Creatine Supplementation and Enhanced Sport and Exercise Performance

Dr Andrew McKune, Exercise Physiologist
Department of Sport and Physical Rehabilitation Sciences
Tshwane University of Technology

What is Creatine?
Creatine is a nonessential dietary compound, that can either be ingested from exogenous (dietary) sources such as fish or meat, or can be produced endogenously by the body, primarily in the liver. The majority of creatine in the human body is located in skeletal muscle with approximately 40% of the creatine in the free form (Cr) and 60% in the phosphorylated form (PCr). In general, a 70kg person with an average Cr pool of 120-140g, would lose about 2g/day as creatinine in the urine. This loss is replaced by both exogenous consumption of about 1g/day from a normal mixed diet and the other 1g being synthesised endogenously.1,2,3

Supplement Strategies
The typical Cr loading programme consists of 20g/day (four doses of 5g each) for 5-7 days followed by a maintenance load of 3-5g/day, although lower dosages (2-3g/day) for a greater length of time (1 month) can be as equally effective in raising intra cellular PCr levels. Similar to most intervention protocols, there are responders and non responders to Cr supplementation. In general, the greatest increases in skeletal muscle levels of PCr and ergogenic benefits following supplementation, occur in...

The possibility of enhanced sport and exercise performance continues to make dietary supplement products a very lucrative industry. Although creatine was discovered 170 years ago, it was not until the 1970s that it was used as a potential performance enhancer by the Soviet States and the Eastern block countries. Due to superb performances by elite athletes in the early 1990s being attributed to creatine, as well as the attention given to the product by the media, the common perception is that creatine supplementation is beneficial and de facto, “essential”, to sport and exercise achievement. For these reasons, creatine has become one of the most popular ergogenic aids and its use is widespread. Professional, elite and amateur athletes, recreational exercisers, children, teenagers, and the elderly, of both sexes, all ingest supra physiological doses of creatine.1,4,5 Today, it is estimated that >2.5 million kilograms of creatine are used in America each year, with creatine sales valued at over $US 200 million in 1998. With the number of South Africans using creatine increasing daily, it is important that the correct advice and education is provided to these individuals regarding the mechanism of action, correct dosage, benefits and possible side affects of supplementation. This will allow individuals to decide whether creatine will actually help them reach their sport and exercise performance goals.
those individuals that have the lowest initial values. In addition, the greatest uptake of Cr into the muscle occurs during the initial stages of the loading regimen.

Exercise seems to enhance the uptake of Cr, especially if the Cr is ingested after the exercise with a carbohydrate or combined carbohydrate/protein drink\(^1,3,4,5\).

**Mechanisms of Action**

Cr exerts various effects upon entering the muscle and it is these effects that have been proposed to elicit improvements in sport and exercise performance.

1. Firstly, elevated PCr concentrations in skeletal muscle ensures the rapid repolyphosphorylation of adenosine diphosphate (ADP) back to adenosine triphosphate (ATP) by the Cr kinase energy reaction. This reaction provides ATP/energy for high intensity activities that last for up to 7 10 seconds, and is beneficial, especially if the bouts of intense activity are repeated with short rest periods between them\(^1,3,4,5\).

2. Cr can enhance muscle contraction through assisting the movement of ATP from the energy “power houses” of the cell, the mitochondria, to the muscle contractile proteins\(^4\).

3. Cr can act as a buffer, maintaining cellular homeostasis by preventing pH changes brought about by an increasing acidosis during high intensity exercise\(^1,3,4,5\).

4. Declining levels of PCr during intense exercise longer than 10 seconds can enhance the activities of another energy pathway, glycolysis, resulting in the rapid production of ATP from carbohydrate, specifically glucose or glycogen\(^1,3,4,5\).

5. It has also been suggested that increased concentrations of PCr stimulates muscle hypertrophy and increased protein synthesis, which may enhance lean muscle mass and muscle force production\(^1,3,4,5\).

Mechanisms 2, 3 and 4 suggest that activities lasting between 10 seconds and 2 minutes could also benefit from Cr supplementation\(^1\).

**Ergogenic Effects**

The majority of the scientific literature dealing with young, healthy males, demonstrates that exercise performance, involving short periods of intense activity (1 2 seconds), can be enhanced by Cr supplementation, especially if the activity is performed in repetitive bouts separated by short rest periods (30 seconds to 1 minute)\(^1,3,4,5\). Specifically, research has shown that exercise performance during the latter bouts of repeated sprints (e.g., third, fourth, fifth) can be increased by 5 20\% over that measured for a placebo group\(^4\). Activities that involve repeated jumping, sprinting (100 200 m) and middle distance running (400 800 m), swimming, all out cycling, kayaking, rowing, and resistance training generally show improved performance following Cr ingestion. Performance in team sports that require repeated sprint activity (e.g., football) has also been shown to benefit from Cr supplementation\(^1,3,4,5\).

When maximal force or strength is the outcome measure following Cr ingestion, it generally appears that Cr impacts significantly on force production regardless of sport, sex or age\(^3\).

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**Potential Adverse Effects**

There is no direct evidence that Cr supplementation can induce muscle cramping. Rather, it has been suggested that the cramps are most likely due to either the high intensity of the work out or to a disruption in electrolyte balance\(^1,3,4,5\).

**Gastrointestinal (GI) distress**

This is the most frequently reported adverse effect of Cr supplementation, but double blind, placebo controlled studies have demonstrated no detrimental effect on the GI system\(^1,4,5\).

**Renal Function**

Studies have investigated renal function following Cr supplementation by assessing urinary creatinine clearance. These studies have found no indication of impaired function. It has been suggested however that care should be taken in individuals with pre-existing compromised renal function\(^1,4,5\).

**Liver Function**

There is no scientific evidence that liver function is impaired by either short term, high dosage Cr ingestion or longer term, low dosage programmes\(^1,4,5\).

**Muscle Cramping**

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**Water Retention**

The early increase in body weight following Cr supplementation is explained by retention of body water, especially within the muscle cell\(^1\). This is associated with a substantial reduction in urine production during the first 3 days of the loading period\(^3\). It is thought that the reason for the retention of intracellular water is the elevated osmotic load associated with the increased Cr concentrations within the cell\(^1,4,5\). Studies have reported increases in body mass of 1 3 kg after short term (5 7 days) Cr supplementation\(^1,4,5\).
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Conclusion

This information will allow individuals, contemplating using creatine, to make informed choices about the possible benefits and risks associated with the product. In summary, Cr supplementation provides the most beneficial effects for sport and exercise performance when the activity involves repeated, short bouts of high intensity exercise. Both men and women can benefit from Cr, as well as young and old participants. Presently, there appears to be no detrimental effects of acute supplementation, although further research examining chronic use, supplementation in the paediatric age group, as well as during pregnancy and lactation, is required. Finally, it should be remembered that there are both responders and non responders in all groups and that this can impact the potential ergogenic effects of Cr.

REFERENCES