ORAL CREATINE SUPPLEMENTATION AND SHORT-TERM DYNAMIC POWER PRODUCTION IN HEALTHY YOUNG MEN

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This experiment examined the effect of creatine monohydrate supplementation on corrected peak power output and peak acceleration during repeated, high intensity sprint cycling. The investigation was randomised, placebo-controlled, double-blind and adopted a crossover design. Eight male, adult volunteers participated in this study. Subjects were administered with creatine monohydrate (0.28g.kg-1 per day) or a glucose placebo. Following experimental treatments, subjects underwent 10 maximal effort, 6-s sprints on a cycle ergometer with a work to rest ratio of 5:1. The exercise protocol was fatiguing in nature with peak power output and peak acceleration decreasing significantly from the first to last sprint. Creatine supplementation significantly attenuated the decline in peak power output in the latter stages of the intermittent sprint cycling.

KEY WORDS: fatigue, intermittent exercise, peak power output, acceleration.

INTRODUCTION: The ability of skeletal muscle to maintain power output during repeated concentric contractions is extremely important for humans in a wide range of working and sporting situations. Phosphocreatine (PCr) plays a central role in short-term dynamic power production. Depletion of muscle PCr during intense exercise is associated with the onset of muscle fatigue and with a reduced maximum velocity during contraction (Rossiter et al., 1996). Oral creatine supplementation increases total creatine content (TCr) of skeletal muscle. Such augmentation of skeletal muscle TCr has been demonstrated to increase work capacity during intermittent bouts of fatiguing, high-intensity exercise. Commonly, these studies have utilised isokinetic dynamometers (Greenhaff et al., 1993) or cycle ergometers used to monitor the maintenance of a specific pedal velocity (Balsom et al., 1993; Balsom & Sjödin, 1995) or other devices in which the velocity of the work challenge is held constant (Yquel et al., 2002). However, in “real life” situations, generation of muscle power output requires rapid changes in velocity (i.e. acceleration and deceleration). Lakomy (1986) determined that the traditional calculations of power output on a cycle ergometer as a product of pedal velocity and resistive load (RL) were fundamentally flawed and underestimated true power output. During sprinting on a cycle ergometer, an excess load is applied by the individual in the form of acceleration of the flywheel, which requires significantly more work to be done than would be needed to simply maintain constant velocities (Lakomy, 1986). Accordingly, Lakomy (1986) developed a mechanism for calculating “corrected” power output, which accounts for this excess load. The purpose of this investigation is to examine creatine supplementation’s ergogenic effect during fatiguing, intermittent sprint cycling on an ergometer that is allowed to accelerate freely. Previous studies, which utilised uncorrected methods of power output calculation, or did not examine creatine supplementation’s effect on capacity to accelerate repeatedly may have over- or under- estimated the magnitude of performance improvement associated with creatine supplementation. The examination of peak acceleration rates and the corrected method of power output calculations utilised in the current study, allows the opportunity to examine the effect of creatine supplementation on this accelerative component of performance that previous studies, which held the velocity of work challenge constant, do not observe.

METHOD: Eight male adults, of varying activity profiles, participated in the study (mean ± S.D.) age: 21.1 ± 0.7 years; height 1.80 ± 0.05 m, mass: 79.6 ± 6.3 kg. Subjects who had supplemented with a creatine product within the previous 6 months were excluded from participation. The University’s research ethics committee approved the study and informed consent was obtained in writing, from all subjects prior to their participation.

Procedures: Performance testing in this study utilised repeated 6-second maximal sprints on a friction braked MONARK 814E with a hanging weight basket for the application of the RL. Prior to creatine or placebo supplementation, subjects underwent habituation sessions. Subjects performed a maximal sprint four times against a RL of 6% of body mass. Full recovery was allowed between each sprint. Subjects were deemed habituated when measures of corrected peak power output (PPO) and peak acceleration ($Peak_{acc}$) could be reproduced within 10% for each sprint. Following successful habituation, subjects consumed a dosage of creatine monohydrate (CR) (0.28g.kg-1 per day) in 500g of flavoured yoghurt, or a glucose placebo (PLA), mixed in flavored yoghurt, for five days. The experimental intervention employed a randomised, double blind, crossover design. PLA administered subjects received CR following a washout period and vice versa. Subjects consumed the yoghurt in quarter portions at equal time intervals throughout the day. Mean ingested creatine monohydrate was 22.5g ± 2.4g per day. A washout period of 12 weeks (87 □ 4 days) was provided between experimental treatments. On the day following the experimental treatments and after a standardised submaximal warm-up, subjects performed 10, 6-s maximal sprints against a RL of 6% body mass, with 30-s recovery between trials representing a work to rest ratio of 5:1. This testing protocol has been demonstrated in the literature to predominantly tax the PCr energy pathway (Gaitanos et al., 1993) and induce significant fatigue (Billaut et al., 2005; Gaitanos et al., 1993).

Subjects were restrained by pedal toe clips and were harnessed around the waist to ensure a consistent, seated, body position throughout all sprints and between experimental treatments. A photo-optic sensor measured the angular velocity of the of the ergometer's flywheel. The rim of the flywheel was divided into 120 segments. One full revolution of the flywheel corresponded to the sensor being interrupted 120 times. The sensor was interfaced with a PC running the Wingate Test Software (Cranlea, Birmingham, UK). This software was used to determine the inertia and frictional torque of the flywheel through a series of deceleration trials. The trials were performed from a maximum speed of 140rpm with the applied RL ranging from 1-3kg in 0.5kg increments. These values were used to correct the derived power outputs from the maximal effort sprints. The Wingate software provided values for pedal velocity, flywheel acceleration and corrected power output at a sampling frequency of 18Hz. The raw data were exported to software package Microsoft Excel (version 9.0.6926), smoothed through 1-second averaging and graphically represented with respect to time. $Peak_{acc}$ and PPO were manually determined by identifying the maximum value of each variable in each sprint from the graphs of this smoothed data. The total work done per sprint was calculated by integrating the area under the power curve from the point at which the subject starting sprinting.

Statistical Analysis: All statistical analysis of the data was carried out in SPSS © (Release 13.0.1). The fatiguing effect of the procedure was assessed under the PLA condition utilising a paired student t-test between the first and last trials, for the dependent variables. Comparative analysis, between the creatine and placebo groups utilised a general linear model (GLM), ANOVA with repeated measures. The effect size between interactions was determined using partial eta squared (η_p^2). The GLM had two within-subjects factors: namely, Group (with 2 levels: Cr or PLA supplementation) and sprint number. The dependent variables were $Peak_{acc}$, corrected PPO and total work done. The model included all interaction terms. A significance level of 0.05 was adopted for all statistical analysis of the data.

RESULTS AND DISCUSSION: Fatigue, during activities such as cycling which involve repeated concentric contractions, has been described as a loss of maximal force generating capacity or a loss of maximal power output (Vøllestad, 1997). During the intermittent maximal exercise, under the PLA condition, corrected PPO decreased significantly from sprint number one to 10 (-21%; $p = 0.0005$), as did peak acceleration (-28%; $p \leq 0.00009$) and total work done per sprint (-21%; $p = 0.0007$). This established that the testing procedure induced fatigue in the subjects and that no "pacing effect" occurred. Pair-wise comparison results for

PPO under the PLA condition confirmed the exhausting effect of the protocol and revealed three distinct phases of fatigue: An un-fatigued phase (sprint 1 and 2) where peak power output was unchanging, a fatiguing phase (sprints 3 through 7) where peak power output was progressively decreasing and a fully fatigued phase (sprints 8, 9 and 10) where peak power output was significantly lower than the previous 2 phases but was neither further decreasing nor increasing. With no changes in PPO taking place across sprints 8, 9 and 10 it suggests that PCr stores may be reduced in their contribution to energy provision and that it may no longer be the primary metabolic pathway driving performance.

Table 1: Mean (± S.E.M.) corrected and uncorrected PPO, $Peak_{acc}$ and total work done per sprint (* denotes significance at 95% confidence interval).

Sprint	Placebo	Creatine	p, η_p^2
	Corrected PPO (W)		
1-10	820 (±117)	856 (±117)	0.085, 0.364
1-2	934 (±77)	973 (±97)	0.206, 0.218
3-7	819 (±100)	846 (±97)	0.209, 0.215
8-10	744 (±108)	794 (±105)	0.014*, 0.602
	Peak Acceleration (rads.s-2)		
1-10	11.0 (±2.2)	11.5 (±2.1)	0.305, 0.149
1-2	13.2 (±1.5)	13.5 (±1.4)	0.681, 0.026
3-7	11.1 (±1.7)	11.7 (±1.8)	0.247, 0.186
8-10	9.4 (±1.9)	9.9 (±1.7)	0.350, 0.125
	Total Work Done (J)		
1-10	5515 (±820)	5707 (±875)	0.106, 0.329
1-2	6329 (±454)	6566 (±672)	0.125, 0.302
3-7	5498 (±707)	5614 (±827)	0.367, 0.117
8-10	5000 (±769)	5289 (±682)	0.074, 0.386

Table 1 presents data of corrected PPO, $Peak_{acc}$ and total work done per sprint during the intermittent sprint testing protocol. When analyzing a main effect over all 10 sprints no significant differences were observed between treatments. However a trend toward increased corrected PPO under the CR condition was observed with a moderate effect size ($p = 0.085$, $\eta_p^2 = 0.364$). No significant differences were observed in any of the measured variables during in the un-fatigued phase (sprints 1 and 2) or the fatiguing phase (sprints 3 - 7) between experimental treatments ($p \geq 0.1$, $\eta_p^2 \leq 0.302$). When comparing the fully fatigued phase (sprints 8, 9 and 10) between treatments it was observed that, under the CR condition, subjects generated significantly greater peak power ($p = 0.014$, $\eta_p^2 = 0.602$). Following the CR treatment, subjects also demonstrated a trend toward an increase in total work done in each of the final three sprints ($p = 0.074$, $\eta_p^2 = 0.386$). No significant difference in $Peak_{acc}$ was observed between protocols ($p = 0.350$, $\eta_p^2 \leq 0.125$).

Corrected power output = (RL + excess load) x flywheel speed (m.s-1), where, the excess load is determined by acceleration of the flywheel. $Peak_{acc}$ was unaffected by the CR treatment. The ergogenic effect evidenced during the end-phase of fatigue must then be due to an increase in flywheel speed (since the third variable, RL is held constant). CR supplementation therefore does not affect the maximal rate of acceleration but may increase the amount of time for which a high acceleration can be maintained, increasing flywheel speed and subsequently increasing peak power output.

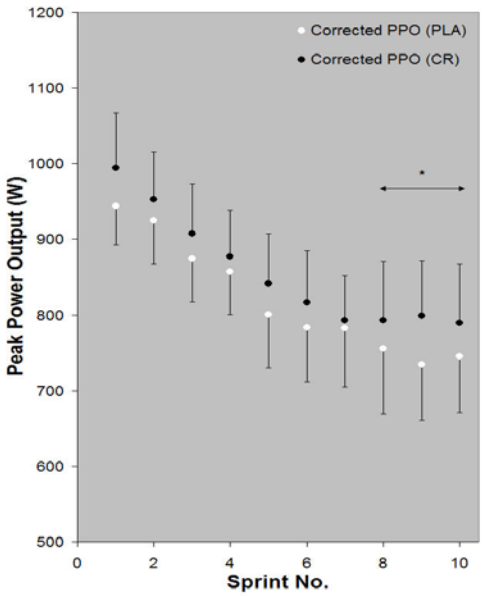

Figure 1: Mean (± 95% confidence interval) Corrected PPO under both experimental conditions during the intermittent sprint protocol (* denotes significance at 95% confidence interval).

CONCLUSION: The repeated maximal sprinting decreased PPO, peak acceleration and the total work done per sprint over the course of the ten sprints. The results of this study demonstrate that 5 days of CR supplementation (0.28 g.kg-1) attenuated the decline in PPO in the latter stages of intermittent sprint cycling. The ergogenic effect of CR supplementation allows for a greater maintenance of power production during repeated maximal effort bouts of work. This in turn may result in significant training effects over time. The study indicates the importance CR supplementation can have in activities requiring repeated maximal power production.

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