Creatine supplementation nullifies the adverse effect of endurance exercise on the subsequent strength performance

Rodrigo Vitasovic Gomes¹ and Marcelo Saldanha Aoki¹,²

ABSTRACT

Objective: The objective of this study was to verify if creatine supplementation exerts an ergogenic effect during concurrent exercise. Methods: Sixteen female university students were divided into two groups: placebo (P) and creatine supplemented (CRE). The participants received 20 g of placebo or creatine for five days and 3 g for the following seven days in a double-blind design. Before supplementation, the participants were submitted to a 1-RM test in the leg press followed by maximum repetition test (three sets of repetitions-to-fatigue, performed at 80% of the 1-RM and separated from 150 seconds of recovery – 1st set: 9.0 ± 2.4; 2nd set: 8.9 ± 2.9 and 3rd set: 8.3 ± 3.3 and CRE 1st set: 10.2 ± 2.2; 2nd set: 9.8 ± 2.9 e 3rd set: 9.7 ± 3.5 reps). After 12 days of supplementation, the participants were submitted to aerobic test in which they were instructed to cover the maximal distance as possible in 20 min. Subsequently, the participants were submitted to 1-RM test once again followed by the maximum repetition test. Results: No differences were observed in the aerobic task performance and in the 1-RM test. After the aerobic test, a decline on the repetition maximum capacity was observed during the last two sets in P (Reps – P: 1st set: 7.6 ± 2.6; 2nd set: 4.3 ± 2.9*; p < 0.01 and 3rd set: 4.6 ± 2.3*; p < 0.01). This reduction was not observed in CRE (Reps – CRE: 1st set: 10.9 ± 2.9; 2nd set: 9.5 ± 2.7 and 3rd set: 9.0 ± 3.0). Conclusions: There is a hypothesis that the performance of resistance exercise is reduced by a residual fatigue from the previous aerobic exercise bout. One of the peripheral causes of acute fatigue during resistance exercise is related to creatine-phosphate depletion. Probably, the supplementation-induced greater muscle creatine-phosphate content accelerates the recovery and the ATP re-phosphorylation, serving as an additional energetic substrate during concurrent exercise.

INTRODUCTION

In the last decades, several studies have investigated the effect of the concurrent training, in which endurance and resistance exercises are performed concurrently at the same training session(1). Once athletes and individuals physically active adopt this training strategy, there is a great interest in relation to the interference the first activity would exert on the subsequent one.

Results obtained in our laboratory demonstrated that the endurance exercise (70% of the VO2max for 45 minutes in treadmill) promotes a reduction on the performance of the subsequent maximum repetition test in the leg press at 45°(10). Other studies corroborate our findings that the aerobic exercise affects the subsequent strength and power development when endurance exercise is previously performed(11).

In another study, it was observed that the resistance exercise (six series of maximum repetitions in the leg press at 45° with three series at 60% of the 1-RM value and the other three series at 90% of the 1-RM value) did not interfere on the posterior aerobic power performance(9). These results are also corroborated by other researches that demonstrated that the aerobic power performance does not seem to be influenced by the previous execution of resistance exercises(4-8).

However, the literature presents conflicting results(11). Some researches suggest the non existence of interference from the concurrent training on the aerobic power or strength performance(5-12). However, in a study conducted by Nelson et al.(13), it was demonstrated that the performance of concurrent training hinders the aerobic power development. This controversy may be related to the adaptation level to the concurrent training stimulus. It seems that individuals adapted to the concurrent training undergo less interference in relation to untrained individuals(3,14). Other factors also contribute for the discrepancy of results obtained by researches that analyzed concurrent training such as the exercise protocols used and the organization of their variables (intensity, duration and frequency)(15).

Currently, the most consistent data on the concurrent training indicates that this strategy lessens the power and strength gains when compared to the resistance training alone(4,8,16).

There are two hypotheses to explain this harmful interference from the concurrent training. These hypotheses are related to acute or chronic processes(1,18). The chronic hypothesis consists of the idea that after the concurrent training, the muscle would try to adapt itself to both stimuli. However, this is not possible because the endurance training-induced chronic adaptations are frequently inconsistent with adaptations observed during the resistance training. According to the chronic hypothesis, the combination of these two different stimuli could affect the development of these two physical capacities (aerobic power and strength) due to the fact that both induce to different adaptations(1,4,5).

With relation to the acute hypothesis, it is based on the idea that the former activity would lead to a residual fatigue. This fatigue would hinder the performance of the subsequent activity through alterations on the energetic metabolism (lower substrate availability, acidosis, increase on the ammonia concentration)(1).

Considering that the acute hypothesis is a possible explanation for the interference observed in the concurrent exercise, two studies using carbohydrate supplementation during concurrent exercises were performed(2,8). In both studies, the carbohydrate intake exerted no ergogenic effect(2,3).

Key words: Creatine. Supplementation. Concurrent exercise. Interference.
These results led us to consider that the availability of other energetic substrate would be the limiting factor for the performance of the subsequent resistance exercise. Considering that the creatine-phosphate contributed significantly for the performance of the high-intensity exercise, the objective of this work was to verify the effect of the creatine supplementation on the performance of the concurrent exercise (endurance exercise performed previously to the 1-RM test and the maximum repetition test performed at 80% of the 1-RM value).

**METHODOLOGY**

**Sample**

Sixteen female Physical Education students (20.1 ± 1.9 years) from the UniFMU University Center were selected. The practice of strength exercises at least three times a week as well as endurance exercises for at least 30 minutes in alternated or simultaneous days was established as inclusion criterion. Other criterion adopted for the participation in this study was the minimum period of 12 months of previous experience in strength training. The sample selection was performed by means of a questionnaire in which the consumption of other nutritional supplements and controlled substances was evaluated. The experimental protocol was approved by the Ethics Committee in Researches involving human beings (CEP-06) of the Biomedics Sciences Institute – University of São Paulo (Nº 015.00). The experiments were conducted according to specific resolution of the National Health Council (Nº 196/96). All individuals were informed in details on the procedures used and agreed in participating voluntarily in the study, signing a term of free and informed consent and privacy protection.

**Determination of 1-RM and maximum repetition capacity**

After a quick warm up exercise, the 1-RM value was determined through three increasing attempts in the leg press exercise at 45°. Later, the percentile value equivalent to 80% of the 1-RM value was calculated for the performance of the three maximum repetition sets with intervals of 150 seconds.

**Endurance exercise**

The exercise protocol adopted consisted of 20 minutes running in delimited track field in which the subjects ran the longest distance as possible in 20 minutes. As the exercise maintained a constant step rhythm during the entire activity, the test started with a command voice “ready, go”, with chronometer turned on simultaneously. The test ended with a whistle sound.

**Supplementation protocol**

The participants were divided into two groups randomly selected. The creatine supplementation (or placebo) was conducted according to double-blind design. In the first phase (overload), 20 grams a day of creatine (or placebo) were administered, being divided into four doses, during five days. During the second phase (maintenance), three grams of creatine (or placebo) were administered during seven days. The group placebo was used as control during the first five days of the overload phase, while the group creatine was supplemented with creatine; however, this group received only carbohydrate (maltodextrin).

**Experimental procedure**

Two data collections were performed in distinct days 12 days away from one another. At the beginning of the supplementation protocol, both groups were initially submitted to the 1-RM test and to the maximum repetition test in the leg press at 45° (80% of the 1-RM). Twelve days after supplementation (creatine or placebo), both test (1-RM and maximum repetitions) were once again performed shortly after the 20-minutes running test. Therefore, the objective of this work was to verify the effect of the endurance exercise (running) on the strength development in groups placebo and creatine supplemented for 12 days.

**Statistical analysis**

The results were analyzed using the analysis of variance (ANOVA – two way) (time factor x supplementation factor) followed by the Tukey test (GraphPAD software). The minimum significance level adopted in the present study was of p < 0.05. The results are expressed as average and standard deviation.

**RESULTS**

The value obtained in the 1-RM test presented no alteration between groups placebo and creatine, with or without the previous execution of the endurance exercise (table 1). The 1-RM value/body weight ratio also remained unchanged in relation to groups placebo and creatine at the beginning (without the previous execution of the endurance exercise) and at the end of the experiments (with the execution of the endurance exercise) (table 1).

**TABLE 1**

<table>
<thead>
<tr>
<th>Placebo (n = 8)</th>
<th>Creatine (n = 8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-RM (kg)</td>
<td>Weight (kg)</td>
</tr>
<tr>
<td>Initial</td>
<td>180.4 ± 20.1</td>
</tr>
<tr>
<td>Final</td>
<td>179.1 ± 18.3</td>
</tr>
</tbody>
</table>

Values expressed as average and standard deviation.

However, in the maximum repetitions test, a decrease on the number of repetitions performed by the group placebo after the performance of the aerobic exercise was observed in the two last sets in relation to the beginning of the experiment (P: 1st set: 9.0 ± 2.4; 2nd set: 8.9 ± 2.9 and 3rd set: 8.3 ± 3.3 vs. P: 1st set: 7.6 ± 2.6; 2nd set: 4.3 ± 2.9*; p < 0.01 and 3rd set: 4.6 ± 2.3*; p < 0.01) (table 2). This response was not observed in the group creatine (CRE: 1st set: 10.2 ± 2.2; 2nd set: 9.8 ± 2.9 and 3rd set: 9.7 ± 3.5 vs. CRE: 1st set: 10.9 ± 2.9; 2nd set: 9.5 ± 2.7 and 3rd set: 9.0 ± 3.0). At the end of the experiment, after the endurance exercise, the average number of maximum repetitions performed by the group creatine in the last two sets was higher than that of the group placebo (table 2).

**TABLE 2**

<table>
<thead>
<tr>
<th>Placebo (n = 8)</th>
<th>Creatine (n = 8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st set</td>
<td>2nd set</td>
</tr>
<tr>
<td>Initial</td>
<td>9.0 ± 2.4</td>
</tr>
<tr>
<td>Final</td>
<td>7.6 ± 2.6</td>
</tr>
</tbody>
</table>

Values expressed as average ± standard deviation.

Regarding the 20-minutes running test, no difference was observed on the performance of both groups (table 3).
In relation to the capacity of performing maximum repetitions (80%-1-RM) in the group placebo, the endurance exercise promoted a decrease on this parameter in relation to the initial test, as expected. A possible explanation for the reduction on the number of maximum repetitions is that the endurance exercise would promote a depletion of the energetic substrates, thus generating a residual fatigue (acute interference hypothesis)\(^{(1,15)}\). On the other hand, in the group supplemented with creatine, the capacity of performing maximum repetitions (80%-1-RM) in the leg press at 45° after endurance exercise was maintained.

The fatigue installation in the resistance exercise seems to be multifactorial, presenting as potential causes the CP depletion, the intramuscular acidosis (increase of H\(^+\) ions) and/or the reduction on the muscular glycogen\(^{(25)}\). MacDougall et al.\(^{(26)}\) observed that the combination between the CP depletion (62% in relation to the rest situation) and the muscular acidosis (21.3 mmol.kg\(^{-1}\) of wet weight) was the responsible for the fatigue at the 1\(^{st}\) series of maximum repetition at 80% of the 1-RM value. These authors also reported that after three series of maximum repetitions at 80% of the 1-RM value, the incapacity of maintaining the movement pattern seems to be limited by the increase on the H\(^+\) ions concentration\(^{(28)}\). The elaboration of this hypothesis was based on the fact that the CP reduction degree (50% in relation to the rest situation) was smaller than that observed in the 1\(^{st}\) series (62% in relation to the rest situation). Reinforcing this hypothesis, the lactate production had been higher at the end of the last series (1\(^{st}\) series – 21.3 mmol.kg\(^{-1}\) wet weight vs 3 series – 27.4 mmol.kg\(^{-1}\) wet weight)\(^{(26)}\).

Considering that the fatigue at the 1\(^{st}\) series may be related with the CP reduction, one may speculate that the higher content of this substrate in the muscle would minimize the CP depletion in the group supplemented with creatine, thus favoring its subsequent re-synthesis for the next series. Furthermore, it is important mentioning the buffering capacity exerted by the ATP-CP system\(^{(27)}\). The immediate re-phosphorylation of ADT into ATP through the CP hydrolysis requires one H\(^+\) ion\(^{(27)}\). As result, this buffering capacity would lessen the harmful effects of the acidosis\(^{(25,27,28)}\), such as the inhibition of enzymes involved in the energetic metabolism\(^{(25,27)}\) and the reduction on the sensitiveness of the contractile proteins to ions Ca\(^{2+}\)\(^{(28)}\).

Therefore, the increase on the availability of this substrate and its buffering capacity would be responsible for the maintenance of the performance in the subsequent maximum repetitions test in the group supplemented to creatine supplementation.

**CONCLUSION**

According to other results available in literature, the present study demonstrated that the previous performance of endurance exercises affects the subsequent resistance exercise. It was also verified in this study, that the creatine supplementation is able to nullify the adverse effect induced by the endurance exercises on the subsequent performance on the maximum repetitions test at 80% of the 1-RM value. These results suggest that the ATP-CP system contributes significantly for the performance of the concurrent exercise in which the subsequent resistance training is performed at high intensity.

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