

CREATINE SUPPLEMENTATION ALTERS POWER IN THE WINGATE TEST BUT INCREASES CREATININE CONCENTRATION



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ABSTRACT

The aim of this research was to verify the effect of the creatine supplementation on performance in the 10 and 30-second Wingate tests, besides its influence in the creatinine, urea and lactate concentration and body mass of physically active men. This research selected nine volunteers, who were then separated in two groups using the double-blind procedure: creatine group (n=4) and placebo group (n=5). The supplementation was orally administered during ten days. The creatine group ingested 20g of creatine (4 times a day) in the first five days, followed by an ingestion of 5 g/day until the tenth day. The placebo group received the same dosage, but of maltodextrine instead, as placebo. The test protocol performed before and after the supplementation period consisted of an adapted 10-second Wingate test, followed by an interval of 20 minutes for application of the 30-second Wingate test. Blood samples were collected before and after the supplementation period for analysis of creatinine and urea, lactate at rest, 90 seconds after the 10-second test and 180 seconds after the 30-second test. Creatine supplementation promoted significant raise ($p < 0.05$) in maximal power output during the 30-second test, in the mean power output in the 10 second-test, besides the creatinine concentration. The results suggest that creatine supplementation can improve individual performance in high intensity activities and short duration made in cycle ergometer; however, creatine supplementation increases the creatinine concentration at rest.

Keywords: performance, cycle ergometer, ergogenic effects, metabolites

INTRODUCTION

The Wingate test has been used for the assessment of maximal power (P_{max}) and anaerobic capacity, which are important variables for sports performance. In muscle contractions of short duration, the used energy is mainly derived from the high-energy phosphates, adenosine triphosphate (ATP) and phosphocreatine (PCr), being essential to sports performance¹. Creatine (Cr) is necessary to the formation of PCr, which phosphorylates adenosine diphosphate (ADP) resynthesizing the ATP² molecule and hence, its supplementation would increase performance in anaerobic activities of short duration. According to Smith and Hill³, during high-intensity exercise with 30 second (s) duration, maximum power is reached in the first 5s and until this period, there is greater contribution of the high-energy phosphates.

Due to their energetic power, creatine supplementation (CrS) is fairly spread and used by athletes⁴, physically active individuals^{5,6} and also particularly by those who compete or practice high-intensity sports with short duration. However, the effects of CrS supplementation are very controversial, even with studies demonstrating increase in muscular strength and power^{7,8} and further studies not presenting effects in performance in exercises predominantly anaerobic⁹⁻¹¹.

The urea concentration [urea]¹² and creatinine concentration [Crn]¹³ are considered some of the renal function markers and some

studies have shown that CrS may increase the creatinine concentration [Crn]^{2,14}, being hence related to disturbs in the renal function caused by the CrS. Thus, the present study had the aim to verify the effect of CrS, in the adapted Wingate (W10) and Wingate (W30) tests and the metabolic parameters such as lactate concentration [LA], creatinine [Crn] and [urea] of physically active men.

METHOD

Sample

12 healthy¹⁵, non-vegetarian male physical education students who had no previous experience with Cr supplementation (table 1) were selected for the study. The individuals should present normal renal function based on blood exams for determination of serum [Crn] and [urea]¹² and sign a free and clarified consent form. The study was approved by the Ethics Committee of the University Center of Belo Horizonte, law nº 085/2005.

During this research, two volunteers were excluded from having not met the criteria set by the researchers in the supplementation period and one volunteer gave up in a total final sample of nine volunteers. Out of the nine volunteers, four were included in the group supplemented with Cr (CRE group) and five were part of the group which received placebo (PLA group).

Table 1. Characteristics of the creatine (CRE) and placebo (PLA) groups.

| Variable | CRE group N = 5 | PLA group N = 4 |
|---|-----------------|-----------------|
| Age (years) | 22 ± 2.8 | 25 ± 1.8 |
| Body mass (kg) | 68.9 ± 7.5 | 64.9 ± 10.3 |
| Stature (cm) | 177.5 ± 2.4 | 172.6 ± 3.6 |
| VO _{2max} (mlO ₂ .kg ⁻¹ .min ⁻¹) | 42.3 ± 4.0 | 44.3 ± 7.4 |

Procedures

After anamnesis the questionnaires of risk stratification (PAR-Q and Coronary Risk Factors) were applied. Maximal oxygen consumption (VO_{2max}) of the volunteers was set with the application of the direct protocol in cycle ergometer starting with load of 50 watts (W) and addition of 25W at every two minutes, where 50 rotations per minute should be performed until voluntary fatigue. Analysis was performed with the breath-by-breath open circuit spirometer, with the gas analyzer (VO2000, Imbrasport® brandname), previously calibrated, a heart monitor (POLAR®, model S610i – Finland) for heart rate recording (HR).

Minimum time of 48h were given after the aerobic test, always between eight and 10 o'clock in the morning, for blood samples collections (4ml) through puncture in the vein in the antecubital fosse for serum [Crn] and [urea] analyses, by the Labtest® method. Prior to the beginning of the Cr supplementation, the volunteers were familiarized with the test through performance of one W20 test with 20s duration and at the days of the pre-supplementation tests, body weight and height were checked with a scale with Filizola® stadiometer with 100g and 0.01m precision and subsequently they were taken to a room for performance of the preparatory exercise (activation).

Two minutes after the preparatory period, the W10 and W30 tests with duration of 10 and 30s, respectively were applied and the P_{max} and the mean power (P_{med}) during the two performed tests were analyzed. The volunteers performed the W10 test and after 20min of rest they performed the W30 test¹⁶. During the W10 and W30 tests, resistance of 0.075kg.kg⁻¹ was added to the body weight and they were told to pedal as fast as possible during the pre-set time¹⁷ besides receiving verbal encouragement during the exercise.

Blood samples (20µl) from the digital pulp of the volunteers were collected before and after the supplementation period, being performed 1.5min after the W10 test and three minutes after the W30^{5,6} test for [LA] analysis with a portable lactimeter (Accusport®). Two days after the pre-supplementation tests, the volunteers started the supplements ingestion, under double-blind procedure, receiving hence on the first five days plain Cr (Probiótica®) 20g/day (4 x 5g of Cr, in alternated times, or maltodextrin (Probiótica®) as placebo, followed by a phase of 5g of Cr or placebo per day for five extra days, being then divided in two groups: group CRE and group PLA. The supplements were given in kits with the products numbered and airtight packed.

At day 10 of supplementation, new blood samples were collected (4ml) for analysis of the [Crn] and [urea], body weight check and application of the W10 and W30 tests with P_{max} and P_{med} analyses in the two tests. Additionally before and after the tests the blood [LA] was also analyzed as in the pre-supplementation phase.

During the study the volunteers received recommendation to maintain normal diet, avoid physical activities during the supplementation period, especially 24 hours before the tests, and not to ingest alcohol and caffeine in that period. In addition to that, inges-

tion of the supplementation at the standardized days and times was recommended. The volunteers received telephone calls to verify if they were following the recommendations, and exclusion criteria were volunteer dropout, lack of recommendations following in the supplementation period and non-conclusion of the tests.

STATISTICAL ANALYSIS

The data met normal distribution for evaluation of the pre and post-supplementation variables and paired Student's t test with significance level of p < 0.05 was applied. The statistical software Sigma stat® was used. Data are presented as mean ± standard deviation. Sample calculation was performed considering the variability of the main variable (P_{max}) and confidence interval of 95% as parameters for determination of a minimum N able to identify possible differences¹⁸ and it was set that there would be four individuals per group.

RESULTS

Table 2 presents the results of the P_{max} and P_{med} reached during the W10 and W30 tests before and after the supplementation period in the CRE and PLA groups. Increase in P_{med} was observed in the W10 and P_{max} in the W30 (p < 0.05) in group CRE, which did not occur in the PLA group. No difference has been presented in the P_{max} in W10 and in P_{med} in the W30 when the pre and post-supplementation test are compared.

Table 3 presents the [LA] at rest, 90s after the W30 test and 80s after the W30s test, before and after the supplementation period. No significant difference has been found in either studied group.

Table 4 presents the data concerning the [Crn], plasma [urea] before and after the supplementation period in the CRE and PLA groups. Increase of [Crn] is observed when the pre and post-supplementation periods are compared in the CRE group (p < 0.05), the same situation did not occur with the PLA group. Concerning the [urea] and body weight values, no significant alterations have been found in these variables in the CRE or PLA groups.

Table 2. Mean and standard deviation of maximal power (W) and mean power (W), in the adapted Wingate test (W10) and 30s Wingate (W30) before and after the supplementation period of the CRE and PLA groups. Significance level: * p < 0.05 pre x post.

| Power | CRE group (Pre) | CRE group (Post) | PLA group (Pre) | PLA group (Post) |
|---------------|-----------------|------------------|-----------------|------------------|
| Maximal (W10) | 808.8 ± 58.2 | 829.5 ± 72.4 | 732.8 ± 112.0 | 732.6 ± 116.8 |
| Mean (W10) | 729.8 ± 53.1 | 755.8 ± 63.6* | 665.4 ± 97.9 | 664.6 ± 104.5 |
| Maximal (W30) | 789.5 ± 90.0 | 825.3 ± 94.6* | 736.4 ± 109.1 | 719.5 ± 126.0 |
| Mean (W30) | 643.0 ± 49.4 | 656.3 ± 53.3 | 587.4 ± 81.8 | 573.4 ± 81.5 |

Table 3. Blood [LA] (mmol/L) at rest, 90s after the W10 test and 180s after the W30 before and after 10 days in the CRE and PLA groups. Values in mean ± standard deviation.

| [LA] (mmol/L) | CRE group (Pre) | CRE group (Post) | PLA group (Pre) | PLA group (Post) |
|----------------|-----------------|------------------|-----------------|------------------|
| Rest | 1.8 ± 0.75 | 1.8 ± 0.71 | 2.2 ± 0.4 | 1.8 ± 0.30 |
| 90s after W10 | 6.7 ± 0.83 | 7.5 ± 0.22 | 7.4 ± 1.71 | 7.7 ± 1.15 |
| 180s after W30 | 14.3 ± 1.17 | 16 ± 1.8 | 16 ± 2.98 | 13 ± 3.6 |

Table 4. Values in mean and standard deviation of [Crn], [urea] and body weight before and after the 10 days of supplementation in the CRE and PLA groups. Significance: *p < 0.05 pre x post.

| Variable | CRE group (Pre) | CRE group (Post) | PLA group (Pre) | PLA group (Post) |
|-------------|-----------------|------------------|-----------------|------------------|
| Creatinine | 0.9 ± 0.08 | 1.3 ± 0.08* | 1.0 ± 0.16 | 1.26 ± 0.15 |
| Urea | 36.8 ± 3.3 | 40.3 ± 6.3 | 33.01 ± 6.9 | 41.8 ± 13.4 |
| Body weight | 68.9 ± 7.5 | 70.2 ± 8.5 | 64.9 ± 10.3 | 65.1 ± 12.6 |

DISCUSSION

The main finding of this study was the increase in P_{max} reached in the W30 test and in the P_{med} in the W10 test in the CRE group, which did not occur with the PLA group. Cr is a substance which is not present on the list of prohibitions by the World Anti-Doping Agency¹⁹ and despite the possibility of increase in the Cr concentration by specific training, evidence shows that supplementation is more efficient to increase the total content of this substrate².

The result of the P_{max} in the W30 corroborates the findings by Birch et al.²⁰, who used interval isokinetic exercises and duration of 30s before and after five days of CrS divided in four daily portions of 5g. These authors observed that CrS increased the power peak in the two first exercise sessions and suggest that the ingestion of Cr may increase performance in the proposed exercise.

The data found in the investigation by Dawson et al.²¹ also corroborated the findings of the present study, and the authors submitted the individuals to an exercise protocol in which they performed a cycle of runs of short duration and the volunteers received 5g of Cr or placebo four times a day during five days before repeating the tests. Additionally, optimization in performance of five sprints of 15s of duration in cycle ergometer was observed, followed by six sprints of 80m of ice skating and finally, a sprint of 47m of skating in the shortest time possible, before and after 10 day of supplementation with Cr²².

The study of the authors aforementioned used an exercise frequency which led to high anaerobic demand and depletion of specific energetic substrates. Additionally, the authors suggest that the Cr ingestion optimizes performance in the activity proposed and described above.

The result of the W30 test of the present study contrasts with the previous studies^{6,11}, which did not identify significant alterations in P_{max} during high-intensity and short duration test in the cycle ergometer after the CrS use. However, these authors used a protocol which consisted only of one stimulus and did not perform repeated stimuli which can cause the PCr depletion according to the present study, in which the 10s test was used. Probably, performance optimization after repetitive sprints caused by the CrS may occur due to increase of PCr resynthesis during the recovery period between them²³, which could have contributed to increase of P_{max} in the W30 test in the present study.

Concerning the P_{max} produced during the W10 test, no alterations have been identified in either group, (CRE and PLA), a result which is in concordance with the ones found in maximal exercise in cycle ergometer with 15s¹⁶ and 10s duration⁹.

Contrasting with the results of the present study, another investigation showed that performance in the adapted Wingate test was optimized as influence of CrS⁸; nevertheless, the W10 test occurred after performance of five sprints of 6s, which probably caused depletion in the PCr storage, differently from the present study, in which the W10 was performed with subjects coming from rest.

The results of the present study indicate increase of P_{med} in the W10 for the individuals who received the CrS, a fact which did not occur with the PLA group. This finding corroborates the results by Santos et al.²⁴, who observed increase of P_{med} in a sprint performed in cycle ergometer, being this alteration related with the 12 days of Cr supplementation performed between tests, a period similar to the

one adopted in the present study, which may have caused increase in the P_{med} . However, this finding contrasts with the ones observed in a study carried out in 20s¹¹ and 15s tests¹⁰. These authors did not report alteration in this variable after the use of CrS. Thus, considering that up to the 5s, greater contribution of the high-energy phosphates occurs³, for the calculation of the P_{med} these values would be more representative in evaluations with duration up to 10s, as occurred in the present study and in the one by Santos et al.²⁴.

Another factor which may have contributed so that the studies by Snow et al.¹¹ and Hoffman et al.¹⁰ have not found increase in P_{med} in the W10 is the fact that these authors used the CrS during five and six days, respectively, while in the present study and in the one by Santos et al.²⁴, the CrS occurred during 10 days. Additionally, increase in P_{med} in 10s has not been observed in the Wingate test after the CrS during three days with 20g/day either⁶.

The supplementation time is a factor to be considered since it is able to determine the increase of the CP plasma concentrations and hence enable the alteration in performance in high-intensity and short duration activities. Vandenberghe et al.⁷ verified increase of 7% in the CP/ATP ratio after four days of CrS, and increase 15% in the CP/ATP ratio was observed in another study after six days of CrS²⁵. Increase of 21% in the CP/ATP ratio was also observed after 12 days of CrS²⁴.

Concerning the P_{med} in the W30 test, there was no difference between the pre and post-CrS situations. This situation also occurred in the study by Odland et al.⁶, who submitted physically active individuals to CrS and the W30 test. The authors used a CrS protocol of only three weeks, and despite the use of a longer CrS protocol and a test which increased the substrate depletion, namely the W10, which would enable boosting of the CrS benefits, performance in the W30 has not been altered. No study which verified increase in P_{med} in the W30 was found.

Although in the present study the PCr and total Cr has not been analyzed, it is suggested that the Cr supplementation may have contributed to increase the supplied of this substrate and consequently, optimize performance. Studies have shown that CrS may result in increase of Cr concentration in the blood and in the muscle. Previous studies identified increase in the plasma Cr concentration, and the authors stated that this factor would increase the capacity of Cr incorporation by the muscle cells and hence, increasing the concentrations of this substrate in the muscle^{2,26}. Additionally, increase in the muscular Cr has been identified by biopsies performed after individuals have been submitted to CrS^{5,8}.

Possibly, performance increase in high-intensity and short duration anaerobic activities is justified by the fact that CrS enables increase of the PCr muscular concentration, contributing hence to the fast rephosphorilation of ADP in ATP through the creatine kinase enzyme²⁷. Moreover, a probable means for the CrS alters performance in high-intensity and short duration exercises is the increase in the supply of PCr at rest and higher availability of this substrate during exercise⁵. Hultman et al.²⁵ suggest as theoretical grounding for supplementation from 5 to 6g of Cr the capacity of these values to be able to maximize the concentration of muscular Cr, which can be corroborated by the increase in the Cr, PCr and [TCr] content reported after five days with 20g/day of CrS²⁸.

In clinical practice, [Crn] is used for estimation of the glomerular filtration rate (GFR), being it a subproduct of the muscle Cr metabo-

lism, produced with steady velocity and its quantity is proportional to the muscular mass¹³. Increase in plasma [Crn] may be an indication of disease progression, while its decrease suggests recovery in renal function¹³. As presented here, there was alteration in [Crn] after CrS. It is suggested that the Cr use may cause disturbs in the renal function of humans²⁹, especially in ingestion of high doses, and the high [Crn] in urine or plasma probably occurs due to the limited capacity of the muscle fibers to store Cr²; however, the values found are considered normal for the analysis of renal function.

The result of the present study is in accordance with the findings by Derave et al.¹⁴, who, in a study with ingestion of 20g of CrS during a week, also observed increase in [Crn]. Similar results were found after six days², and five days of CrS²⁶.

The [urea] analysis performed in the present study is justified by the fact that like the [Crn], [urea] is an indicator of renal function¹²; however, difference between pre and post-supplementation [ureia] has not been identified in this study in the CRE or PLA group.

The results of the present study corroborate the findings by Cañete et al.³⁰ through seven days of CrS. Nevertheless, they disagree with the findings of a study which found significant increase of [urea] six weeks after CrS¹². However, the CrS period was longer than the one adopted in the present study. No further studies which evidence increase in urea concentration has been found, suggesting hence that short-term CrS does not promote alteration in this variable.

CrS may result in reduction of [LA] due to the increase in reserves of muscular Cr⁸; however, according to the results presented, no alterations have been verified when the pre and post-supplementation periods were compared in both CRE and PLA groups. These results corroborate the findings by Mujika et al.⁴ and Balsom et al.⁵, comparing before and after six days of CrS. Jumps with high-intensity runs and high-intensity exercises in cycle ergometer were used, respectively.

Nevertheless, the result of this study clash with the findings by Söderlund et al.⁸, who presented reduction in [LA] after the use of CrS in high-intensity and short duration exercises. According

to these authors, this decrease may be explained by the increase in the concentration of muscular PCr verified after CrS; however, the different exercise protocol used by the authors in their studies may have influenced on this [LA] decrease. In this study, exercise consisted of five 6s-sprints and one 10s-sprint in cycle ergometer, differently from the exercise protocol of the present study.

After the supplementation period of this study, no change in body weight has been observed in the CRE or PLA group. These results corroborate the findings of the research carried out with CrS during five⁹ and seven days³⁰. However, further studies showed significant increase of body mass after a short period of CrS⁴. However, these findings related the increase of body mass with the use of CrS and did not relate a consistent justification and in agreement for this alteration.

According to Mujika et al.⁴ and Engelhardt et al.², the increase in body weight caused by the CrS may be due to the water retention, a fact which is corroborated by Hultman et al.²⁵, who observed reduction of urinary volume consequent of the CrS besides suggesting that the body weight increase derived of this supplementation may have been caused as a consequence of the water retention.

As a conclusion, CrS promoted increase in P_{max} during the W30 test and in the P_{med} in the W10 test. Additionally, the CrS did not interfere in health parameters, considering the acceptable levels or altered body weight of the volunteers.

Thus, it is suggested that the CrS may improve performance of high-intensity and short-duration exercise in cycle ergometer, as in the Wingate test; however, the correlation of [Crn] increase with renal function should be observed; therefore, medical and nutritional follow-up before the use of Cr as an ergogenic device is recommended.

All authors have declared there is not any potential conflict of interests concerning this article.

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