

ACUTE EFFECTS OF MOVEMENT VELOCITY ON BLOOD LACTATE AND GROWTH HORMONE RESPONSES AFTER ECCENTRIC BENCH PRESS EXERCISE IN RESISTANCE-TRAINED MEN

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ABSTRACT: This study aimed to compare the effects of different velocities of eccentric muscle actions on acute blood lactate and serum growth hormone (GH) concentrations following free weight bench press exercises performed by resistance-trained men. Sixteen healthy men were divided into two groups: slow eccentric velocity (SEV; $n = 8$) and fast eccentric velocity (FEV; $n = 8$). Both groups performed four sets of eight eccentric repetitions at an intensity of 70% of their one repetition maximum eccentric (1RM_{ecc}) test, with 2-minute rest intervals between sets. The eccentric velocity was controlled to 3 seconds per range of motion for SEV and 0.5 seconds for the FEV group. There was a significant difference ($P < 0.001$) in the kinetics of blood lactate removal (at 3, 6, 9, 15, and 20 min) and higher mean values for peak blood lactate ($P = 0.001$) for the SEV group (9.1 ± 0.5 mM) compared to the FEV group (6.1 ± 0.4 mM). Additionally, serum GH concentrations were significantly higher ($P < 0.001$) at 15 minutes after bench press exercise in the SEV group (1.7 ± 0.6 ng·mL⁻¹) relative to the FEV group (0.1 ± 0.0 ng·mL⁻¹). In conclusion, the velocity of eccentric muscle action influences acute responses following bench press exercises performed by resistance-trained men using a slow velocity resulting in a greater metabolic stress and hormone response.

KEY WORDS: eccentric velocity, lactate, growth hormone, bench press exercise

INTRODUCTION

Concentric and eccentric muscle actions at the same constant load have been the common method of choice in resistance training programs and for the majority of studies analyzing acute hormonal responses to resistance training protocols [1,2,3]. Therefore, manipulation of variables influencing the acute growth hormone (GH) and blood lactate response include the rest intervals between sets [4, 5,6], volume lifted [7,8,9], intensity [10,11] and the velocity of movements [12].

Another variable of growing interest is the type of muscle actions since there are distinct characteristics for each muscle action. Durand et al. [13] compared the acute hormonal response between concentric and eccentric muscle actions after a resistance exercise bout at the same absolute load (80% of 1RM). They reported that a concentric resistance exercise bout elevated GH concentrations much more than an eccentric resistance exercise bout.

However, eccentric muscle actions have been shown to have a lower metabolic demand, lower motor unit recruitment, and a greater capacity for strength production compared with concentric

muscle actions [14,15,16]. Thus, the relative intensity of the load is reduced in eccentric muscle actions when using a constant load exercise.

The intensity prescription in free weight exercises is often set by the one repetition maximum (1RM) test. The 1RM method involves application of the maximum load for a single muscular contraction (eccentric and concentric) [17]. Thus, it is common practice in an eccentric exercise bout to increase the intensity (~100% to 130% of the 1RM concentric test) to increase the load and the acute stimuli for eccentric muscle actions [18,19]. In this context, when the relative load between eccentric (120% 1RM) and concentric (65% 1RM) contractions is equalized, there are similar GH responses [16].

Hollander et al. [15] evaluated the maximal muscle strength using a one repetition maximum eccentric (1RM_{ecc}) and 1RM concentric test. They reported a 20% to 60% greater strength capacity for eccentric muscle action compared to concentric muscle action, depending on the exercise evaluated in resistance-trained men. Therefore, it is important to individualize eccentric muscle action when

designing resistance eccentric exercise bouts with the aim of determining the eccentric exercise intensity more exactly and better investigating the influence of other variables.

Therefore, the purpose of this investigation was to evaluate the effects of different velocities of eccentric muscle action prescribed by a 1RM_{ecc} test on acute blood lactate and serum GH concentrations following free weight bench press exercises performed by resistance-trained men. Previous studies have documented that slow muscular actions (eccentric and concentric) can promote greater acute metabolic and hormonal responses [12,21]. Therefore, our hypothesis was that a slow eccentric velocity could induce greater concentrations of blood lactate and serum GH compared to a fast eccentric velocity.

MATERIALS AND METHODS

Subjects. Sixteen healthy men who were experienced in resistance training participated in the study and were divided into two homogeneous groups ($n = 8$ for each group) by their maximum eccentric strength: a slow eccentric velocity (SEV) group and a fast eccentric velocity (FEV) group.

Inclusion criteria for the subjects included: (a) at least two years of continuous recreational resistance training experience; (b) engagement in resistance exercise at least four times per week; (c) familiar with the exercise used in the experiment; and (d) between 18 and 30 years of age. Exclusion criteria were: (a) no previous injuries that might interfere with the study; (b) no use of nutritional supplements containing creatine; and (c) not taking medications or anabolic steroids.

All the participants completed a health questionnaire and signed an informed consent document after being informed about the research and experimental protocol. This study was approved by the local research ethics committee (Protocol no. 21/11) and is in accordance with the legal requirements of the Declaration of Helsinki.

Procedures

The eccentric exercise is known as an effective training method to increase strength and muscle hypertrophy [22]. So, this study was designed to compare the effects of different eccentric muscle actions on the acute lactate and GH response of resistance-trained men. We chose the bench press for the experimental protocol, because this is a common exercise in resistance training routines.

In the week prior to the experimental protocol each subject visited the laboratory on two separate occasions before the main session with each visit being separated by at least 48 hours. On the first visit, each subject was familiarized with the 1RM_{ecc} test and the velocity of execution in the bench press free weight exercise. On the second visit, each subject performed a 1RM_{ecc} test to set the eccentric exercise intensity for the experimental protocol.

The subjects were divided into two experimental groups (SEV and FEV groups) and after five days, the experimental protocol was performed. The serum GH concentration was evaluated: before exercise

(pre-values), at 0 minutes (immediately after), and 15 minutes after exercise. Blood lactate samples were evaluated: before exercise and at 0, 3, 6, 9, 15, 20, and 30 minutes after exercise. The subjects were instructed to drink water (ad libitum) prior to the experimental protocol to prevent dehydration. All subjects were verbally encouraged to make maximal efforts during the experimental protocol and tests. All experimental analyses were performed between 7:00 and 9:00 a.m. Figure 1 illustrates the experimental design of the study.

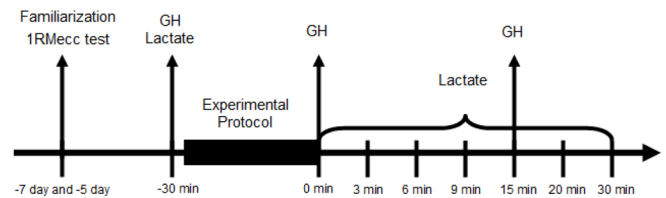


FIG. 1. SCHEMATIC DIAGRAM OF THE EXPERIMENTAL DESIGN OF THE STUDY

Eccentric Muscle Strength – 1RM_{ecc} Test

The 1RM_{ecc} bench press was assessed according to the protocol by Hollander et al. [15]. Briefly, each participant performed 2–3 sets of 5–10 repetitions with 40–60% of their 1RM before the 1RM_{ecc} test. After a 3-minute rest interval, a single maximum eccentric repetition was performed in which the load was increased by 10% in successive attempts until the participant was unable to complete an attempt with an appropriate technique. The 1RM_{ecc} was performed at a cadence of 3 seconds for the entire range of motion with a metronome control set at 60 beats per minute. An observer watched the range of eccentric motion to ensure that the control of the movement pace was 3 seconds. The test was performed with a maximum of four attempts with rest intervals of 3–5 minutes between each attempt.

Experimental Protocol

The experimental protocol consisted of only the eccentric phase of movement in the bench press exercise (free weight), which was performed with four sets of eight repetitions at 70% of 1RM_{ecc} and 2-minute rest intervals between sets. The movement began with the elbows extended, and after a start signal, the participants in the SEV and FEV groups lowered the bar to the chest with durations of 3 and 0.5 seconds, respectively. The bar was raised to the initial position of the eccentric exercise in 2 seconds with the aid of two assistants with the subject not using any muscle strength in the concentric phase. The velocity of execution was based on other studies that investigated the influence of eccentric velocity on isokinetic dynamometers (a time ratio of 6:1, similar to Chapman et al. [23]). A metronome, set at 60 and 120 beats per minute for the SEV and FEV groups, respectively, was used to control the velocity of movement; the cadence of movement was also directed using simultaneous verbal instruction. In accordance with the data obtained from a pilot study of individuals with the same characteristics as the study

participants, an intensity of 70% of 1RMecc was chosen in the present study to ensure that both groups (SEV and FEV) completed a similar volume (4 sets of 8 repetitions) while varying the eccentric velocity.

Growth Hormone (GH) Analysis

After 24 h without physical exercise and an overnight fast, the subjects came to the laboratory and rested for 30 minutes before the first blood collection. Blood samples were obtained by venipuncture with dry vacuum (Becton Dickinson®, Juiz de Fora, Brazil). The samples were allowed to clot at room temperature for 30 minutes. The serum was separated by centrifugation at 2000 rpm for 20 minutes at 4°C and was stored at -70°C for subsequent analysis. The serum GH concentration was measured using a commercially available chemiluminescent enzyme immunoassay kit (Access hGH kit; Beckman Coulter®, USA) on automated equipment Unicel DXL 800 (Beckman Coulter®, USA). The normal reference range value for serum GH concentration using this method is 0.02–0.97 ng·mL⁻¹. The intra assay coefficient of variation was < 5%.

Blood Lactate Analysis

Blood samples (25 µl) from the fingertips were collected in heparinized capillary tubes and transferred to microtubes containing 50 µL of sodium fluoride at 1%. The lactate concentration was analyzed via an electro-enzymatic method with a lactate analyzer (YSI 2300 Stat Analyzer®; Yellow Springs Instruments, Yellow Springs, OH, USA). Lactate concentrations in blood are expressed in millimoles (mM).

Statistical Analysis

The results were analyzed by a two-way repeated measures analysis of variance (ANOVA) followed by a Bonferroni post-hoc test for comparisons of serum GH concentration and blood lactate between the two groups. An independent t-test was used to compare anthropometric and load values. A significance level of P ≤ 0.05 was chosen for all comparisons. The results are presented as mean ± standard error of the mean (SEM).

RESULTS

Anthropometric and Load Values. The descriptive characteristics of the subjects and load values are presented in Table 1. No statistically significant differences between the groups (SEV and FEV) were evident for body mass (P = 0.42), height (P = 0.28), experience

with resistance training (P = 0.54), 1RMecc test (P = 0.26), and total volume of load lifted (sets x repetitions x load) (P = 0.26). However, a significant difference was observed for age (P = 0.02).

Blood Lactate

The SEV group had a significant difference (P < 0.05) in blood lactate concentrations at 0, 3, 6, 9, 15, and 20 minutes after exercise, when compared to pre-values. However, the FEV group showed significant differences (P < 0.05) in blood lactate values only at 0, 3, and 6 minutes. The results for the kinetics of blood lactate removal revealed that the SEV group had significantly (P < 0.001) higher values for blood lactate concentrations compared to the FEV group at 3, 6, 9, 15, and 20 minutes following the eccentric exercise (Figure 2). Additionally, significant differences (P = 0.001) were found for peak blood lactate values between groups, with mean values of 9.1 ± 0.5 mM for the SEV and 6.1 ± 0.4 mM for the FEV group.

Growth Hormone (GH)

Before the experimental protocol, mean serum GH concentrations did not exceed the reference values (0.02–0.97 ng·mL⁻¹) and were in the ranges 0.02–0.56 ng·mL⁻¹ and 0.02–0.06 ng·mL⁻¹ for the SEV and FEV groups, respectively. No statistically significant (P > 0.05)

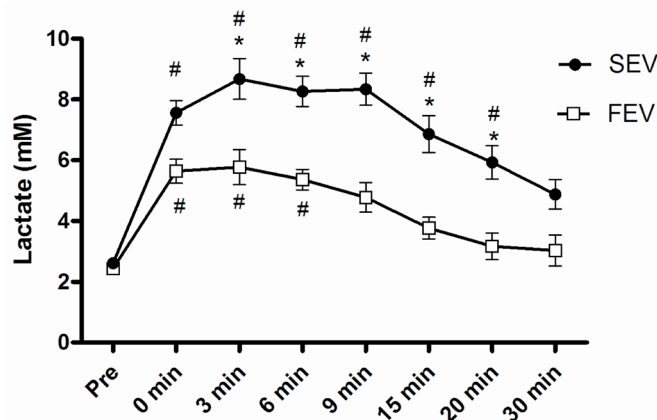


FIG. 2. BLOOD LACTATE CONCENTRATION (MM) AT TIMES: PRE-, 0 (IMMEDIATELY), 3, 6, 9, 15, 20, AND 30 MINUTES AFTER BENCH PRESS ECCENTRIC EXERCISE FOR SLOW ECCENTRIC VELOCITY (SEV) AND FAST ECCENTRIC VELOCITY (FEV) GROUPS. THE DATA ARE EXPRESSED AS MEAN ± SEM

* Significant difference (P < 0.05) between groups
Significant difference (P < 0.05) compared with pre-value (SEV and FEV group)

TABLE I. SUBJECT CHARACTERISTICS FOR BOTH EXPERIMENTAL GROUPS

Group	Age (years)	Weight (kg)	Height (cm)	Experience with resistance training (years)	1 RMecc (kg)	Total volume of load lifted (kg)
SEV (n = 8)	26.5 ± 0.6 *	76.3 ± 2.6	175.3 ± 0.8	5.6 ± 1.2	120.8 ± 6.1	2704.8 ± 137.3
FEV (n = 8)	23.6 ± 0.4	81.0 ± 4.1	176.2 ± 1.2	4.8 ± 0.86	132.2 ± 7.7	2962.4 ± 171.9

Note: Values are means ± SEM. * Significant difference between groups (P = 0.02)

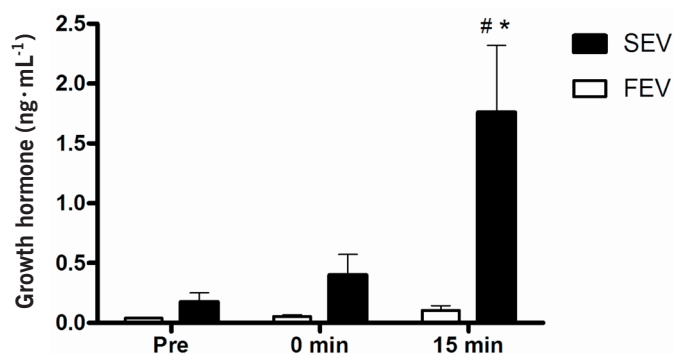


FIG. 3. SERUM GROWTH HORMONE CONCENTRATIONS (NG/ML) AT TIMES: PRE-, 0 (IMMEDIATELY), AND 15 MINUTES AFTER BENCH PRESS ECCENTRIC EXERCISE FOR SLOW ECCENTRIC VELOCITY (SEV) AND FAST ECCENTRIC VELOCITY (FEV) GROUPS. THE DATA ARE EXPRESSED AS MEAN \pm SEM

* Significant difference ($P < 0.05$) between groups

Significant difference ($P < 0.05$) compared with the pre-value

changes were observed for serum GH values before and at 0 minutes after eccentric exercise between groups. However, the acute serum GH level was significantly ($P < 0.001$) higher for the SEV group ($1.7 \pm 0.6 \text{ ng} \cdot \text{mL}^{-1}$) compared to the FEV group ($0.1 \pm 0.0 \text{ ng} \cdot \text{mL}^{-1}$) at 15 minutes after eccentric exercise (Figure 3).

DISCUSSION

This study aimed to compare the kinetics of blood lactate removal and serum GH concentration following bench press free weight exercise using slow or fast velocities of eccentric muscle action prescribed with a 1RMecc test in resistance-trained men. The main findings were as follows: the SEV group showed greater blood lactate and serum GH concentrations compared to the FEV group. These results demonstrate the influence of eccentric velocity on metabolic stress and acute hormonal responses (Figure 2 and Figure 3), thereby confirming the hypothesis of this study.

The manipulation of eccentric velocity directly affects the time the muscles remain under tension performing the exercise; consequently, this may affect acute metabolic responses. Thus, the eccentric exercise intensity in this study was individualized and the total volume of the load lifted was equalized for both groups. The only difference between the groups was the eccentric velocity, which was six times slower for the SEV group (3 seconds) compared to the FEV group (0.5 seconds). Therefore, the total time under muscle tension for the performance of the entire eccentric exercise bout (4 sets of 8 repetitions) was 96 seconds in the SEV group and 16 seconds in the FEV group.

From this point of view, the kinetics of blood lactate removal showed significant values until 20 minutes after eccentric exercise for the SEV group and until 6 minutes for the FEV group, when compared to pre-values. Additionally, peak values for blood lactate were higher in the SEV group. These data indicate that both ve-

locities increased blood lactate concentration, but with greater activation of glycolytic metabolism in the slower eccentric velocity group at the same absolute exercise intensity (70% of 1RMecc).

In this context, Goto et al. [12] observed higher blood lactate concentrations after slow concentric movement (5 seconds for concentric and 1 second for eccentric) than fast concentric movement (1 second for concentric and 5 seconds for eccentric) at the same absolute intensity (50% of 1RM). Therefore, higher blood lactate values in the SEV group were expected since the time that muscles were under tension was longer and the eccentric exercise intensity was equalized by a specific muscle eccentric test.

GH is highly responsive to resistance training and is influenced by the manipulation of resistance training variables that induce increases in blood lactate concentrations [4,5,6]. Additionally, low-intensity resistance exercise (20% of 1RM) with moderate vascular occlusion results in greater GH release than in controls (without occlusion) using the same intensity [24]. These data suggest that metabolic stress and metabolite accumulation induced by resistance exercise are associated with enhanced GH secretion after exercise.

In our study, although both groups performed the bench press eccentric exercise with the same intensity and total load volume, the exercise-induced GH release was clearly different. Consequently, the slow eccentric velocity resulted in a greater metabolic stress to perform the exercise, resulting in increased GH secretion after an eccentric exercise bout ($\sim 1700\%$ higher). Corroborating our data, Wahl et al. [25] demonstrated that bicarbonate supplementation before a high-intensity interval bout resulted in lower values of blood pH and lactate concentrations which resulted in attenuation of the GH response after exercise. Therefore, the modulator mechanisms involved in the GH response after resistance exercise could be related to glycolytic metabolism, accumulation of metabolic products, and acidosis.

The limitation in our study is that a different eccentric muscle action velocity (0.5 and 3 s) has a specific inertial component and a different force-velocity relationship. In addition, our study did not evaluate the surface electromyography (EMG) activity – information that could evaluate the motor unit activations better in both conditions (fast and slow). Previous studies in the literature demonstrated that force output is increased with fast eccentric velocity [26,27,28]. On the other hand, there are studies that did not find a difference in force output [29,30] and changes in EMG activity at different velocities of eccentric muscle actions [30].

Regarding methodological issues, most studies used isokinetic dynamometers to manipulate and control the eccentric exercise velocity [23,26,27,28,29]. Thus, a practical limitation in applying the results from research studies is the difficulty in reproducing the resistance training routines. Despite these limitations, our data provide new insights to manipulate eccentric exercise bouts with free weights.

It is not well established whether resistance exercise protocols that induce significant increases in the acute GH response will lead

to superior muscular adaptations in a chronic process [31,32,33]. However, we believe the results presented in this study will assist strength and conditioning coaches in prescribing eccentric training bouts for resistance-trained men. Muscular adaptations result from a multifactorial process involving mechanical, metabolic, and immune/inflammatory factors in addition to various hormonal responses [34]. Therefore, if the emphasis in resistance training periodization is to induce a greater acute metabolic stress and GH response, we recommend manipulating the eccentric movement velocity.

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CONCLUSIONS

In conclusion, slow velocity eccentric muscle actions influence acute responses after bench press exercise performed by resistance-trained men, resulting in a greater metabolic stress and hormone response. These results suggest that slow eccentric bench press exercise prescribed by a specific muscular strength test (1RMecc) is an effective way to induce a significantly greater GH release.

Conflict of interest: the authors of the manuscript declare no conflict of interests regarding the publication of this manuscript.

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