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Original Article

Influence of creatine supplementation on 800 m wheelchair performance: a pilot study

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Study design: Double-blind, placebo-controlled, randomly assigned, crossover.
Objective: To assess the influence of a short-term oral creatine supplementation on 800 m wheelchair performance.
Setting: Swiss Paraplegic Centre, Nottwil, Switzerland.
Subjects: In total, six (four male, two female subjects) competitive wheelchair athletes participated in the study. Their age was 33.0 ± 9.1 years, height 171.5 ± 7.7 cm and weight 63.1 ± 6.2 kg. Average weekly training volume was 10.0 ± 3.7 h. All of them have been engaged in regular training for over 10.5 ± 7.2 years.
Methods: During the two treatment periods, subjects ingested 4×5 g of creatine monohydrate or placebo (maltodextrin) daily during 6 days in a randomised order. A washout period of 4 weeks lay in-between the two supplementation periods. Before and after each treatment period athletes performed an all-out 800 m wheelchair test on a training roller. Time to complete 800 m, rate of perceived exertion (RPE), lactate concentrations and heart rate were measured. Before each test, body weight was determined.
Results: Times to complete 800 m before and after creatine supplementation (102.8 ± 13.9 *versus* 100.5 ± 11.3 s) compared to before and after placebo supplementation (101.6 ± 15.6 *versus* 99.5 ± 13.8 s) were not significantly different. Moreover, for all other parameters measured, no significant differences between creatine and placebo supplementation were found.
Conclusion: A short-term oral creatine supplementation compared to placebo seems not to enhance performance over 800 m in trained, spinal cord-injured, wheelchair athletes.
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Keywords: SCI; wheelchair racing; RPE; exercise performance; creatine

Introduction

The positive ergogenic effect on exercise performance after creatine supplementation in healthy, able-bodied subjects was shown by several studies in the past few years.[1–9] In general, enhanced performance was found in repetitive, high-intensity, short-term exercise tasks. Furthermore, creatine was successfully used also in patients with chronic heart failure, mitochondrial cytopathies and neuromuscular disease.[10–12] In spinal cord-injured (SCI) persons, there exists only one study[13] that shows a beneficial effect of creatine supplementation on exercise performance in a group of 16 untrained tetraplegic subjects. In this study, subjects significantly increased peak power output in an incremental peak arm ergometry test by 6.7% and maximal oxygen uptake by 17.4%.[13] So far, to our knowledge, no study investigated the influence of oral creatine supplementation on exercise performance in competitive wheelchair athletes. Moreover, scientific data on single bout exercise performance under sport specific competition-like conditions are limited in highly trained athletes.[14] Independent of this fact, some wheelchair athletes regularly ingest creatine expecting an increased exercise performance during competitions. Since arm muscles contain more type II fibres than leg muscles and since type II fibres have initially a higher phosphocreatine content than type I fibres,[15] it could be speculated that creatine supplementation would be less efficient for arm exercise. Thus, the aim of the present study was to investigate the influence of a short-term oral creatine supplementation on 800 m wheelchair performance in competitive SCI athletes.

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Methods

Subjects
In total, six healthy, nonsmoking, trained wheelchair racers (four male, two female subjects) participated in the study. Their anthropometric data as well as impairment and training information are shown in Table 1. All subjects were familiar with exercise testing procedures and the equipment used. Five out of six athletes reported that they have never supplemented any creatine so far. The sixth subject confirmed not to have ingested creatine for at least 6 months preceding the study. The study was approved by the local ethical committee. Written informed consent of the subjects was obtained prior to the start of the study.

Study design
A double-blind, placebo-controlled, crossover study was performed. Therefore, subjects were randomly assigned into two groups A and B. The study protocol consisted of two treatment phases lasting for 6 days, separated by a washout period of at least 28 days, which was found to be adequate to allow serum creatine levels to return to baseline.[16–18] Before and after each treatment phase, subjects had to perform an exercise test as described in detail below.

Group A received creatine monohydrate (4×5 g per day) during the first and placebo (maltodextrin; 4×5 g per day) during the second treatment phase. Subjects in group B were supplemented conversely with placebo during the first and creatine during the second treatment period. Both supplements were similar in colour and texture, so that subjects were not able to identify which supplement they ingested.

Subjects were asked to perform no strenuous exercise the day before a test and to abstain from caffeine intake on the day of the test as well as during the 2 weeks of supplementation during the study. Additionally, subjects were instructed to follow their habitual dietary regimen during the study. Training over the period of the study as well as nutrition of the day before and on the test days was held constant and recorded.

Equipment
All tests were performed on a free wheeling trainer (Spinner, New Halls Wheels, Cambridge, USA). Distance covered as well as top and average speed was measured by a speedometer (CicloMaster, CM 209, KW Hochschorner GmbH, Krailling, Deutschland), which was calibrated and mounted on the training roller.

Heart rate was recorded by a heart rate monitor (Polar Vantage NV, Polar Electro, Kempele, Finnland) and rate of perceived exertion (RPE) was determined by a Borg scale ranging from 6 to 20.[19] Blood lactate concentration was analysed enzymatically (Super GL Ambulance, Ruhrtal Labor Technik, Möhnesee, Germany).

Experimental procedure
Before each test session, body weight of the subjects was determined. The test session started with a warm-up period of 10 min at a predetermined velocity corresponding to 65% of the velocity of the personal best time over the distance of 800 m. After 4 and 6 min of the warm-up session, subjects had to start sprinting and to hold top speed for 10 s and subsequently continued at the predetermined velocity. This regimen was chosen to simulate the warm-up before a competition.

The warm-up period was followed by a 10 min rest. Thereafter, subjects had to complete 800 m as fast as possible. Verbal encouragement was given and subjects were informed about the distance completed every 100 m. Completion of the 800 m distance was followed by a 6 min resting period.

Heart rate was measured from the beginning of the warm-up period to the end of the test. Lactate was sampled before and after warm-up, before and after completion of the 800 m distance, as well as 2, 4 and 6 min postexercise. RPE was asked before and after the warm-up and before and at the end of the 800 m distance.

Statistics
Results are given as means $\pm$ SD. A two-way ANOVA (analysis of variance) for repeated measures was used to

Table 1 Anthropometric data, impairment and training information of subjects

Sex	*Age (years)*	*Height (cm)*	*Weight (kg)*	*Lesion level*	*ASIA/ impairment*	*Impairment since (years)*	*Training volume (h/week)*	*Training since (years)*
m	23	170	68.9	L 1	A	23	8	8
m	39	173	61.1	Th 4	A	17	10	15
m	45	180	61.2	Th 5	A	25	17	22
m	36	164	60.7	—	Spina bifida	36	9	5
f	33	162	54.9	Th12	A	28	10	11
f	22	180	71.8	—	Hemiparese	3	6	2
Mean	33.0	171.5	63.1			22.0	10.0	10.5
SD	9.1	7.7	6.2			11.2	3.7	7.2

SD = standard deviation

assess differences in measured parameters. Values were considered to be significantly different if $P<0.05$.

Results

Creatine supplementation showed no influence on 800 m all-out wheelchair performance compared to placebo (Figure 1). Further, no differences were found between creatine and placebo intake during 6 days for body weight, RPE, peak heart rate, mean heart rate, maximal velocity and lactate concentrations (Table 2) during the 800 m exercise test.

During the warm-up periods preceeding the 800 m exercise tests, no significant differences were found for all measured data.

Discussion

The main finding of the study was that a short-term creatine supplementation did not enhance 800 m wheelchair racing performance compared to placebo (Figure 1). Furthermore, all other parameters measured, for example, body weight, lactate concentrations, heart rate and RPE were not different between the creatine and placebo treatment (Table 2).

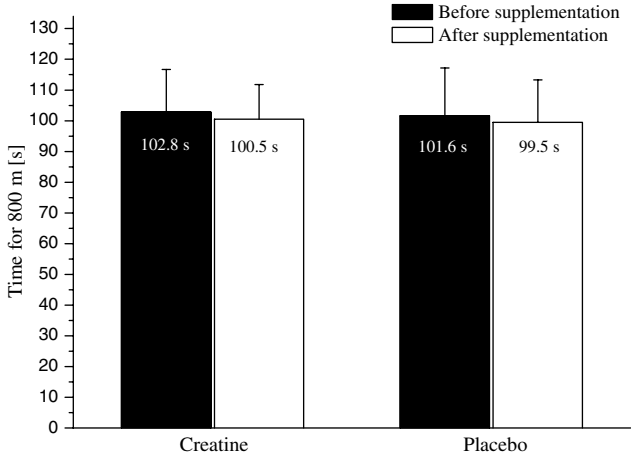

Figure 1 Time to complete an all-out 800 m wheelchair exercise test before and after a short-term creatine and placebo supplementation. Note that there were no significant differences between tests

Although the creatine kinase system is not the principal energy supplier during an 800 m wheelchair race, an increased level of phosphocreatine may possibly diminish lactic acid formation[20] and therefore enhance performance. This provides some evidence for the use of creatine supplementation for exercise bouts lasting longer than 30 s. In fact, a significant increase of 8.5% of time to exhaustion from 130 to 141 s at a workload corresponding to 125% of maximal oxygen uptake during cycle ergometry was demonstrated,[6] and Prevost *et al*[8] found a 23.5% increase of total work time during cycling at 150% peak oxygen uptake. Further, creatine supplementation enhanced exercise performance in elite kayak paddlers during time trials between 90 and 300 s duration.[7]As during the propulsion of a wheelchair, less but similar muscle groups are involved as during kayaking, a positive ergogenic effect of a creatine supplementation was also expected during an all-out 800 m wheelchair test, a hypothesis that was not confirmed by our study. Possibly, the differences in total muscles mass involved during kayaking compared to wheelchair racing seemed to be of higher impact than expected and might be responsible for the reported discrepancies concerning an ergogenic effect. Moreover, lactate concentrations were not influenced by creatine supplementation in the present study, which supports the hypothesis that the glycolytic pathways were unaltered by creatine supplementation as proposed by Birch *et al*.[2]

Many studies in the past reported positive effects on performance of different types and durations after a short-term creatine supplementation,[1–8,21] whereas others found no effect.[16,22–26] Interestingly, in most of the studies showing no ergogenic effect on exercise performance after creatine supplementation, a time or distance trial was performed,[22–26] whereas in studies with a positive effect the time to exhaustion at a given workload was determined.[3,8,9,21] This type of exercise test depends mainly on metabolism and remaining energy stores, whereas during time trials higher movement frequencies are required to improve test results. This is also a neuromuscular problem that not only depends on energy sources. Hence, also during our

Table 2 Parameters measured before and after creatine as well as placebo supplementation of an all-out 800 m wheelchair racing exercise test

Parameter	*Creatine supplementation*		*Placebo supplementation*	
	Pre	*Post*	*Pre*	*Post*
Body weight (kg)	63.1±6.2	63.1±6.2	63.0±6.0	63.0±6.0
RPE	18.5±1.9	18.2±1.6	18.5±1.2	18.7±1.5
Lactate (mmol/l)	7.07±1.82	7.21±2.42	6.72±1.69	6.06±2.23
Peak HR (bpm)	181.3±5.6	180.5±6.2	178.2±6.9	182.5±7.9
Max. velocity (km/h)	31.8±4.4	32.0±3.2	32.4±4.6	33.1±3.8

RPE = rate of perceived exertion; HR = heart rate

800 m wheelchair test, neuromuscular coordination possibly was one of the limiting factors of exercise performance and might explain that in the present study performance did not improve due to creatine supplementation. Nevertheless, one could speculate that athletes indirectly benefit from creatine supplementation during intense interval training sessions using repeated bouts of shorter distances with limited recovery durations, which may lead to an enhanced performance during competitions. Further investigations are needed to prove this hypothesis.

The lack of beneficial effects of creatine ingestion on exercise performance in the present study may also have further reasons. Most studies investigated the influence of creatine supplementation on leg muscle performance.[1–6,8,9,16,24–26] Since arm muscles contain more type II fibres than leg muscles and since type II fibres have initially a higher phosphocreatine content than type I fibres,[15] it could be hypothesised that creatine supplementation would be less efficient for arm exercise, an assumption that is supported by our findings. However, this hypotesis has to be investigated in further studies, as one cannot conclude definitely if an initially higher phosphocreatine content of arm muscles limits the effectiveness of a creatine supplementation in this muscle group.

Further, a methodological bias in the oral supplementation design is possible. There is some evidence that this assumption can be discarded, as the present type of supplementation programme has previously been successful in other studies.[4,13,27] In the study of Jacobs *et al*,[13] an increased peak power and maximal oxygen uptake in an incremental peak arm ergometry test after short-term creatine supplementation was even found in SCI patients. As subjects (tetraplegic patients *versus* top class wheelchair athletes) and exercise testing (incremental test on an arm ergometer *versus* 800 m all-out test in a racing wheelchair) completely differ from the present study, results are difficult to compare. It has also to be taken into account that SCI subjects often suffer from malnutrition[28] and therefore possibly benefit from creatine supplementation. In contrast, athletes usually pay attention to their diet, being aware of the positive effects of nutrition on exercise performance. This might explain the different results between the two studies investigating SCI subjects.

Test preparation and warm-up procedure may influence results of a subsequent exercise test. Hence, warm-up in the present study was standardised and no significant differences were found between different test days concerning all measured parameters.

It was also demonstrated by Vandenberghe *et al*[29] that caffeine intake counteracts the ergogenic effect of muscle creatine loading. In order to avoid this negative effect in the present study, subjects had to abstain from caffeine intake in any form on test days as well as during the 2 weeks of supplementation. We are therefore confident that caffeine intake is not responsible for the lack of a beneficial effect on 800 m wheelchair performance.

Body mass increases up to 2 kg were reported after short-term creatine supplementation.[1,7,23,30] Interestingly, one study with women only found a small, nonsignificant increase in body mass compared to placebo.[31] This could possibly be due to their smaller muscle mass. This assumption is supported by other investigations in older men, where only a small or no increase in body mass was reported after creatine supplementation.[32,33]

A SCI leads to a muscle atrophy particularly in the paralysed limbs but also in the lower trunk, depending on lesion level. Thus, the decreased total muscle mass of SCI compared to able-bodied athletes possibly impedes weight gain after creatine supplementation due to lower net creatine retention in total.

Finally, concerning exercise performance, the placebo effect may be an important phenomenon.[34] In our study, the mean improvement in 800 m exercise performance was 2.3 s after creatine supplementation and 2.1 s after placebo treatment, which suggests that also in the present study a placebo effect may not be excluded.

Conclusions

The present study suggests that a short-term creatine supplementation seems not to enhance 800 m wheelchair performance in trained SCI athletes.

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