Analysis of two training programs with different rest periods between series based on guidelines for muscle hypertrophy in trained individuals

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ABSTRACT

The prescription of weight training programs for muscle hypertrophy are usually based on the values recommended by the literature for determining the training load. The prescription of the pause duration ranges from one to three minutes and comparisons between these two durations leads to differences in hormonal and metabolic adaptations and performance. There is a lack of studies investigating if is it possible the realization of the training program for hypertrophy with different pauses, and the significance of the addition of 30 seconds for recovery. The purpose of the present study was to analyze two different trainings for muscle hypertrophy with the same volume and intensity, but different rest periods between sets, at the bench press exercise. Twenty-six trained male volunteers took part in the training sessions. After the familiarization procedure and the 1 maximum repetition (1RM) test, the group took a four set exercise with 70% of 1 RM on the bench press, aiming to accomplish 12 repetition for each set, with a constant rest period of 90 and 120 seconds. No significant difference was found on the number of repetitions throughout the sets when comparing the results of the 90 and 120 second group. Despite the rest duration (90 or 120 sec) the performance lowered during the sets, registered by significant reduction in the number of repetitions. The results indicated that, even for trained individuals, there is a limitation to apply the reference values presented in the literature for muscle hypertrophy training. Moreover, the performance may be not different despite changing the rest interval from 90 to 120 seconds between sets.

Keywords: Weight training. Fatigue. Pause. Strength.

INTRODUCTION

The prescription of strength training in weight training should consider the different components of the load training and the structural variables which may influence them[1]. Different values for the load components have been suggested for the strength training focusing muscular hypertrophy Volumes ranging from four to six series of eight to twenty repetitions, with pauses from two to three minutes between series and intensities from 60 to 85% of a maximum repetition (1MR) are frequently mentioned[2-3]. Training loads characterized by one to three series, with eight to twelve repetitions, intensities of 70 to 85% of 1MR and pauses between one and two minutes, correspond to the recommendations for muscular hypertrophy training with amateur/intermediate individuals[4]. It is suggested from three to six series, one to twelve repetitions between 70 to 100% of 1MR with pauses between two and three minutes respectively, for advanced individuals[4]. It is generally expected that the individuals submitted to these training values are able to reach significant morphological adaptations, that is, muscular hypertrophy. The training programs in weight training are usually prescribed based on these values, regardless its applicability to different individuals. Therefore, it is important to investigate the possibility of trained people using the suggested values by the literature in their training programs for muscular hypertrophy.

The pause represents an important variable in the training program elaboration[4-5], being able to directly influence the physiological adaptations and the individual's performance. Studies demonstrated that different intensities and training pause duration may significantly alter hormonal[6-7], cardiovascular[8] and metabolic[9-10] responses.

In the studies conducted by Kraemer *et al.*[6-7] pauses of one to three minutes between series in protocols of eight exercises for women and men were used. The blood lactate concentrations were significantly higher for the one minute pause in relation to the three minutes one. Other researchers have examined the result of the pause of one, three and five minutes, on the blood lactate concentration after each series[10]. In that study, the subjects did ten series, with six repetitions each, in the intensity of 70% of a maximum repetition (1MR) in the bench press exercise. The results indicated that after the fourth series, there was a more significant increase of blood lactate concentration for the one minute pause condition compared to the three and five minutes ones. Moreover, with the one minute pause, only four out of ten volunteers completed the ten series, indicating that such pause duration affected the volume of prescribed training.

According to these studies, it is expected that great differences in the pause periods between the series (one, three and five minutes) directly influence the hormonal and metabolic responses, as well as the training load. However, information about smaller differences between pause duration in the training load has not been reported in the literature. Pauses of 90 to 120 seconds have been classified and prescribed as a moderate and ordinary recovery period for many programs of strength training[11]. Studies that show whether these different pauses (90 and 120 seconds) are sufficient for the conduction of other expected values for the hypertrophy training, and if an increase of 30 seconds allows better individual's recovery, are still needed.

The aim of the present study was to analyze the conduction of two training programs based on expected values for muscular hypertrophy and differentiated by the 90 and 120 seconds pauses between the series, in the bench press exercise.

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Received in 3/6/05. Final version received in 28/10/05. Approved in 17/4/06.

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METHODS

Sample

26 male volunteers, used to weight training and who did not have history of shoulder, elbow and wrist musculotendinous or articulatory lesion, participated in the research. The individuals presented an age average of 24,4 ± 4,0 years, body weight of 75,6 ± 9,0 kg and height of 174,4 ± 6,6 cm. The weekly frequency averages and of the total training time were 55.7 ± 44,6 months, respectively. The individuals who were able to do a repetition in the bench press exercise with weight equivalent to their body weight[12] and who regularly practiced weight training for at least six months[4], were considered trained. This was the chosen inclusion criterion. The volunteers were informed about the objectives and procedures of the study and signed a free and clarified term of consent. The project was approved by the ethics committee of the Universidade Federal de Minas Gerais (Regulation # ETIC 338/03).

Instruments and execution standardizing

A MASTER guided bar of 20 kg and a straight bench were used to do the exercise. A metal handrail would indicate the upper limit of the bar dislocation and a rubber board (12 x 6.7 x 2 cm) positioned on the chest, the lower limit.. The pulling traction, the maximum height reached by the bar, the head's position on the bench, the apparel position and the bench's position on the floor, were controlled to standardize the following reproduction of the volunteers' positioning. The training was filmed with a DX 2000 SONY mini DV for repetitions analysis. Many different free weights were used. They were weighted in a FILIZOLLA scale, which was also used to measure the volunteers' body weight.

Procedures

Four test sessions were conducted in four different days. The volunteers were told not to perform any strength activity that involved the major thoracic muscle groups, anterior deltoid and brachial triceps, 24 hours before each test session. In the first tests session, after the consent term's signature, the height and body weight of the volunteers were measured. Afterwards, the individuals went through a familiarization session in order to standardize the individual positions and were submitted to the 1MR test aiming the selection of the volunteers who fulfilled the inclusion criterion. It was suggested to the volunteers to keep the routine of preparatory activity in order to avoid changes that could negatively influence their performance. Such procedure was kept during the entire experiment. In the second test session, the 1MR test was done to determine the maximal strength and the weight corresponding to 70% of 1MR. This test followed the criteria: maximum number of six trials[13] (4,1 ± 0,77 completed), pause duration between three and five minutes[14] and weight progression based on the 1MR test data of the familiarization session.

In the other two test sessions, the group did the guided bench press exercise at the 70% intensity of 1MR in four series, with the aim to reach 12 repetitions per series, with constant pauses of 90 and 120 seconds. In the first of these two test sessions, half of the individuals were randomly placed in the pause group of 90 or 120 seconds, rotating the group in the second test sessions. The minimum interval of two and maximum of four days was established between the test sessions.

The repetitions were discarded in the following situations: incomplete breadth for two repetitions in a row (not touching the metal bar and/or the handrail on the chest), transition time longer than two seconds between the concentric and eccentric phases of each repetition, removal of the volunteer's body from the bench during the exercise (lifting the lumbar spine or the buttocks). These criteria were again controlled through the filming analysis for the collected data validation and no irregularity was verified.

Statistics analysis

A two-way variance analysis with repeated measures was conducted to verify the differences in the average values of the number of repetitions for the weight corresponding to 70% of 1MR in the pauses between 90 and 120 seconds (factor 1-pauses) in the four completed series (factor 2- series). The *post-hoc scheffé* test was applied in order to identify the differences location. The statistics procedure was done based on the Statistica 5.0 program. A significance level of $p < 0,05$ was adopted.

RESULTS

The descriptive analysis related to the 1MR test and the weight corresponding to 70% of the 1MR is presented in table 1.

TABLE 1
Minimum, maximum, average and standard deviation values for the 1MR test and for 70% of 1MR

	Minimum	Maximum	Average	s.d.
1MR (kg)	68	140	91,1	16,2
70% MR (kg)	48	98	63,7	11,3

s.d. = standard deviation

The average and the standard deviation of the number of repetitions done in each of the four series for the 90 and 120 seconds pauses are referred to on table 2. The *post-hoc scheffé* test showed that for both pauses the number of repetitions significantly decreased in the second, third and fourth series when compared to the number of repetitions reached in the precedent series.

TABLE 2
Averages and standard deviation of the number of repetitions completed in each of the four series using pauses of 90 and 120 seconds between the series

Pauses (sec.)	1st series	2nd series	3rd series	4th series
90	11,5 (1,0)	9,4 (1,9)*	6,5 (2,4)*	4,7 (1,8)*
120	11,7 (0,7)	10,4 (1,4)*	7,2 (2,2)*	5,5 (1,2)*

* $p < 0,05$ compared to the precedent series

In the comparison of the number of repetitions done in each of the four series between the 90 and 120 seconds pauses, no significant difference was found (figure 1).

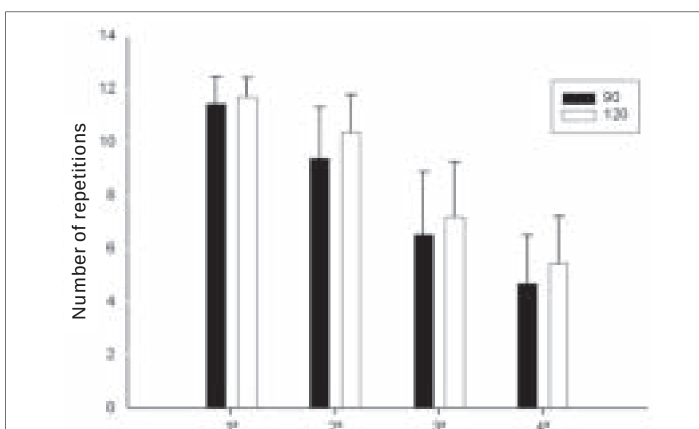

***Figure 1** – Comparison of the number of repetitions done in each of the four series between the 90 and 120 seconds pauses*

DISCUSSION

The experimental protocol adopted in this study consisted of four series, 12 repetitions per series, intensity of 70% of 1MR and 90 and 120 seconds pauses between the series. These values are mentioned by many authors for strength training with emphasis on muscular hypertrophy. A number between eight and twelve repetitions per series has been suggested for the increase of muscular mass[5] and from three to six series for significant strength gains[15]. Some researchers affirm that the hypertrophy may occur in a training with volume of eight to twenty repetitions per series for a total of three to five series per exercise[2,16]. Concerning the pause timing, from two to three minutes for programs aiming the muscular hypertrophy[2], while other authors suggest that the pauses should be between one and three minutes[4-5]. According to the expected values, a pause of 120 seconds has been pointed by almost all mentioned authors, as sufficient for promoting the necessary recovery between series.

The results have indicated that the volunteers, despite being weight trained, were not able to complete the four series of 12 repetitions with any of the pause durations – 90 and 120 seconds. A statistically significant decrease in the number of repetitions from the second series for both pauses, showing that 90 and 120 seconds intervals were not sufficient to the individuals' recovery.

According to Sahlin and Ren[17], the strength performance reestablishment occurs approximately in two minutes. Thus, the 120 seconds pause should be sufficient to partially or totally recover the energetic storage of the ATP-CP system. However, the individuals started a fatigue process, characterized by performance loss, independently of the pause.

Information about the metabolism specificity during typical activities of the weight training is scarce yet[18]. During an intense activity and of short duration, many physiological reactions could contribute to the fatigue process in different moments of the activity. Lambert and Flynn[18] reported that the fatigue related to an exercise series (ten repetitions) completed until the 'temporal failure' is possibly caused by phosphocreatinine low concentration. In these authors' opinion, the intramuscular acidosis seems to be the predominant reason for fatigue in the third series of the exercise completed until the 'temporal failure' point, even if a suitable recovery occurs (from one to three minutes) between series. However, the authors mentioned that it is difficult to determine the cause(s) for muscular fatigue during this kind of exercise, since changes in some substrates and metabolites related to fatigue coincide with modifications of others. For instance, during high intensity exercises, the hydrogen (H^+) ions accumulation is accompanied by increase in the amonia (NH_3) concentrations and inorganic phosphate (Pi). Such metabolites influence different mechanisms that may contribute for a decrease in muscular strength[19], and consequently of the physical performance. It has been reported that three series of elbow flexion to 80% of 1MR completed until the muscular 'failure' resulted in a decrease of 24% in the muscular glycogen concentration[20]. This result indicates that glycogen availability may not be the main fatigue mechanism, considering the experimental protocol of this study.

No statistical difference was verified in the comparison of the average number of repetitions per series between the two pauses in the four series completed. This result showed that the effects of the fatigue mechanism in the performance in each series were not diminished with the increase of 30 seconds in the pause duration. Due to the high physiological demand of the adopted training protocol, a significant accumulation of metabolites is expected[19,21], which negatively interferes in the contraction mechanism. Consequently, the strength production by the muscular fibers is caused, and contributes to a similar fatigue process in the two experimental conditions.

The interval of two to four days between sessions, the fact that only one exercise with a submaximal training load is being used, and weight trained individuals being subjected, eliminate the possibility that the results are being influenced by a residual fatigue of the training sessions. Moreover, a possible interference of the training effect caused by the test sessions sequence is not expected, since the interval between the sessions is insufficient to alter the trained individuals' performance. One half of the individuals started with the 90 seconds pause, and the other with 120 seconds, therefore, if there was training effect, this was balanced, similarly influencing both results. Based on this research's data, the generalized expectation is relative concerning the training values. Research has shown that a certain number of repetitions for preestablished 1MR percentages may be influenced by the kind of exercise, gender and individual's training level[22-25].

Factors related to the specificity of the breadth of movement and of the exercise may have contributed for the lack of fulfillment of the expected values. The movement's breath control during repetitions and the fact that the tested individuals did not train the bench press in the guided bar, may have contributed to increase the task's difficulty. The need of maximal breadth maintenance in all repetitions may result in higher energetic cost, given the bigger duration of the training stimulus. Besides that, the volunteers had not been training this exercise in a guided bar, which represented a motor task with modified standard movement (biomechanical specificity) which may have negatively influenced the strength performance.

The results of this research support important criticism related to the weight training programs elaboration which proposes to be based on the expected values in the literature. In the present study, none of the weight trained individuals were able to perform the training in a single exercise within the expected values, which are suggested by different authors[2,16]. It is worth mentioning that this study limited to investigate determined values for the training load components (4 series, 12 repetitions, 70% of 1MR). However, if these values were different, even within the existing values in the literature for muscular hypertrophy, the individuals would not be able to conduct the training either. Moreover, it should be taken into consideration that the training programs always consist of many exercises, which would make the application of these values for training even more difficult. The prescription of training loads should be carefully considered, so that uniform expectations are not generated in relation to the performance parameters, leading to unrealistic evaluations of the training process.

CONCLUSION

The results of this research showed that none of the training programs based on the expected values in the literature for the muscular hypertrophy training were feasible, once a significant decrease of the performance characterized by the reduction of the number of repetitions during the series was verified. Furthermore, the difference of 30 seconds in the pause duration did not result in difference statistically significant in the number of repetitions completed by the individuals.

Thus, the professionals should be aware that the values may not be available to a great number of weight training participants.

All the authors declared there is not any potential conflict of interests regarding this article.

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