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Original Article

Influence of execution speed on blood lactate concentration in strength training protocol in bench press exercise

Influência da velocidade de execução na concentração de lactato sanguíneo em protocolo de treinamento de força no exercício de supino

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ABSTRACT

The aim of this study was to analyze the influence of two velocities of execution relative to blood lactate concentration in strength training exercise until the momentary concentric failure. Fifteen men (29.1 ± 5.9 years), trained, participated in the experiment. The volunteers performed three bench press sessions, with an interval of 48 hours between them. At the first session, individuals determined loads through the 10-12 RMs test. In the following two sessions, three series with 90 seconds of interval were performed, in the second session slow execution speed (cadence 3030) and later in the third session fast speed (cadence 1010). For statistical analysis, the Student-T test was used for an independent sample study and considered the value of probability (p) ≤ 0.05 statistically significant. By comparing the number of repetitions and time under tension of the two runs, all series compared to the first presented significant reductions ($p < 0.05$). The total work volume was higher with the fast speed ($p < 0.05$). The study revealed that rapid velocities (cadence 1010) present a higher concentration of blood lactate when compared to slow runs (cadence 3030). The blood lactate concentration, in maximum repetitions, is affected by the speed of execution.

Key-words: Resistance Training, Cadence, Blood Lactate.

RESUMO

Trata-se da análise da influência de duas velocidades de execução relativas à concentração de lactato sanguíneo em exercício de treinamento de força até a falha momentânea concêntrica. Participaram do experimento 15 homens (29,1 ± 5,9 anos), treinados. Os voluntários realizaram no exercício de supino máquina, três sessões, com intervalo de 48h entre elas. No primeiro encontro, os indivíduos determinaram as cargas através do teste de 10-12 RMs. Nas duas sessões seguintes realizaram-se três séries com 90 segundos de intervalo, sendo na segunda sessão velocidade de execução lenta (cadência 3030) e posteriormente, na terceira sessão velocidade rápida (cadência 1010). Para análise estatística utilizou-se o teste T-Student para um estudo de amostra independente e considerou o valor de

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probabilidade (p) ≤ 0,05 estatisticamente significativos. Comparando o número de repetições e tempo sob tensão das duas execuções, todas as séries comparadas à primeira apresentaram reduções significativas ($p < 0,05$). O volume total de trabalho apresentou-se maior com a velocidade rápida ($p < 0,05$). O estudo revelou que velocidades rápidas (cadência 1010), apresentam maior concentração de lactato sanguíneo quando comparado a execuções lentas (cadência 3030). A concentração de lactato sanguíneo, em repetições máximas, é afetada pela velocidade de execução.

Palavras-chave: Treinamento Resistido, Cadência, Lactato Sanguíneo.

Introduction

The aim of weight training, also popularly known as bodybuilding, is to improve the overall fitness level as well the aesthetics. Training results from different mechanical stimuli that seek to stimulate protein synthesis for muscle hypertrophy to occur. This objective is verified every day by coaches throughout the gym halls.

For there to be hypertrophy, it is necessary that there are neuromotor stimuli that cause an imbalance to the organism. These provide physiological reactions of metabolic magnitude, more precisely a bioenergetic stress, which can occur through the anaerobic lactic route, being one of the products of this process, the production of blood lactate. The production of this metabolite will depend on the intensity of the training. However, for responses in strength training, blood lactate is a biochemical signal for hypertrophy [1].

Considering that for the prescription of strength training, the manipulation of variables of volume and intensity is of fundamental importance. The American College of Sports Medicine [2] recognizes that the variable intensity-speed of execution directly impacts on internal physiological mechanisms. This study aimed to understand the consequences resulting from different execution speeds until the momentary concentric failure in the blood lactate accumulation.

Such interest emerged from the academic learning process developed in the bodybuilding sector; personal experiences in strength training and curiosity to further explore the theme.

It was often questioned about the difficulty of slow execution until reaching the momentary concentric failure, because the fast execution provides the same perception of effort when looking for muscle failure. Is the metabolic stress the same in front of different execution speeds?

Thus, with the development of this study, we sought to identify whether the speed to the momentary concentric failure would influence blood lactate levels, regardless of the cadence adopted.

Methods

The study consists of exploratory research, approved by Ethical Committee of *Centro de Estudos Superior Positivo*, no 2.278.668, conducted at the gym of *Centro de Estudos Superior Positivo*. The sample was composed of 15 male volunteers (29.1 ± 5.9 years), experienced in strength training, which, for the present work, is understood by subjects who have body and technical mastery for high intensity resistance training, that is, attendance and not only the practice time and weight to perform the exercises [3]. In addition to this understanding, individuals should exercise regularly for at least 8 months. The volunteers signed a consent form after learning the objective and the procedures of this study.

The exclusion criteria were subjects with injury and surgery history in the glenohumeral, scapulae, elbows and wrists joints and the usage of ergogenic drugs was prohibited, as these could influence the results. The volunteers were instructed not to perform training of upper limbs during the week of data collection so as not to interfere with the development of the work.

Standardization of exercises and instruments

To perform the research, we used the bench press machine - Chest Press from the brand Precor® - which was used for a pilot test at the University, aiming to evaluate all the selected procedures based on the literature.

For this purpose, the standardization of the test was determined as follows: first, the volunteer is seated with his feet resting on the ground and his trunk completely supported on the bench. The grip was determined when the arm and forearm were approximately 90º (assessed by a Goniometer) at the point of transition between the eccentric and concentric phases.

The concentric phase was characterized by the complete extension of the elbows, and the eccentric phase by the maximum amplitude allowed by the device. In the period of data collection, we tried to film the exercise for a better analysis of the execution.

Thus, for the control of time under muscle tension and recovery intervals, a Vollo® chronometer was used.

Regarding the collection of blood lactate, it was initially estimated that it would be performed in the 3rd and 5th minute, as a study about the time of blood lactate collection showed that during passive recovery, after maximum run of 500m, blood samples were collected from the 3rd to the 20th min. It appears that, although there was a point where the lactate peak occurs, the lactate concentrations close to this point hardly changed, demonstrating even a tendency to form a plateau [4].

Therefore, in line with what was evidenced by the author with the pilot test, it was identified that all collections had a higher concentration of lactate in the third minute and, therefore, due to financial issues, collection was defined only in the third minute in passive recovery, through the Accutrend Plus® lactimeter. Finally, to control the cadence, a metronome was used by a smartphone application.

Procedures

Initially, the participants were warmed up to prepare them for the series, an extremely important strategy in strength training to minimize future injuries.

Three sessions were held for each individual, with the second and third sessions being three sets of exercise and interval of 48 hours, aiming to ensure the physiological recovery of the volunteers [5].

In the first session, a load test of 10-12 RMs was performed, according to the guidelines of the ACSM [2], which suggests submaximal repetitions for heating. Also as indicated, a load was sought that would make possible to perform at least 10 and maximum of 12 repetitions. The volunteers had four attempts with an interval of three to five minutes.

The second session followed three sets of the bench press exercise on the determined load and standardization in the previous session. The cadence was slow, 3030, with the number "3" representing 3 seconds in the eccentric phase and 3 seconds in the concentric phase, the number "0" refers to the transition time between the phases, that in this case was without pause. Bearing in mind that the similar time between the two phases is one of the characteristics of training with lower loads [1]. The cadence was controlled by a metronome until the individual reached the momentary concentric failure. Considering that the interval of less than one minute limits the recovery of CP and ATP, as well as a drop in performance, the 90-second interval was adopted, as it is widely used for training the muscle hypertrophy [6].

Data collection was performed through the digital pulp in the pre- and post-test, in the 3rd minute at the end of the session, as previously assessed in the pilot test.

The 3rd session, it was performed similarly to the previous one, but only with a fast cadence, 1010, being 1 second of eccentric phase and 1 second of concentric phase, without pause between them.

And, as a strategy to ensure maximum physical efficiency in the sessions, along with the execution by the volunteers, the students used verbal motivation, as this encouragement is an important aspect when seeking maximum performance during exercise [7].

Data analysis

The treatment given to the collected information occurred in the perspective of the quanti-qualitative approach, as well as in line with the literature review carried out and the statistical treatment.

Initial and final analysis of the training sessions was carried out, as well as the use of the central tendency measure, more precisely the arithmetic mean, as well as the dispersion characteristics, in the case of variability measures. Therefore, the measure adopted in this study was the standard deviation.

T-Student test was utilized for statistics analysis for an independent sample study and level of significance accepted was $p \leq 0.05$.

Results

Considering the procedures described initially, it was possible to identify that regarding the load test value 10-12 RMs for the bench press exercise (Chest Press) the average was (37.3 ± 7.2 kg).

However, with regard to the maximum number of repetitions per set with the load established in the test, at the different execution speeds (shown in Table I), the number of repetitions performed was significantly higher in the first series, when compared with the second and with the third series, for both executions. But, when comparing the two forms of execution, the number of maximum repetitions per serie was significantly higher from series to series for fast execution (cadence 1010) in correlation with slow (cadence 3030).

Table I. Number of completed repetitions in the Chest Press exercise. Results expressed in average number and standard deviation

Execution	1st Serie	2nd Serie	3rd Serie
Slow	9 ± 1.7[1]	5 ± 1.3*[2]	4 ± 0.8*[3]
Fast	19 ± 2.5[1]	10 ± 2.5*[2]	6 ± 2.0*[3]

*p<0.05 compared to previous serie. [1]p<0.05 compared to respective serie. [2]p<0.05 compared to respective serie. [3]p<0.05 compared to respective serie.

Now, the time under tension of the three series on both execution speeds (Table II), there was a significant cutback in the three series of both groups. The time under tension was found significantly lower with a fast cadency when compared to slow execution serie.

Table II. Time under tension, in seconds, in the Chest Press exercise. Results expressed in average and standard deviation.

Execution	1st Serie	2nt Serie	3rd Serie
Slow	53.2 ± 10.2[1]	30.9 ± 7.2*[2]	25.3 ± 5.7*[3]
Fast	30.0 ± 3.9[1]	20.9 ± 5.2*[2]	15.5 ± 3.9*[3]

*p<0.05 compared to previous serie. [1]p<0.05 compared to respective serie. [2]p<0.05 compared to respective serie. [3]p<0.05 compared to respective serie.

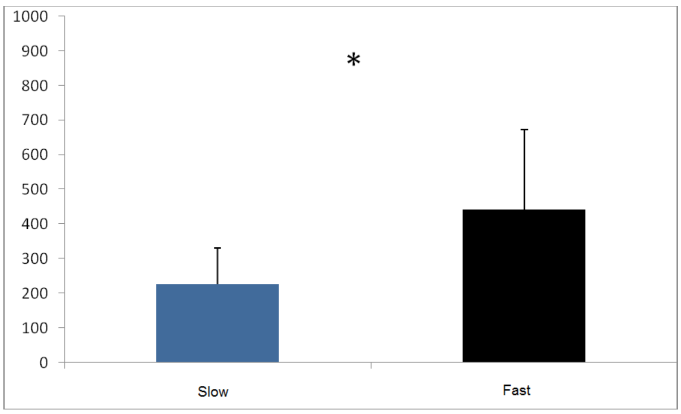
In view of the general objective of the study, the lactate concentration in the pre-test did not show any significant difference between the groups (shown in Table III). There was a statistical difference in the pre and post-test at both execution speeds. However, the fast execution group (cadence 1010) showed a significantly higher blood lactate concentration (10.6 ± 1.3 mmol/l) in the post-test when compared to the slow execution (cadence 3030) (8.7 ± 1.6 mmol/l).

Table III. Blood lactate levels on Chest Press exercise. Results expressed in average and standard deviation.

Execution	Before (mmol/L)	After (mmol/L)
Slow	2.2 ± 0.9	8.7 ± 1.6*†
Fast	1.9 ± 0.7	10.6 ± 1.3*†

* p<0.05 compared to pre-test. † p<0.05 compared to post-test among the groups.

Regarding the total work volume the analysis showed that despite the time under tension is lower with the fast execution, the total work volume was higher in this group (443 ± 230.2) when compared to the slow execution (227 ± 103.7), with p ≤ 0.05 (figure 1).



* p<0.05 compared to both execution speeds.
Figure 1. Total work volume (average ± standard deviation), in kg, on both execution speeds.

Discussion

The fast execution speed (cadence 1010), determined in this study, contributed to the greater accumulation of blood lactate in the Chest Press exercise.

The primary factors involved in increasing the intensity are increased recruitment of fast fibers and increased levels of adrenaline in the bloodstream, which contribute to higher rates of glycolysis and blood lactate production. In addition, the energy metabolism is determined by the intensity of the exercise and, in this case, as the speed is a variable of effort intensity, the increase in the execution speed causes the energy metabolism to differ from the slow execution [8].

It is worth mentioning that regarding the slow cadence, it is believed that this speed recruited more type 1 fibers that are requested when the speeds are intentionally controlled and, because of this, they remain under tension longer, emphasizing muscular resistance [9]. In a review article [10], the authors observed that slow executions in the eccentric phase provide more mechanical stimuli, thus increasing the levels of strength and hypertrophy. In another study [11], the effects of slow eccentric contractions were evaluated, and a process of tissue hypoxia was evidenced, due to the strangulation of blood vessels due to the mechanical tension of the fibers, being an important process to trigger hypertrophic mechanisms.

In the study of Hunter *et al.* [12] the energy expenditure and the lactate levels of the Super Slow (SST) and Traditional (TT) methods were compared and their findings are in line with the present study, regarding the lactate concentration that was significantly higher for the TT method (7.9 ± 1.7 mmol/l) with 65% 1RM for TT vs. 28% for SST, concluding that one of the factors that justifies the results is the total work, as evidenced in the results obtained in the data collection. Similar to the present study, which identified that the metabolic response occurred due to the greater number and speed of repetitions, the study by Lacerda *et al.* [10] evaluated muscle activation and blood lactate concentration, in two protocols in which the cadences were different, however the TST was equalized between the groups and concluded, similarly, that the lactate was significantly higher with fast speed.

In this sense, a study [13] evaluated explosive and slow speeds and their impact on energy expenditure in squat exercise; and in line with the mentioned articles, as well as the results found in the development of this work, the blood lactate value was significantly higher in the fast cadence compared to the slow cadence. The author evidenced that the slow movement obtained a statistically higher TST (126 seconds) when compared to the explosive execution (96 seconds), as, also, presented in table II of this work, and concluded that the fast speed, as verified in a previous study [12], has a higher energy expenditure.

However, the work of Gentil *et al.* [14] evaluated different training methods, including 10 RMs, SST, adapted occlusion and peak contraction until the momentary concentric failure in only one serie, and found that, unlike all the results presented in our study, the methods that promoted less number of repetitions and higher TST showed higher lactate concentrations, except for SST.

The VTT is the product of the number of sets by the number of repetitions and load (kg), as explained by Ratamess *et al.* [15], and was significantly higher with rapid execution as can be analyzed in figure 1.

In another study [16], simple and multiple series were compared and significant higher values were found in the concentrations of cortisol and lactate hormones for multiple series, thus reinforcing the results obtained in the data, however opposing the evidence that Gentil *et al.* [14] points out in the mentioned study.

Thinking about the contribution of the execution speed in the resistance training and even in the risks, a research was observed in the literature [17] that evaluated two execution speeds, fast and slow, in the squat exercise with a load relative to 70-75% of 1RM, whose objective was to measure strength and neuromuscular performance, and identified that the execution speed has greater representation than the TST for strength gains, showing that fast execution speeds promote greater gains in strength and athletic performance.

In their experiment, Tanimoto *et al.* [18] evaluated body composition in a longitudinal study, comparing the traditional method (fast cadence and 80-90% 1RM) vs. low load intensity method (slow cadence and 55-60% 1RM) and demonstrated that both methods obtained effective results.

In this perspective, Santos *et al.* [19] evaluated the impact of fast and slow speeds, on the double product (DP), through heart rate (HR), blood pressure

In this perspective, Santos *et al.* [19] evaluated the impact of fast and slow speeds, in the double product (DP), through heart rate (HR), systolic blood pressure (SBP) and diastolic blood pressure (DBP) and the equalized TST, showing that all parameters evaluated were higher in the fast execution and understood that the fast cadence promoted greater DP, due to HR.

Given the above, it was possible to clarify that the speed of execution has significant impacts in relation, mainly, to blood lactate and with number of repetitions, TST, VTT and FC in agreement with some referenced works. However, some studies show different responses at the metabolic and physiological level due to different protocol configurations. More studies should be carried out on the topic, since different training methods have different physiological responses.

Conclusion

Therefore, after the development of this research, we identified that the fast speed in cadence 1010 significantly influenced the lactate concentration as can be seen in the course of this work. Considering that the results obtained were only from the execution of an exercise and not from a training session, we suggest that studies be carried out under the same conditions of muscle failure and cadences, to evaluate the impact of lactate levels, as well as longitudinal researches. in order to assess chronic effects, not only on the male profile, but also on the female profile in order to contribute to gender studies.

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