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Influence of Different Speeds of Muscle Actions in the Maximum Dynamic Strength, in the Maximum Volume of Repetitions, and Rated Perceived Exertion

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ABSTRACT

Souza HLR, Campos YAC, Moreira OC, Guimarães MP, Silva GP, Silva SF. Influence of Different Speeds of Muscle Actions in the Maximum Dynamic Strength, in the Maximum Volume of Repetitions, and Rated Perceived Exertion. **JEPonline** 2016;19(1): 57-65. The purpose of this study was to investigate the influence of different speeds of muscle action on the maximum volume of repetitions (MVR), rated perceived exertion (RPE), and maximum dynamic muscle strength of 9 women. At the end of 3 series of each execution, protocol was added the MVR, and collected the RPE, the maximum dynamic strength was assessed 72 hrs after each protocol. The results showed no statistically significant differences in RPE, maximum number of repetitions, and maximum dynamic strength among the three protocols: concentric protocol (CP); eccentric protocol (EP); and control protocol (CoP). This study does not support the earlier observations of a decrease in the maximal contraction strength with eccentric protocols. Also, in regards to RPE, there were no statistically significant differences at the end of the execution of the 3 sets in the three different protocols analyzed.

Key Words: Resistance training, Eccentric actions, Hypertrophy

INTRODUCTION

Currently, resistance training (RT) is arousing interest in a large number of practitioners who seek the benefits of muscle improvement for athletics, aesthetic purposes, and/or the search for a better quality of life (1). Since RT promotes muscle strain that is essential to the adaptation and growth of skeletal muscle (22), knowing the different adaptations that occur during concentric contractions (CC) and eccentric contractions (EC) is important in prescribing a safe and beneficial RT program. No doubt this is why the scientific community has turned to studying the behavior of different contractions in muscle adaptation (20). In this regard, the research helps to demystify the existing controversy regarding the benefits and the complications that result from inappropriate usage of CC and EC training (2).

Concentric contractions are directly involved in daily human movement (1), and it is well reported in the literature that fatigue generated by CC causes a decrease in torque, muscle strength, electromyographic activity, and higher metabolic cost (8). On the other hand, the benefits of the CC are also very clear in the literature, such as the increase in muscle strength from the adaptation to training and the fewer micro muscle injuries (13).

Eccentric contractions represent muscle actions that are characterized by muscle stretching that generates a higher level of muscle injury and subsequent muscle stiffness (19,24). Yet, there are reports that EC is helpful in the rehabilitation of muscles. Aside from the increase in muscle strength, EC result in lower metabolic cost compared to CC (19,25). Hollander et al. (17) highlighted this point during a study of eccentric and concentric strength under isokinetic conditions in flexion and elbow extension. They found that EC resulted in a strength increase of 14% to 89% compared to concentric strength.

Roig and colleagues (27) reported that when RT is given a greater emphasis on EC training, it generates muscular strength that keeps for a longer time period since the loss of concentric strength is much sharper with the aging process. Thus, when comparing concentric strength to eccentric strength, the latter shows a power of conservation that is 20% higher (27). The mechanisms that regulate the advantage of EC originally appear to be neuronal, given that EC generates greater stimulation of the motor cortex during maximum voluntary contraction (MVC) (14,18,28).

In addition to the questions about concentric and eccentric muscle contraction and force generated, there is still the need for greater clarification regarding the acute effects of each in regards to the volume of repetitions, maximum strength, and the internal load such (as defined by rated perceived exertion, RPE). Thus, the role of speed in the execution of muscle action in RT is not fully understood, thus leaving room for structuring the hypothesis that the different emphases in muscle actions often result in contradictory responses in the RT training variables.

The purpose of this study was to investigate the influence of different speeds of muscle action on the volume of repetitions, perceived exertion, and maximum dynamic muscle strength.

METHODS

Subjects

The subjects in this study consisted of 9 females with a mean age of 22 ± 1.8 yrs. All subjects were familiarized with the proposed exercise and had minimum experience of 6 months in RT. They were not using drugs and/or steroids to influence muscle development, and none had any bone-joint injuries or acute infection. All subjects read and signed the Informed Consent Form, and the study was approved by the Ethics Committee with the CAAE number: 13480213.7.0000.5148.

Procedures

This study used the squat exercise with a guided bar. Each subject assumed a standing position with the bar on the shoulders. The feet and knees were lined up with the hip joints. Then, the subject assumed the squat position by flexing the hips and knees. The latter achieved an angle of 90° that was controlled with the aid of a digital goniometer GN360 of Miotec®. The subjects performed 3 sets that resulted in concentric failure with 60% of maximum load, which was followed by a rest interval of 90 sec between sets. To control the subjects' speed of movement (i.e., muscle contraction), the Metronome Plus 2.0.0.5 software® was used.

The evaluation of all protocols was conducted by the same researchers. The subjects underwent a familiarization process during which they performed the speeds prescribed for each protocol three times with a total of nine familiarization visits. The subjects were evaluated at four different moments. Starting at the 2nd moment, there was a randomization to determine the exercises that would be executed. A 7 day interval was observed between the moments.

- Following the reading and signing of the Informed Consent Form and an overview of the research procedures, the subjects underwent the anthropometric evaluation. Then, their maximum dynamic strength was determined using the 1RM test in order to determine the load that would be used during the study.

- In a second moment, the subjects were instructed to perform 3 sets of exercise that emphasized the concentric phase of the movement, which consisted of a concentric protocol (CP): 30 rad·sec^{-1} (3 sec) for the concentric action and 90 rad·sec^{-1} (1 sec) for the eccentric action (3CC to 1EC).

- In a third moment, the subjects were instructed to perform 3 sets of exercise that emphasized the eccentric phase of the movement, which consisted of an eccentric protocol (EP): 90 rad·sec^{-1} (1 sec) for the concentric action and 30 rad·sec^{-1} (3 sec) for the eccentric action (1CC for 3EC).

- In a fourth moment, the subjects were instructed to perform 3 sets of the exercise with a balance between the times of muscle actions, which consisted of the control protocol (CoP): 45 rad·sec^{-1} (2 sec) for the concentric action and 45 rad·sec^{-1} (2 sec) for the eccentric action (2CC for 2EC).

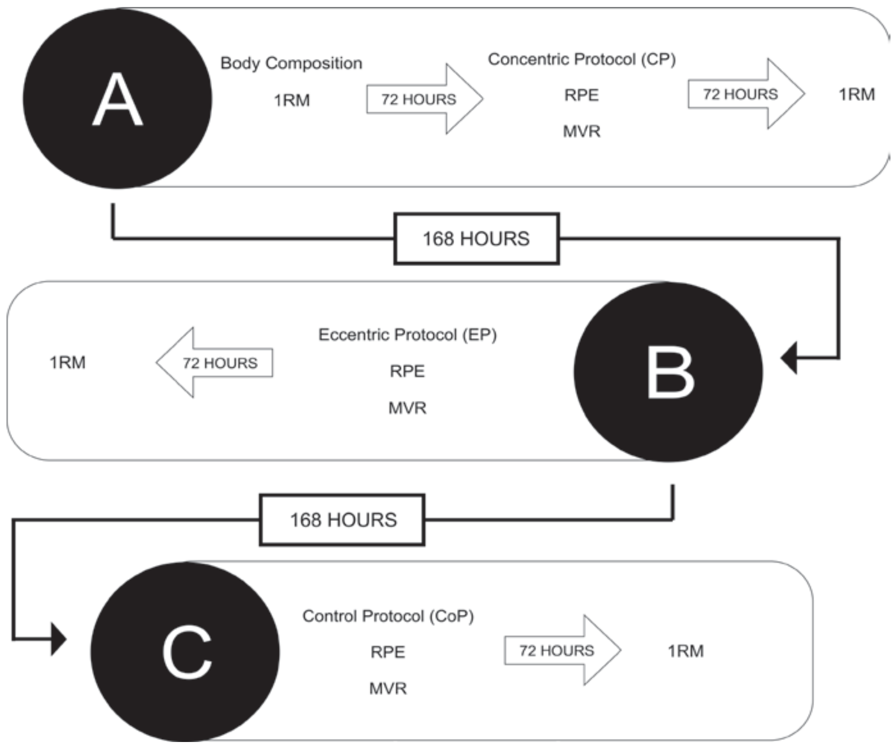

Figure 1. Investigation Outline

At the end of each set of exercises and each protocol, the subjects' RPE was recorded (26) and used to analyze the average RPE of 3 series. In the volume of repetitions analysis (Warren, #167), the sum of the number of repetitions in each set of each protocol was determined. The maximum dynamic force was evaluated by the 1RM test, which was determined 72 hrs after each protocol (CP, EP, and CoP).

Rated Perceived Exertion (RPE)

In order to collect the data for RPE, the Omni Resistance Exercise Climb Scale (OMNI-RES) was used. It was developed by Robertson et al. (26) especially for the assessment of perceived exertion during resistance training. This scale presents only numerical and verbal descriptors. The OMNI-RES is a numerical scale with values between 0 and 10 in which 0 is an extremely easy effort and 10 is an extremely difficult effort.

Evaluation of Maximum Dynamic Strength (1RM)

The one repetition maximum test (1RM) was used to analyze the subjects' maximum dynamic strength. The subjects were instructed to complete a set of 4 repetitions at 60% of the estimated 1RM, 1 set of 3 repetitions at 70% of estimated 1RM, a set of 2 repetitions at 80% of estimated 1RM, and 1 repetition at 90% of estimated 1RM. Then, the subjects started the attempt of 1RM, being the maximum number of 5 attempts to identify 1RM. A 3-min interval used between sets (4).

Statistical Analyses

The statistical analysis of the data was done based on the comparison of means and standard deviations. To verify the distribution of the sample, Shapiro-Wilk normality test was used. To compare the data between concentric, eccentric, and control groups, the ANOVA with repeated measures was used along with Scheffé *post hoc*. The nonparametric Wilcoxon Test was used to compare the variables of the same group. To verify the effect of the sample, the Cohen's D Test was adopted. Statistical significance was set at P≤0.05 for all tests.

RESULTS

Table 1 presents the anthropometric data that characterizes the subjects used in this study.

Table 1. Anthropometric Characteristics of the Sample.

N	Age (yrs)	Height (m)	Weight (Dideriksen, #339)	BMI	Body fat (%)
9	22 ± 1.8	1.71 ± 3.96	68.3 ± 12.94	23.63 ± 5.45	32.12 ± 6.30

In Table 2, the subjects' initial maximum dynamic strength (RMi) is presented relative to each protocol. There were no statistically significant differences between protocols on RM72 compared with RMi. The RMi was 103.33 kg. After the CP load, it was 104.44 kg. This is a non-significant increase of 1% after 72 hrs compared to the CoP in which there was a non-significant decrease of 2%. There was a non-significant decrease in the EP load after 72 hrs, which represents a reduction of 6.40%. The subjects' RPE responses across the three phases of muscle contraction were not significantly different, which was also the case with the subjects' maximum volume of repetitions (MVR) for each of the three different protocols.

Table 2. Comparison of Maximum Dynamic Strength Before and After the Different Protocols.

Variables	Contraction CP	EP	CoP	P			Size Effect
RMi (kgf)	103.33 ± 20.61	103.33 ± 20.61	103.33 ± 20.61	CC-EC	CC-CT	EC-CT	
RM72 (kgf)	104.44 ± 18.10	97.77 ± 15.63	102.22 ± 15.89	0.387	0.863	0.297	d= 0.039
%	+ 1%	- 6%	- 2%	-	-	-	-
RPE	6.37 ± 1.85	6.48 ± 1.68	6.37 ± 2.23	0.113	0.605	0.113	d= 0.146
MVR	39.22 ± 5.35	34.77 ± 6.68	41.66 ± 9.32	0.720	0.931	0.863	d= 0.001

RMi: initial maximum dynamic strength; **RM72:** maximum dynamics strength 72 hrs after the realization of the protocol; **RPE:** rated perceived exertion; **MVR:** Maximum volume of repetitions; **CP:** concentric protocol; **EP:** eccentric protocol; **CoP:** control protocol

DISCUSSION

The purpose of this study aimed to investigate the influence of different speeds of muscle actions on the volume of repetitions, rated perceived exertion, and maximum dynamic muscle strength. There were no statistically significant differences in the maximum dynamic strength between the 3 protocols (CP, EP, and CoP). These results are contrary to that found in other studies reporting loss of maximal contraction strength after performing eccentric muscle contraction (3,5,9). While the acute effects of performing concentric muscle actions do not result in significant changes in the production of maximum dynamic strength (8), there is generally an observed transient decrease in the maximal contraction strength with eccentric protocols. Yet, the findings in the present study do not support the earlier observations. Whether there is muscle damage caused by this type of muscle action with disturbances in the sarcolemma and disruption of the Z lines (5,6,12) that are manifested through muscle injury markers such as creatine kinase (CK) and lactate dehydrogenase (LDH) (10,11) remains unclear.

Regarding the RPE, there were no statistically significant differences at the end of the execution of the 3 sets in the three different protocols analyzed. The literature shows controversial data about RPE and exercises using different types of muscle actions, in which there are studies that show higher RPE after CC (16), and studies that have higher RPE after performing an eccentric fatigue protocol (7). The higher values of RPE and CC can be justified in terms of a higher energy cost caused by the same when compared to EC (8). On the other hand, the psychobiological theory of exercise performance, supports the increase in RPE as a function of exercise intensity (7).

The lack of a significant difference between the protocols used in the present study and the inconsistencies reported in the literature regarding the RPE and its role in analyzing the internal load in exercises with emphasis on different muscle actions may be related to intrinsic and extrinsic factors that may affect in greater or lesser degree the response of the same to the exercise (23). Thus, the RPE might not be a very accurate measure to evaluate the workload when performing resistance training protocols at different speeds of execution.

Regarding the total volume of repetitions in the three different protocols evaluated, the results indicate no statistically significant differences. Although there was no statistically significant difference among the groups, one might speculate that a tendency towards the execution of fewer repetitions in the EP did exist. Although the literature suggests that the eccentric stimulus leads to a decreased range of motion in response to localized muscle pain that may be induced by increased CK in the blood (21), the present study does not support this point. Perhaps, it is worth noting that more research is needed in this area, given that Chen et al. (5) showed smaller number of repetitions performed after eccentric stimuli, and increased number of repetitions after repeated eccentric stimuli. More recently, Fernandez-Gonzalo et al. (11) found loss of strength, muscle power, and increased muscle pain after performing a set of eccentric exercise.

The free weights exercises are not commonly used in the literature to verify the acute effect of CE, and most of the studies analyzed seek to present muscle power as a reliable marker to evaluate these acute effects (11). Following this line of using functional markers to verify the effects of eccentric training, it is feasible to think that the total volume of repetitions could represent an interesting strategy to check the acute and chronic responses to EC. As demonstrated by the abovementioned studies, the reduction in the total volume of repetitions after CE becomes an effective indirect response when is associated with markers of muscle damage and metabolites and electromyographic activity in regards to EC (15).

Limitations of this Study

The findings in the present study are limited due to the lack of control of biochemical markers of muscle damage, which could have helped to explain the results. As well, the small number of subjects in the sample was a limitation. More research should address these concerns and others such as the subjects analyzed in relation to age and characteristics (physical, physiological, and environmental) that may have interfered with results.

CONCLUSIONS

The findings indicate there were no statistically significant differences in the maximum dynamic strength between the 3 protocols (CP, EP, and CoP). This study does not support the earlier observations of a decrease in the maximal contraction strength with eccentric protocols. Also, in regards to RPE, there were no statistically significant differences at the end of the execution of the 3 sets in the three different protocols analyzed.

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