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Research Article

Review on Impacts of Nutritional Supplement Creatine on Explosive Force and Anti-Fatigue Ability of Athletes

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Abstract: The aim of this study was to review the impacts of nutritional supplement creatine on explosive force and anti-fatigue ability of athletes. The high-intensity exercises will cause sports fatigue and the improvement of anti-fatigue ability and elimination of fatigue will directly affect the completion of training plan. Vitamins and minerals, proteins, health foods and energy drinks etc. nutrition supplements have been widely accepted by athletes and coaches in China for a long time. The sports practices showed that the creatine plays an important role to human body, especially in strengthening the explosive force and anti-fatigue ability of athletes. This study mainly discusses how athletes and coaches supplement creatine in a correct way and whether there is a certain side effects if taking creatine for a long term.

Keywords: Anti-fatigue ability, athlete, creatine, nutritional supplement

INTRODUCTION

Creative, also called methyl guanidine acetic acid, is composed of arginine, glycine and methionine and it can provide energy to the muscle body, increase the muscle strength and buffer the alkaline and acid substances in blood, thus to resist fatigue and accelerate the recovery of physical energy (Zhao, 2013). Domestic and foreign scholars agreed that: supplementing creatine can improve the exercise capacity of athletes and delay fatigue (Head *et al*., 2011; Watanabe *et al*., 2002). The creatine is also used by many domestic sports teams as nutritional supplement for improving the exercise capacity (Qiu and Sun, 2006). However, there is no consistent conclusion on experimental effect of supplementing creatine and it is unclear to which items the supplementation of creatine has best effect (Lu, 2015). This study aims to discuss the development in this field for recent decades to provide a scientific basis for better supplementing creatine and using creatine to improve the athletic performance. Especially, this study discusses how to use creatine to improve the athletic performance without breaking the rule in the case of disabling stimulant. Therefore, it has more practical values for researching the supplementation of creatine.

RESULTS AND DISCUSSION

Impacts of implementing creatine to anti-fatigue ability: In previous studies, almost all scholars think supplementing creatine contributes in eliminating and delaying fatigue. It is generally known that the vigorous exercise in short time will cause accumulation of lactate and decline the PH value of muscle, resulting in fatigue. When the buffer substances in muscle cells cannot resist the change of PH value, the creatine phosphate in the muscle will decompose under the catalysis of creatine kinase to produce ATP and creatine and buffer the decline of PH value. In this sense, supplementing creatine can reduce the lactate accumulated in exercises, thus to improve the exercise tolerance and delay the occurrence and development of fatigue.

Creatine has highest concentration in muscle, about 60% of which exist in muscle as creatine phosphate. The content of creatine phosphate in the quiet state is 3-4 times of that of ATP. ATP refers to the energy material for muscle contraction, which has limited content in muscle cell. The excessive decrease of ATP content in muscle will result in fatigue. The ATP content can be decreased 25-30%. To delay fatigue, the resynthesis rate of ATP must be close to its hydrolysis rate. One phosphate group is removed from creatine phosphate and transferred to ADP under the catalysis of creatine kinase, ADP synthesizes into ATP with creatine released during the process; the energy metabolism in the muscle is as shown below: ATP→Pi+ADP; CP+ADP→ ATP+C. In the recovery phase after exercise, the reaction catalyzed by creatine kinase is antidromic and the energy used is provided by the aerobic metabolism of mitochondria:

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ATP+C→CP+ADP; Pi+ADP+metabolic energy of mitochondria→ATP. It can be seen from above formula that creatine phosphate is a transmitter of energy. There is no direct evidence showing that this process is limited by the content of creatine, but this process deserves further study.

Currently, many scholars speculate and verify the impact of supplementing creatine to sports fatigue based on changes of physiological and biochemical indicators of subject after exercise. They deduce the sports fatigue of athletes according to the detection and changes of serum CK and BUN, fatigue index and blood lactate content. Serum CK and BUN are important indicators for evaluating the degree and capacity of athletic load and sensitive indicator for evaluating the sports fatigue. Serum CK is a kind of non-functional enzyme of plasma and is mainly derived from skeletal muscle under normal condition with a relatively stable concentration. BUN is a metabolite of protein; the catabolism of protein is maintained at a lower level under normal physiological conditions, indicated by the stability of BUN; the heavy exercise will result in increased catabolism of protein and BUN value.

Liu *et al*. (1998) assigned 16 athletes into two groups randomly and observed their progressive functions status and exercise capacity before and after taking creatine and glucose respectively. The results showed that the blood lactate of the group taking creatine declined significantly after experiencing 30 s of maximum strength load, from 13.52±0.96 mmol/L to 12.08±1.15 mmol/L, while there were no significant changes in anaerobic power. This indicated that the energy supply from the glycolysis system reduced, while that from the phosphagen system increased relatively, which meant the energy supply ability of the phosphagen system was enhanced. The improvement of the energy supply ability of the phosphagen system was concerned with the increase of creatine phosphate content in the muscle after supplementing the the creatine; the increase of creatine phosphate content would result in less energy supply from the glycolysis system and consequently less accumulation of lactic acid, thereby delaying the occurrence and development of fatigue. Odland *et al*. (1997) arranged the subjects to supplement creatine 20 g/d for 3 days and then measured the energy generation of the subjects during a 30 s cycling, their post-exercise fatigue index and the content of blood lactate; no differences were showed comparing these items with that of the control group. Therefore, it is still unable to confirm with present findings that supplementing creatine can improve the exercise capacity. Cooke *et al*. (1995) assigned 12 healthy men without formal training into two groups randomly and supplemented them with creatine and placebo respectively; five days later, he measured their indicators including energy generation peak, peak energy occurrence time, total work and fatigue index in cycling. The results showed that there were no significant differences in these indicators compared with the group providing with the placebo before and after supplementing the creatine. The author thus concluded that supplementing the creatine orally cannot significantly change the energy generation and fatigue development of men without formal training in high intensity cycling. Lu (2015) observed changes in some biochemical indexes of 12 national short track speed skating athletes before and after taking Dajingzao creatine (12.5-22.5 g/d for 5 days) in short term during the high intensity training before participating in the United States and Canada challenges in 1996. The results showed that after supplement of high-dose creatine in short term, no significant increases of serum LDH and AST activity closely related to amount of exercise and intensity as well as the activity of CK- Mb enzyme related to muscle damage occurred in the athletes during the high intensity training, while the content of serum BUN in their bodies declined sharply compared with the content before supplementing creatine. After the supplement of high-dose creatine in short term, the activity of L(DH), AST and Ck-Mb in the athletes did not change significantly during high intensity training, while the content of serum urea nitrogen declined sharply compared with the content before supplementing creatine. It concluded that supplementing creatine would help improve exercise capacity, delay fatigue or even allay fatigue. Li (2005) assigned 16 basketball players into the creatine supplement group and the placebo group randomly for study. After certain amount of exercise, the measuring results of corresponding indexes showed that after exercise, serum CK and BUN change declines in the basketball players. Spradley *et al*. (2012) assigned 12 ordinary men into the creatine supplement group and the placebo group randomly for a test of three weeks. The results showed that showed the subjective fatigue of the creatine supplement group was significantly less than that of the placebo group. Zhao (2013) assigned 48 four-month-old mice (male or female) into the control group, the exhaustive swimming group and the exhaustive swimming group with creatine phosphate supplement. The creatine phosphate supplement group received the creatine phosphate (500 mg/kg) by intraperitoneal injection 30 min before the experiment started, while the exhaustive swimming group received hysiological saline by intraperitoneal injection as a negative control group. It was found that the time of swimming to exhaustion of the creatine supplement group was significantly longer, but the blood lactate concentration was up to 4.7 times compared to that in the sedentary state at the time of exhaustion; the accumulation of blood lactate was up to 5.6 times and the lactate in the hippocampus increased 1.9 times after supplementing creatine.

Table 1: Effect of fatigue resistance of creatine supplement

Researcher	Date	Sample size	Design	Dose (g×d = Total)	Testing index	Effect
Spradley *et al*.	2012	12 ordinary male	RDBPC	Supply before exercise	Subjective feeling	Effective
Li	2005	16 basketball players	RDBPC	20 5 100	Serum CK, BUN	Effective
Zhao	2013	48 4-month rats	RDBPC	5 g/kg 3 15 g/kg	Blood and brain lactate	Ineffective
You	1999	12 national short track speed skaters	RDBPC	12.5~22.59 5 62.5~112.95	CK-MB, BUN	Effective
Odland *et al*.	1997	17 ordinary people	RDBPC	20 3 60	Fatigue index, blood lactate	Ineffective
Cooke *et al*.	1995	12 untrained healthy males	RDBPC	20 4 80	Fatigue index	Ineffective
Liu *et al*.	1998	16 athlete	RDBPC	12 28 336	Blood lactate	Effective

RDBPC＝Randomized, Double-Blind, Placebo Control

There are different opinions as well as positive and negative findings on the impacts of creatine supplements on anti-fatigue ability. Based on findings of the above 7 studies (Table 1) with 133 subjects in total (including 48 four-month-old mice and 85 people), those with significant increase in anti-fatigue ability after creatine supplement accounted for 42.11%, while those with no significant increase accounted for 57.89%. In fact, most researchers hold a positive attitude the impact of creatine supplement on anti-fatigue ability; those negative results may result from the differences in subjects and experimental designs. In addition, the impact of creatine supplement on the anti-fatigue ability can be obvious generally only in the case of high intensity exercise training; In addition, the impact of creatine supplement on the anti-fatigue ability can be obvious generally only in the case of high intensity exercise training (Meeusen *et al*., 2006).

Impacts of creatine supplement on explosive force: Most scholars hold a positive attitude toward impacts of creatine on exercise capacity, but researchers have been exploring the specific effects of creatine supplement on muscle explosive force, which is also concerned by exercise physiologists and exercise nutritionists at home and abroad through various creatine supplement methods; force growth through creatine supplement is mainly due to increasing creatine in skeletal muscle, thereby accelerating the generation of CP, which is energy to maintain the explosive force. 36 players of the China Youth Basketball Team were assigned randomly to placebo and creatine supplemented groups by Wang *et al*. (2004) for 6 weeks of normal training. Creatine group took 5 g creatine after breakfast and lunch at a daily base and the results showed that the two groups had a significant increase in strength and explosive force, while the creatine supplemented group is more significant.

9 athletes of National Short Track Speed Skating Team were assigned randomly to placebo and creatine supplemented groups by Qiu and Sun (2006) for 8 weeks of clinical studies on exogenous creatine supplement, during which creatine group took 0.1 g creatine before meal at a daily base. 27 track and field athletes were assigned randomly to placebo and creatine supplemented groups by Wang *et al*. (2004). Creatine group took creatine 0.3 g/kg/d for 5d, then changed the dose for 5 g/d and lasted for 1 month. Results showed that creatine group performed better than placebo group in strength load test. 12 subjects were assigned randomly to placebo and creatine supplemented groups by Izquierdo *et al*. (2002), in which creatine supplemented group took 15 g~25 g creatine for 5d~7d, then changed the dose to 2 g~25 g for 7 d~84 d. Results showed that strength, sprint capacity and fat free mass increased in creatine group. Some researchers (Gagnon *et al*., 2002) gave creatine (21 g/d) for 18 young professional swimmers in training for 9 d and another group was given for 9 d as comparison. Then, 3 sets 100 m sprint swimming ability tests were carried out with interval of 60s. Results showed that experimental group was faster than control group in the first test and swimming time in the second test was significantly shortened; total time of experimental group after 3 tests was shorter than that of the control group. Results showed that 9 d creatine supplement increased capability in repeated sprint swimming. Balosm and other researchers have carried out similar tests. 2 groups of subjects took creatine or placebo for continuous 6 d (20 g/d) after 2 times of 6 s 65% Max intensity exercise on cycle ergometer, with interval of 30 s. Subjects are required to try to keep 140 cycles/min frequency during exercise. Results showed that creatine group performed better in maintaining the speed. Harrzdge *et al*. (1994) divided his experimental subjects, trained runners, to the experimental group and the placebo group. Each person of the experimental group took 30 g creatine for continuous 6 d. Comparison between 4×300 m and 4×1000 m performance found that creatine group has significant improvement in the performance of the last 300 m, 13s reduction in total time of 4×1000 m and 5.5 s reduction in the last 1000 m, while the control group remains the same. Bosco *et al*. (1997) observed the jumping ability change of subjects with creatine supplement (20 g/d for 5d). Results showed that measured average capacity (w/kg) and jump height of subjects often supplemented with creatine were improved after 5 s and 45 s successive jumps, while that of the placebo group were decreased significantly after 45 s jumps. What indicated from the above is that creatine supplement may increase energy for exercise and helpful for extending time for the maximum energy generation. It is thus clear that creatine can significantly improve short time explosive exercise capacity and exercise endurance.

Table 2: Effect of explosive power of creatine supplement

Researcher	Date	Sample size	Design	Dose (g×d = Total)	Testing method	Enhancing effect
Hong Ping	2010	36 national youth basketball players	RDBPC	10 42 420	Single and double jump for touching	Effective
Gao Zhishan	1998	9 national short track speed skaters	RDBPC	0.3g/kg body mass 56 16.8g/kg	Single and double jump for touching	Effective
Ma Yun	1997	27 national athletes	RDBPC	0.3g/kg body mass 5 1.55 30 150	Power lift, squat	Effective
Harridge *et al*.	1994	12 runners	RDBPC	30 6 180	4×300 m, 4×1000 m	Ineffective
Bosco *et al*.	1997	17 ordinary people	RDBPC	20 5 100	Jump height	Effective
Grindstaff *et al*.	1997	18 professional youth swimmers	RDBPC	21 9 189	100 m swimming	Effective
Izquierdo	1998	12 participants	RDBPC	15g~25g 5d~7d 75g~175g 2 g~25g 7d~84d 14g ~2100g	Sprint (100m)	Ineffective

RDBPC = Randomized, Double-Blind, Placebo Control

Based on the research results of above 7 different documents (Table 2), total subjects are 131, 90.84% of whose explosive force has increased after being supplemented with creatine and 9.16% of whose explosive force hasn't had obvious increase. Most of scholars support the impacts of creatine on explosive force. The increase of explosive force is the key to victory in most of the athletic events. During the nearly hundred-year study on creatine, most of the scholars think the athletic ability will be improved by supplementing creatine. For the studies in which the explosive force doesn't increase, it may be related to the increase of net body weight. Creatine supplement may play positive effect on the increase of net body weight, but it suppresses the increase of certain explosive force to some extent. And in some study designs, it is difficult to determine whether creatin increases endurance or it increases explosive force. In short, different researchers and scholars hold different views on this viewpoint.

Side effects of creatine supplement: Up to now, creatine has been studied for nearly one hundred years at home and abroad. Experimental evidence until now has shown that the only side effect of creatine supplement is the increase of body weight along with the supplement of creatine with the range from 0.9 kg to 3.2 kg which occurs only when large dose (259 per day) is taken in a short time (less than 2 weeks); however, we should pay attention that there isn't any current complete study on whether long time and large dose creatine taking will bring about any side effect. Another problem we should pay attention to is that the supplement of exogenous creatine will suppress the synthesis of endogenous creatine. There isn't any experimental evidence on human bodies that shows the suppression effect will stop when creatine supplement ends. However, an animal experiment shows that the synthesis of endogenous creatine will be recovered to the normal state after the creatine supplement. It remains unknown whether long time creatine taking will have other harmful effects on human health. Therefore, special attention should be paid during creatine supplement. Yang Zeyi said: research reports on the side effects of creatine on liver, kidney and blood system functions and muscle cramp and damages caused by creatine are not available at present.

CONCLUSION

As a kind of prevalent nutritional supplement, creatine appeals to athletes and bodybuilders. And most of the researches are in favor of the view until now that creatine supplement will increase the creatine content in the body. Based on the mechanism of creatine supplement on the increase of athletic ability, we know that the increase of creatine content in the body will promote the energy source of ATP-PC system and especially promote those sports events requiring high energy output in a short time. Therefore, creatine were once taken in such sports events as sprint, weight lifting, throwing and long jump. Creatine is another excellent choice for those who want to increase their athletic ability by means other than exercise training.

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