Sports Nutrition and Therapy

Indranil and Khanna, Sports Nutr Ther 2016, 1:1
DOI: 10.4172/2473-6449.1000106

Research Article OMICS International

Supplementary Effect of Creatine on Cardiovascular Adaptation and Endurance Performance in Athletes

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Received date: January 19, 2016; **Accepted date:** February 15, 2016; **Published date:** February 20, 2016

Abstract

Creatine has beneficial effect on strength training athletes, but it is not clear whether it has any effect on endurance sport. Present study has been designed to investigate the effect of creatine supplementation on cardiovascular adaptation to sub maximal exercise and endurance performance. A total of 60 male athletes (age range 16-19 years) were selected and randomly divided into experimental group (EG, n = 30) and control group (CG, n = 30) and supplemented with 5 g per day of creatine monohydrate (CrM) and moltodextrine, respectively for 4 weeks. A treadmill test was performed to determine the heart rate responses to sub maximal exercise and maximal endurance performance. Blood lactate was measured at the end of exercise. Body mass, body fat and fat free mass were also measured. Repeated measure ANOA followed by t-test was applied to analyze the data.

Significant decreases in heart rates were noted in the experimental group during sub maximal exercise when compared to the control group. Moreover, the maximal endurance time was increase in the experimental group after supplementation of CrM when compared to control group. However, no significant change has been observed in resting heart, maximal heart rate, recovery heart rate, body mass, body fat, fat free mass and blood lactate level.

Keywords: Creatine; Endurance performance; Heart rate; Body composition; Blood lactate

Introduction

Interest of creatine supplementation in exercise and conditioning is increasing day by day [1-3]. Creatine is a naturally occurring crystalline molecule that includes atoms of carbon, hydrogen, nitrogen and oxygen ($C_4H_9N_3O_2$). Creatine plays a vital role in the release of energy in the muscles of humans [4]. In muscle, creatine is reversibly converted to phospho-creatine (PCr) by the enzyme creatine kinase (CK). PCr acts as reservoir for ATP in the muscle. ATP is the molecule that is used to produce the contraction of the muscles proteins. The cellular concentration of creatine is determined by the muscles ability to take up creatine because muscle cannot make it [5]. Creatine is synthesized in the liver, kidney and released into the blood stream to be actively taken up by the muscle cells. The liver plays a central role in the control of creatine in the body [5,6].

Studies indicated that creatine supplementation augmented sprint cycle performance in the heat without altering thermoregulatory responses [7]. Administration of CrM may enhance high intensity exercises performance and increase body mass as well as fat free mass [8,9]. Another study observed that CrM supplementation did not increase total body mass or fat free mass [10,11]. However, it has been noted that acute creatine supplementation favorably affected repeated sprint performance in highly trained soccer players [12]. Research in this area also indicated that short-term creatine supplementation has no effect on endurance running performance and incremental type exercise but has positive effects on short-term exercise [13,14]. Although very few research works indicated that creatine supplementation have a significant positive effect on endurance performance [15-17]. Contradictory results were found in the literatures on the effect of creatine supplementation on short-term and long-term endurance as well as body composition. Whether creatine plays a role in the adaptation of cardiovascular function or changes in metabolic function, studies in this direction are very scanty particularly in Indian context. The objective of the present study was to find out the effect of creatine supplementation on cardiovascular adaptation to sub maximal exercise, maximal endurance as well as body composition in athletes.

Materials and Methods

Subjects

For the present study 60 endurance-trained athletes (middle distance runners of National levels, physical characteristics in Table 1) gave their informed written consent to participate in this study Accordingly, all the subjects underwent medical checkup, and were randomly divided into 2 groups: (1) experimental group (EG, n = 30; age: 18.5 ± 1.4 yrs, height: 176.5 ± 6.7 cm, weight: 63.1 ± 5.1 kg) and (2) control group (CG, n = 30; age: 18.8 ± 3.1 yrs, height: 175.2 ± 8.9 cm, weight: 62.3 ± 5.8 kg). Participants were advised not to engage in strenuous activities two days before an exercise test and not to exercise on the day of the test. Individuals were requested to maintain their normal diet and to refrain from alcohol and caffeinated beverage in the one week preceding the experiment and throughout the experiment. The study was performed in Sports Authority of India and was approved by the committee of the Institute.

Supplementation

A dose of 5 g per day of creatine monohydrate (CrM) (ANS Co., India) and maltodextrine (Sigma Chemical Co., USA) was given orally for a period of 4 weeks to the experimental group and control group respectively. An exercise protocol was performed for determination of cardiovascular adaptation to sub maximal exercise and maximal endurance performance. Body mass, body fat and fat free mass were measured. Each test was scheduled at a similar time of day (± 1 hour) in order to minimize the effect of diurnal variation. All the parameters were measured before (test 1) and after (test 2) the supplementation. During the 4 weeks of supplementation same training program was employed for both the groups.

Anthropometry and body composition

Body mass was measured with the accurately calibrated electronic scale (Seca Alpha 770, Birmingham, UK) to the nearest of 0.1 kg, and stature with stadiometer (Seca 220, Birmingham, UK) recorded to the nearest 0.5 cm [18]. Body density was estimated from the sum of the skin-fold sites based on the standard procedure [19]. Estimation of percentage body fat was calculated using standard equation [20]. Fat free mass was calculated by subtracting fat mass from total body mass.

Exercise testing

The subjects were given a trial run on treadmill (Jarger LE 500, Germany) one week before the experiment in order to familiarize. A treadmill test was performed to determine the heart rate responses to graded exercise so as to find out the sub maximal responses in cardiovascular system [21]. Time taken till exhaustion was noted to determine maximal endurance performance. The test protocol starts with 8-km/h speed and thereafter increased by 2 km/h after every 2 min. This was continued until the subject got exhausted. Resting heart rate was taken 30 min before the experiment. Maximal heart rate and recovery heart rates were also noted [21].

Analysis of blood lactate

Capillary blood was taken from fingertips 2 min post-exercise for subsequent determination of whole blood lactate concentration. Blood samples were obtained using a sterile lancet; collected in 100 µl heparinised capillary tubes and analyzed immediately using an electrochemical analyzer (YSI SPORT 1500, USA) [22].

Statistical Analysis

Repeated measure ANOVA followed by post-hoc analysis was used to test for effects due to supplementation of creatine monohydrate and maltodextrine in experimental and control groups. Results were expressed as mean ± standard error of mean (SEM). All statistical analysis was performed using the 10.0 release version of SPSS for Windows (SPSS Inc., USA).

Results

Effect of creatine supplementation on body composition

It has been observed that supplementation of CrM has no significant effect on body mass, body fat and fat free mass when comparing the data test 1 and test 2 (Table 1).

Parameters	Control group		Experimental group	
	Test 1	Test 2	Test 1	Test 2
Body mass (kg)	62.3 ± 5.8	62.6^{NS} ± 5.5	63.1 ± 5.1	63.4^{NS} ± 5.1
Body fat (%)	11.1 ± 2.2	10.6^{NS} ± 2.9	10.8 ± 2.6	10.7^{NS} ± 2.6
Fat free mass (kg)	48.1 ± 1.9	48.1^{NS} ± 2.2	54.1 ± 1.6	54.5^{NS} ± 2.2

Each value represent mean ± SEM n = 30. (Repeated measure ANOVA followed by post-hoc analysis). Values were not significantly different from each other. NS = not significant.

Table 1: Effect of creatine supplementation on body mass, body fat and fat free mass in athletes.

Tread mill speed (Km/h)	Heart rate response (beats/min)			
	Control group		Experimental group	
	Test 1	Test 2	Test 1	Test 2
8	135.1 ± 2.1	129.2^{*} ± 3.4	135.1 ± 2.2	$125.0^{*\$}$ ± 1.3
10	141.2 ± 2.2	141.0^{NS} ± 2.4	142.2 ± 1.8	$135.3^{*\$}$ ± 2.1
12	152.3 ± 3.4	153.2^{NS} ± 3.4	154.1 ± 2.6	$149.0^{*\$}$ ± 2.1
14	161.2 ± 4.6	159.1^{NS} ± 3.9	162.0 ± 3.3	160.1^{NS} ± 1.9
16	172.2 ± 2.1	169.1^{NS} ± 3.5	173.3 ± 2.3	169.1* ± 3.9
18	185.4 ± 2.3	184.7^{NS} ± 2.1	184.2 ± 1.4	$177.3^{*\$}$ ± 1.5
20	-	-	-	$188.2^{*\$}$ ± 1.7

Each value represent mean ± SEM n = 30. (Repeated measure ANOVA followed by post-hoc analysis). Values were not significantly different from each other. *P<0.05 when compared the data within the groups (test 1 and test 2 in control group, test 1 and test 2 of experimental group). $P<0.05 when compared the data between the groups. NS: Not Significant.

Table 2: Effect of creatine on heart rate responses to sub maximal exercise and maximal endurance performance in athletes.

Effect of creatine supplementation on heart rate responses to rest, sub maximal exercise, maximal exercise and recovery and maximal endurance time

A significant improvement in heart rate responses in sub maximal exercise was noted after 4 weeks in the experimental group (treadmill speed of 8-12 km/h), whereas in control group improvement has been noted only at the initial stage (treadmill speed 8 km/h) (Table 2). Again maximal endurance time has been improved in the experimental group after creatine supplementation (treadmill speed of 16-20 km/h). However, greater significant improvements in heart rate responses in sub maximal exercises were noted in experimental group when compared to control group after creatine supplementation (Table 2). Moreover, the maximal endurance performance (time till exhaustion) increased significantly after supplementation of creatine monohydrate in experimental group as compared to control group (Figure 1). No significant changes have been noted in resting heart rate, maximal heart rate and recovery heart rate responses among the athletes after supplementation of creatine monohydrate (Table 3).

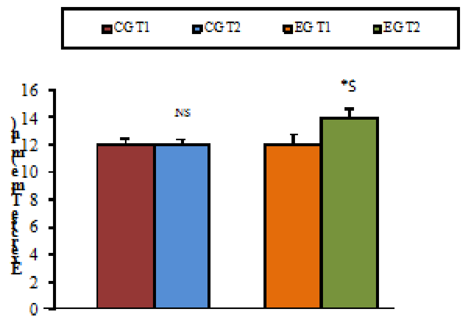

Figure 1: Effect of creatine supplementation on endurance (treadmill) exercise time in athletes. Each bar represents means ± SEM (Repeated measure ANOVA followed by post-hoc analysis). Values were significantly different *p<0.05 when compared within the group $p<0.05 when compared between the groups CG T1: Control Group Test 1, CG T2: Control Group Test 2, EG T1: Experimental Group Test 1, EG T2: Experimental Group Test 2. NS: Not Significant.

Effect of creatine supplementation on blood lactate concentration

Blood lactate concentration was measured before and after the exercise and no significant change has been noted after the supplementation of creatine monohydrate among the groups (Figure 2).

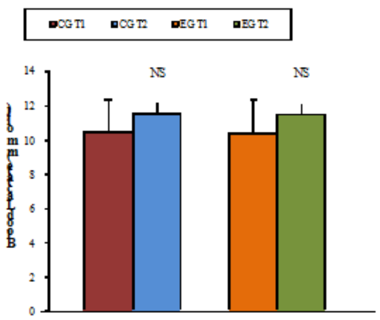

Figure 2: Effect of creatine supplementation on blood lactate concentration in athletes. Each bar represents mean ± SEM (Repeated measure ANOVA followed by post-hoc analysis). CG T1: Control Group Test 1, CG T2: Control Group Test 2, EG T1: Experimental Group Test 1, EG T2: Experimental Group Test 2. NS: Not Significant.

Discussion

In the present study no significant effect has been noted in body mass, body fat and fat free mass following supplementation of creatine monohydrate. The findings of the present study have similarities with the results obtained by a pervious study. Studies performed supplementation of creatine for 4 weeks duration and did not find any change in body mass [23]. Further, it has been noted that short term supplementation of creatine monohydrate has no significant effect on body mass or fat free mass [24]. Although it has been reported that short-term oral creatine ingestion is accompanied by increase in body mass, this weight gain has been explained by water retention [10,11,25].

In the present study, cardiovascular adaptations to sub maximal exercise have shown to increase in the experimental group after creatine supplementation. This was again confirmed by significant decreased in heart rate in test 2 in experimental group when compared to control group. In sub maximal exercise (treadmill speed 8-12 km/h) a significant decrease in heart rate has been noted in experimental group. In the control group significant decrease in heart rate response has been noted only at initial stage (treadmill speed 8 km/h). This might be defined as the effect of training. To nullify the effect of training we compared the heart rate responses obtained in test 2 of control to that of experimental, and a significant improvement have been noted in experimental group. Therefore, it may be stated that this improvement in cardiovascular adaptation during sub maximal exercise may be due to effect of creatine supplementation. Similar observations have been noted by many researchers [13-17]. However, another study reported that creatine supplementation does not enhance submaximal aerobic training adaptations in healthy young men and women [26].

Treadmill speed (km/h)	Heart rate response (beats/min)			
	Control group		Experimental group	
	Test 1	Test 2	Test 1	Test 2
RHR (bpm)	75.3 ± 5.8	70.0 ± 4.2	74.6 ± 2.6	79.0^{NS} ± 9.5
MHR (bpm)	193.5 ± 3.0	195.5^{NS} ± 9.3	191.3 ± 2.3	192.3^{NS} ± 2.1
RecHR1	154.8 ± 5.4	149.0^{NS} ± 7.4	153.1 ± 2.3	153.2^{NS} ± 4.4
RecHR2	133.2 ± 7.8	128.5^{NS} ± 5.1	127.3 ± 4.8	127.1^{NS} ± 2.0
RecHR3	119.7 ± 5.5	118.6^{NS} ± 4.0	116.4 ± 2.7	115.1^{NS} ± 2.1

Each value represent mean ± SEM n = 30. (Repeated measure ANOVA followed by post-hoc analysis). Values were not significantly different from each other. RHR: Resting Heart Rate, MHR: Maximum Heart Rate, RecHR1: Recovery Heart Rate 1st min, RecHR2: Recovery Heart Rate 2nd min, RecHR3: Recovery Heart Rate 3rd min. NS: Not Significant.

Table 3: Evaluation of resting heart rate, maximal heart rate and recovery heart rate responses in athletes.

The effect of creatine supplementation during prolonged continuous exercise has also been studied. It was noted that in the control group no significant improvement in heart rate responses to maximal exercise and maximal endurance time. On the other hand in the experimental group a significant increase in maximal endurance performance has been observed. The improvement in cardiovascular adaptation to maximal exercise has also been noted in experimental group after the supplementation of creatine monohydrate. Therefore, the improvement in cardiovascular adaptation to maximal exercise as well as maximal endurance performance might be due to the effect of creatine supplementation. However, no significant changes in resting heart rate, maximal heart rate as well as recovery heart rate have been noted after supplementation of creatine monohydrate. Similar observations have been noted by many researchers [13-17]. A similar findings stated that creatine supplementation at a dose of 6 g daily has positive effects on short term exercise included into aerobic endurance exercise [16]. Again same controversial results have been noted on the effect of creatine supplementation on endurance performance. According to another study creatine supplementation did not result in any improvement in endurance running performance [13]. Moreover, studies by Demant and Rhodes [14] have shown that creatine supplementation does not appear to aid endurance. Other studies, indicated that neither 7 days nor 28 days of creatine ingestion affect isokinetic muscle endurance as measured during very intense, slow-velocity, concentric bench press and squat performance [25,27].

In the present study no significant change has been noted in blood lactate concentration after creatine supplementation. Similar findings were noted by many researchers. Some researchers reported that creatine ingestion did not change post exercise muscle and blood lactate concentration [27]. On the other hand, another study noted that creatine supplementation increased post exercise muscle and blood lactate concentration following creatine ingestion [28]. However, few studies showed that creatine buffers lactic acid production, thereby, reducing muscle fatigue [22,29]. Several investigators have studied the influence of oral creatine supplementation on muscle and blood lactate concentration following different high intensity short lasting exercise tasks. Some authors, based on their findings of lowered post exercise lactate concentrations, have suggested that the resynthesis of ATP during high intensity exercise relies less on anaerobic glycolysis following oral creatine supplementation [25].

It can be concluded that oral supplementation of creatine monohydrate improves endurance exercise performance. Cardiovascular adaptation to maximal endurance exercise has also been evidence by supplementation of creatine monohydrate. In addition, oral creatine supplementation improves cardiovascular adaptation during sub maximal exercise. The present study will provide valuable information on the effect of creatine supplementation on submaximal as well as maximal endurance exercise performance.

Acknowledgement

The authors wish to thank Mr. Haramal Singh, athletics coach, Sports Authority of India, New Delhi for his active participation and support to carry out the present study.

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