest interval (e.g., no rest, 30 seconds, or 1 minute) versus a longer rest interval (e.g., 3 minutes or 5 minutes) between paired exercises. This suggests that the rest intervals between PS may play a key role in the antagonist preloading effects.[14,17]

To date, this is the only study that we are aware of to investigate the effect of different rest intervals between agonist–antagonist PS on repetition performance and neuromuscular fatigue. Previous studies have found conflicting results with regard to the agonist–antagonist training methods on strength performance and muscle activation, considering that different rest intervals were adopted between sets and exercises.[12,13,18] To date, only one study has investigated the effect of different rest intervals between sets and exercises during an agonist–antagonist training protocol.[15]

Thus, there is a need for further investigation examining different rest intervals in an agonist–antagonist PS type protocol with outcomes such as repetition performance and neuromuscular fatigue. The purpose of the present study was to examine how the length of the rest interval (2 minutes vs. 4 minutes) between agonist–antagonist PS affects maximal repetition performance, rating of perceived exertion (RPE), and neuromuscular fatigue.

Methods

Participants

Fourteen recreationally trained (age, 24.2 ± 1.1 years; height, 175 ± 5.5 cm; body mass, 76.6 ± 7.0 kg) men participated in this study. All were recruited from a local university using convenience sampling. All participants had previous resistance training experience (3.5 ± 1.2 years), with a mean frequency of four 60-minute sessions/wk, using 1- to 2-minute rest intervals between sets and exercises. All were assessed via the Physical Activity readiness Questionnaire[16] and signed an informed consent in accordance with the Declaration of Helsinki. The current study was approved by the Institutional Human Experimental Committee at the Federal University of Rio de Janeiro, Rio de Janeiro, RJ, Brazil. All participants were instructed to avoid any upper-body exercise in the 48 hours prior to each session.

Eight-RM testing

The 8-RM tests were conducted over 2 nonconsecutive days with at least 48 hours between sessions, in the week preceding the experiment.[4] The 8-RM tests and training sessions utilized resistance machines for the BP and wide-grip seated row (SR) exercises (Life Fitness, IL, Franklin Park, IL, USA). Repetitions were conducted at a constant velocity of 4 seconds per repetition (2 second concentric and 2 second eccentric) and controlled by a metronome (Metronome Plus 2.0; M&M System, Lich, Germany).

Experimental protocols

During the third and fourth visits, participants were assigned to two protocols conducted in random order (Figure 1). To assess the acute effects of different rest intervals between PS, the only difference between experimental protocols was resting 2 minutes (P2) or 4 minutes (P4) between agonist–antagonist PS, respectively. The agonist–antagonist PS consisted of performing a BP set to repetition failure followed immediately by a SR set to repetition failure with 8-RM loads, respectively. A total of three PS were performed for each rest interval protocol. Before each protocol, participants performed a warm-up set of 15 BP repetitions using 50% of