

Creatine Supplementation in Young Soccer Players

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The purpose of this study was to examine the effects of acute creatine-monohydrate supplementation on soccer-specific performance in young soccer players. Twenty young male soccer players (16.6 ± 1.9 years) participated in the study and were matched and allocated to 2 randomly assigned trials: ingesting creatine-monohydrate supplement (3×10 -g doses) or placebo for 7 days. Before and after the supplementation protocol, each subject underwent a series of soccer-specific skill tests: dribble test, sprint-power test, endurance test, and vertical jump test. Specific dribble test times improved significantly in the creatine group (13.0 ± 1.5 vs. 10.2 ± 1.8 s; $p < .05$) after supplementation protocol. Sprint-power test times were significantly improved after creatine-monohydrate supplementation (2.7 ± 0.4 vs. 2.2 ± 0.5 s; $p < .05$) as well as vertical jump height (49.2 ± 5.9 vs. 55.1 ± 6.3 cm; $p < .05$) in creatine trial. Furthermore, dribble and power test times, along with vertical jump height, were superior in creatine versus placebo trial ($p < .05$) at post-supplementation performance. There were no changes in specific endurance test results within or between trials ($p > .05$). There were no between-trial differences in the placebo trial ($p > .05$). The main finding of the present study indicates that supplementation with creatine in young soccer players improved soccer-specific skill performance compared with ingestion of placebo.

Key Words: acute creatine supplementation, dribble test, sprint-power test, vertical jump

Introduction

Creatine is a naturally occurring amino acid derivative, but it is also a normal dietary constituent with a daily requirement of approximately 2 to 3 g depending on body size and rate of turnover (25). About 95% of the body's creatine is stored in skeletal muscle, with 60 to 70% of skeletal muscle creatine phosphorylated, creating phosphocreatine (PCr), which is effectively trapped in the muscle where it is involved in the anaerobic production of adenosine triphosphate (ATP; 14). Creatine-monohydrate is a popular nutritional supplement that is used by physically active people to increase lean body mass and improve performance in single and repetitive high-intensity, short-duration exercise tasks such as weightlifting, sprinting, and cycling

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(2, 3, 15). Since the early 1990s, the efficacy of creatine as an ergogenic aid has been studied extensively (5, 6, 25, 34). There is considerable, but not unanimous, support for the ergogenicity of creatine. However, there is a shortage of scientific data concerning the possible effects of oral creatine-monohydrate supplementation on specific performance in sports such as soccer, which consists of intermittent repeated bouts of high-intensity exercise. Moreover, most of the available literature has studied the effects of creatine on physically active adult males and females (4, 8, 18, 24, 29, 32). The effect of creatine supplementation on young competitive athletes has received much less research attention. Hence, the purpose of this study was to examine the effects of acute creatine-monohydrate supplementation on soccer-specific performance in young soccer players.

Methods

Subjects

Twenty young male soccer players (1st Yugoslav Junior league) gave their informed consent and volunteered to participate in the study, which had the approval of the University's Ethical Advisory Commission. All participants were fully informed verbally and in writing about the nature and demands of the study as well as the known health risks. They completed a health history questionnaire and were informed that they could withdraw from the study at any time, even after giving their written consent. The mean \pm *SD* age, height, weight, maximal oxygen uptake ($\text{VO}_{2\text{max}}$), and maximal heart rate (HR_{max}) of the subjects were 16.6 ± 1.9 years, 175.2 ± 9.1 cm, 63.6 ± 5.6 kg, 50.1 ± 6.3 $\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$, and 202 ± 3 $\text{beats} \cdot \text{min}^{-1}$, respectively. All subjects were in good health (free from musculoskeletal dysfunctions, and metabolic and heart diseases), participating in consistent soccer training (average of four times or 6 h per week) for the past 2 years and not currently taking a dietary supplement that contains creatine (or any sport supplement at all).

Experimental Procedures

The players were allocated to two randomly assigned trials: ingesting creatine-monohydrate supplement (CM; 3×10 -g doses) or placebo (P) for 7 days. Subjects in the placebo group ingested an equal number of identical looking pills that contained cellulose. The groups were matched (CM vs. P) for subjects' age (16.9 ± 1.5 vs. 16.2 ± 2.3 years), weight (63.7 ± 3.9 vs. 63.5 ± 7.1 kg), height (175.0 ± 9.2 vs. 175.5 vs. 9.4 cm), maximal oxygen uptake (49.9 ± 6.6 vs. 50.3 ± 6.4 $\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$), and playing positions (all positional roles were equally represented in both groups) to balance the difference in skill. There were no statistical differences between the groups ($p > .05$) on the items they were matched on. Baseline testing was performed prior to supplementation, and the athletes were familiar with testing procedures as part of their regular training process. Seven days prior to the baseline and experimental testing, all subjects consumed the same standardized diet (55% of the calories were derived from carbohydrate, 25% from fat, and 20% from protein) to ensure that their glycogen stores were equally loaded. In the 72 h before the experiment, the subjects were asked to refrain from any prolonged exercise. Subjects reported to the examination field at 11 a.m. after a fast of between 10 and 12 h. On the test day, subjects consumed a controlled breakfast (providing an average of 800 ± 42 kcal) 4

h before the test. After that period, all subjects drank only plain water ad libitum. In order to assess potential side effects to the supplementation regimen, all subjects were instructed to report any adverse effects of supplementation (changes in appetite, thirst, muscle soreness and cramping, stomach distress, diarrhea, aggression).

Before and after the supplementation protocol, each subject underwent a series of soccer-specific skill tests: dribble test, sprint-power test, vertical jump test, and endurance test. The dribble test was identical to that described by McGregor et al. (21), while the sprint-power test was identical to that described by Ostojic (27). Vertical jump height was estimated using a force platform (Newtest Powertimer Testing System, Finland). All subjects had a preparatory bounce before measurement and the computer connected with platform calculated jump height from time the subject was off the mat. The calculation of jump height assumed that the takeoff and landing positions of the body's center of gravity were the same. Subjects were instructed to keep the trunk as straight as possible and to land on the same spot and with the same body position as when they took off (i.e., trunk and legs straight). Subjects were asked to keep hands on the hips to prevent contribution from the arms. Vertical jump height was normalized to standing height and body mass. These instructions have been successful in minimizing computation error (33). The endurance shuttle-run test was identical to that described by Leger and Lambert (20).

Statistical Analysis

The data are expressed as means \pm SD. Statistical significance was assessed using Student's *t* test for correlated samples. Two-way analysis of variance with repeated measures was used to establish if any significant differences existed between subjects' responses over time. Where significant differences were found, the Tukey test was employed to identify the differences. *P* values of less than .05 were considered to be statistically significant. The data were analyzed using the statistical package SPSS, PC program, version 7.5 (SPSS Inc., USA).

Results

Results are shown in Table 1. Specific dribble test times improved significantly in the creatine group ($p < .05$) after supplementation protocol. Sprint-power test times were significantly superior after creatine-monohydrate supplementation ($p < .05$) as well as vertical jump height ($p < .05$) in creatine trial. Furthermore, dribble and power test times, along with vertical jump height, were superior in creatine versus placebo trial ($p < .05$) at post-supplementation performance. There were no changes in specific endurance test results within or between trials ($p > .05$). There were no between-trial differences in the placebo trial ($p > .05$). No subjects reported any untoward side effects from the supplement.

Discussion

The main finding of the present study indicates that supplementation with creatine-monohydrate in young soccer players improved soccer-specific skill performance compared with ingestion of placebo. Short-duration, high-intensity exercise requires the regeneration of ATP primarily from the breakdown of creatine-phosphate (CP) and from anaerobic glycolysis. A significant reduction of CP occurs after

Table 1 Results of Specific Soccer Tests in Creatine-Monohydrate and Placebo Trials

Group	SDT (s)	PT (s)	VJ (cm)	Shuttle run (s)
CM (<i>n</i> = 10)				
Pre	13.0 ± 1.5	2.7 ± 0.4	49.2 ± 5.9	684.8 ± 51.2
Post	10.2 ± 1.8*	2.2 ± 0.5*	55.1 ± 6.3*	654.1 ± 45.5
Placebo (<i>n</i> = 10)				
Pre	12.9 ± 1.9	2.7 ± 0.7	50.1 ± 8.1	672.9 ± 47.6
Post	12.6 ± 1.7†	2.8 ± 0.5†	49.9 ± 6.1†	666.8 ± 58.3

Note. Values are mean ± *SD*. CM = creatine-monohydrate; SDT = specific dribble test; PT = power test; VJ = vertical jump. *Indicates significant differences pre- versus post at $p < .05$; †significant difference CM versus placebo at $p < .05$.

short-duration (6-s) sprinting (7) and depletion is greater in fast twitch than slow oxidative fibers (12). It seems that the availability of CP is one of the limiting factors for maintaining the high rates of energy necessary for anaerobic-type activity. In Harris et al.'s (14) study, it was demonstrated that ingestion of 30 g of creatine-monohydrate per day for more than 2 days increased the muscle creatine content by up to 50%. Creatine-monohydrate supplementation has been reported to improve single or repetitive tasks of dynamic strength (3), sprint cycling performance (2), and isokinetic force production, when these activities last less than 30 s (6). According to the literature, creatine supplementation may also improve performance in longer duration tasks that rely primarily on anaerobic glycolysis but not in tasks that rely primarily on oxidative phosphorylation for ATP synthesis (15). However, the effects of creatine supplementation in competitive team-sport athletes using sports specific protocols are equivocal and less investigated. Recent previous studies of creatine supplementation in competitive team-sport athletes are shown in Table 2. Several studies (1, 8, 11, 16, 17, 19, 24, 30, 31) provide some scientific support for the concept that creatine supplementation may enhance performance in high-intensity, short-duration single or repetitive exercise-specific tasks that may rely on anaerobic energy metabolism. There appears to be less scientific support with respect to performance tasks of longer duration that are dependent primarily on oxidative metabolism (4, 16, 18). Numerous researchers (4, 8, 18, 24) demonstrated that acute creatine supplementation has an ergogenic potential for highly trained soccer players. Creatine-supplemented players showed improved single and repeated sprint performance, increased jump ability, and enhanced endurance and agility. Yet, Smart et al. (29) and Thornesen et al. (32) reported no ergogenic effect of creatine supplementation in repeated running-specific tests.

The results of the present study are, in the main, in accordance with the results of previously reported studies concerning highly trained soccer players (8, 24). Subjects in the creatine trial significantly improved specific dribble and power test times after supplementation regime with better vertical jump performance, while

Table 2 Effects of Creatine Supplementation on Jump and Specific-Running Performance in Competitive Team-Sport Athletes

Investigator	Population	Gender	N	Creatine dosage	Mode of exercise	Ergogenic effect
Aserud et al., 1998 (1)	Handball players	M	14	15 g/d for 5 d	8 · 40-m sprints	Yes
Bosco et al., 1995 (4)	Soccer players	—	—	5 g/d for 42 d	Cooper 12 min run	Yes
Cox et al., 2002 (8)	Soccer players	F	12	20 g/d for 6 d	20-m sprint and agility run	Yes
Goldberg and Bechtel, 1997 (11)	Football players	M	34	3 g/d for 14 d	37-m sprint	Yes
Izquierdo et al., 2002 (16)	Handball players	M	19	20 g/d for 5 d	CMJ, RST, MDRT	Yes
Jones et al., 1999 (17)	Ice-hockey players	M	16	20 g/d for 5 d	6 · 80-m skating sprints	Yes
Larson et al., 1998 (18)	Soccer players	F	14	15 g/d for 7 d	Shuttle run	Yes
Lefavi et al., 1998 (19)	Baseball players	M	11	19 g/d for 5 d	Repeat 55-m sprints	Yes
Lefavi et al., 1998 (19)	Basketball players	M	37	19 g/d for 5 d	Repeat 29-m sprints	No
Miszko et al., 1998 (23)	Softball players	F	14	25 g/d for 6 d	VJ, 5 · 27-m sprint with 60 s rest	No
Mujika et al., 2000 (24)	Soccer players	M	17	20 g/d for 6 d	CMJ, RST, IET, recovery CMJ	Yes
Smart et al., 1998 (29)	Soccer players	M	11	24 g/d for 6 d	30 · 20-m sprints with 30 s rest	No
Stone et al., 1999 (30)	Football players	M	42	20 g/d for 35 d	Static VJ force	Yes
Stout et al., 1999 (31)	Football players	M	24	21 g/d for 5 d	VJ, 91-m sprint	Yes
Thornesen et al., 1998 (32)	Soccer players	M	18	20 g/d for 6 d	6 · 37-m sprints	No

Note. All studies are randomized, double-blind, and placebo controlled. Studies are arranged alphabetically. M: male; F: female; CMJ: countermovement jump; RST: repeated sprint test; MDRT: maximal multistage discontinuous incremental running test; VJ: vertical jump; IET: intermittent endurance test.

endurance times were not different within or between trials. It would appear that creatine-monohydrate supplementation improved performance in short-duration tasks that rely primarily on immediate mechanism of ATP replenishment (the ATP-CP system). The ATP-CP system is essentially a high-power / low-capacity system that can replenish ATP only for a few seconds at the initiation of high-intensity exercise. The creatine-monohydrate supplementation protocol used in the present study has been repeatedly shown to be a useful strategy to CM load human skeletal muscle (2, 6, 10).

However, aspects such as skill and coordination, among other factors, are of primary importance in evaluation of effects of creatine supplementation in soccer-specific tasks and abilities (26). Moreover, people with low to normal endogenous muscle creatine may respond better to supplementation than those with normal to high endogenous muscle creatine (25). Increase in weight after creatine supplementation could further affect performance (5, 9, 23, 25, 28, 31). In addition, performance in mentioned tasks is partly dependent on specific muscular characteristics (distribution and amount of fast twitch muscle fibers; 27). Therefore, any conclusions about creatine supplementation and soccer-specific performance could be incomplete without further investigation. Method of assessment, positional role, nature, and intensity of training are, among others, factors that can influence determination of effects of creatine supplementation (25).

The consumption of oral creatine monohydrate has become increasingly common among professional and amateur athletes. Despite numerous publications on the ergogenic effects of this naturally occurring substance, there is little information on the possible adverse effects of this supplement (28). Usually, consumers do not report any adverse effects, but body mass increases (25). Therefore, creatine is a nutritional supplement that is purported to be a safe ergogenic aid in adults. However, in the last few years, creatine supplementation has become a common practice among young competition athletes participating in different sports (22). Among supplements that college athletes' considered "most helpful" to their athletic performance, creatine was one of the most frequently cited (34). There are concerns regarding the possible negative effects of intense training on growth and maturation and, in particular, the combination of intense training with nutritional supplements intakes. Although as many as 41% of collegiate athletes admit taking creatine, there is little information about creatine use or potential health risk in children and adolescents (13). Though the use of creatine is not recommended for people less than 18 years of age (9), numerous anecdotal reports indicate widespread use in young athletes. Metz et al. (22) demonstrated that, overall, about 6% of middle school and high school athletes admitted taking creatine. Creatine use was reported in every grade, from 6 to 12 (age 10 to 18). Forty-four percent of Grade 12 athletes surveyed reported using creatine, and such use was significantly more common among boys than girls. The prevalence in Grades 11 and 12 (ages 16 to 18) approaches levels reported among collegiate athletes. In spite of current recommendations against its use in adolescents less than 18 years old, middle school and high school athletes are using creatine at all ages. Frequent consumption of creatine in young and adolescent athletes needs clear explanations of all the benefits and risks of usage (26).

The results of the present study as well as previous work in the area (9, 13, 19) concerning young trained athletes performing single or repeated competition-like exercise tasks indicates that this type of population benefits from creatine supplementation. The potential interest of creatine supplementation for young athletes

could be related to an increased ability to perform high-intensity exercise bouts, either during training or during competition in soccer in which short-duration, high-intensity efforts are required, but this possibility needs further scientific confirmation. Subjects in our study reported no acute side effects, yet caution should be used before recommending creatine-monohydrate supplements to young athletes, since the long-term effects of creatine on the immature athlete are not known (13, 19, 28). The consensus of the American College of Sports Medicine Round Table is that athletes under the age of 18 years should not consume creatine (9). This opinion arises from ambiguous scientific evidence about creatine efficacy, unconfirmed level of associated risk and possible side effects and, finally, possible degradation of young athletes' ethics by fostering a "win at all costs" mentality. Although the primary finding of this investigation was that acute creatine supplementation improved specific sport performance in young soccer players, we believe that there is no clear evidence for untoward side effects of acute creatine supplementation in healthy young individuals. Precaution is obligatory, since potential long-term harmful effects are not adequately examined (9). Rather than recommending creatine supplements to young athletes, health professionals, coaches, and athletic trainers should educate their youngsters from up-to-date, peer-reviewed original research about known benefits and risks associated with creatine usage.

In conclusion, acute creatine supplementation favorably affected sprint performance (sprint-power and dribble) and vertical jump performance in young soccer players, while endurance performance was not affected. Further, present data do not confirm anecdotal claims regarding adverse effects of acute creatine use during supplementation period.

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