Creatine Loading Strategies

Creatine is a nitrogenous amine. Normal daily dietary intake of creatine from an omnivorous diet approximates one gram. Exogenous dietary sources of creatine include meat, fish and other animal products, but it may also be formed endogenously in the liver, kidney and pancreas from the amino acids glycine, arginine, and methionine. One-half kilogram of fresh, uncooked steak contains about two grams of creatine.³

Creatine has become a popular nutritional supplement among athletes. In 1998, about $200 million was spent on creatine monohydrate. Of the approximately 300 studies that have evaluated the potential ergogenic value of creatine supplementation, about 70 percent report statistically significant results, while remaining studies generally report non-significant gains in performance.¹ However, studies that have reported no significant benefit of creatine often have low statistical power, have evaluated performance tests with large test-to-test variability, and/or have not incorporated appropriate experimental controls.¹

Creatine supplementation is not banned by the International Olympic Committee and with the exception of a small increase in body mass (about one kilogram) over the initial three to six days, does not appear to have any adverse side effects, at least with short-term use.² Little scientific data is available for more prolonged use, but considering the large numbers of athletes using creatine over the past six-plus years, and the absence of reported problems, it may be that the often discussed somewhat nebulous long-term adverse effects are presently being overestimated.²

Creatine supplementation has been, and continues to be, investigated as a possible therapeutic approach for the treatment of muscular, neurological and neuromuscular diseases (arthritis, congestive heart failure, disuse atrophy, gyrate atrophy, McArdles disease, Huntington’s disease, miscellaneous neuromuscular diseases, mitochondrial diseases, muscular dystrophy, neuroprotection, etc.).

Creatine Storage in the Body

Approximately 120 grams of creatine is found in a 70-kilogram (kg) male (154 pounds), 95 percent in the skeletal muscle.³ Total creatine exists in the muscle as both free creatine and phosphocreatine. About 60 percent of the total creatine is phosphocreatine, and the remainder is free creatine.³ For creatine supplementation to be effective, it must increase the amount of total creatine or phosphocreatine within the muscle, and these increased stores must help rapidly replenish phosphocreatine and adenosine triphopshate (ATP) during exercise. Normal muscle creatine content approximates 125 mmol/kg dry matter, and human muscle appears to have an upper limit of creatine storage of 150-160 mmol/kg dry matter.³

Various supplementation strategies have been used in attempts to increase total creatine concentration, particularly phosphocreatine. The most commonly used protocol is to ingest a daily total of 20 to 30 grams of creatine, usually creatine monohydrate, in four equal doses of five to seven grams dissolved in fluids over the course of day, for five to seven days.³
Rapid vs. Slow Loading
Dr. Hultman and coworkers employed several strategies, including a rapid protocol involving six days of creatine supplementation at a rate of 20 grams per day, and a slower protocol with supplementation for 28 days at a rate of three grams per day. Following the rapid protocol, they also studied a maintenance dose of two grams per day for 28 days. Both the rapid and slow protocols produced similar findings, about a 20 percent increase in muscle total creatine concentration. The elevated muscle total creatine concentration was maintained when supplementation was continued at a rate of two grams per day.

Creatine, Carbohydrates and Protein
Dr. A.L. Green and colleagues reported that creatine ingested in combination with simple carbohydrates substantially increased muscle creatine accumulation compared with the ingestion of creatine alone. Furthermore, ingestion of creatine in conjunction with carbohydrates reduced the inter-individual variability in the magnitude of muscle creatine accumulation, such that all subjects demonstrated an increase in muscle total creatine content greater or equal to 20 mmol/kg dry mass. It was proposed that the stimulatory effect of carbohydrates on muscle creatine accumulation was due to insulin-enhancing muscle uptake, probably by stimulating sodium-potassium pump. Recently, same laboratory has confirmed that insulin can increase creatine accumulation in skeletal muscle, but only when present at a concentration close to, or in excess of, 100 mU/L.

On the basis of these findings, it’s clear that creatine supplements would need to be ingested with very large quantities of simple carbohydrates to achieve an insulin-mediated stimulation of muscle creatine transport. However, it has been reported that the ingestion of proteins in combination with carbohydrates can result in a greater increase in serum insulin concentrations than would be expected from the sum of their individual responses. Thus, the aim of a recent study by Dr. G.R. Steenge and coworkers was to examine whether the ingestion of creatine in combination with a solution containing about 50 grams of protein and about 50 grams of simple carbohydrates could increase serum insulin concentration to a level similar to that observed after the ingestion of about 100 grams of simple carbohydrates.

The second aim was to determine whether this would facilitate creatine retention toward that reported with large quantities of simple carbohydrates. The results of this study indicate that the ingestion of creatine, in conjunction with about 50 grams of protein and about 50 grams of carbohydrates, is as effective in stimulating insulin release and whole body creatine retention as ingesting creatine in combination with almost 100 grams of carbohydrates.

According to Dr. Steenge and colleagues, “This information will be useful to individuals aiming to elevate their muscle total creatine store by supplementing with creatine, particularly those that regularly ingest CHO-protein [carbohydrate-protein] supplements after exercise or several meal replacement supplements per day... The potentiating effect of insulin on creatine disposal was less marked after the fourth oral challenge compared with the first. We would, therefore, propose that ingestion of CHO alone, or in combination with protein, in an effort to augment muscle creatine accumulation will probably only be highly effective on the first day of supplementation.”
Creatine and D-Pinitol
D-pinitol is a plant extract that has been reported to possess insulin-like properties. Thus, the purpose of a recent study by Dr. M. Greenwood and coworkers was to examine whether co-ingestion of D-pinitol with creatine affects whole body creatine retention. Results suggest that ingesting creatine with low doses of D-pinitol (2 x 0.5 grams/day) may augment whole body creatine retention in a similar manner as has been reported with co-ingestion of high levels of carbohydrate or carbohydrate and protein. However, ingestion of a higher dose of D-pinitol (4 x 0.5 grams/day) did not enhance retention. Clearly, more research is needed before conclusions can be drawn.

Effervescent Creatine
Effervescent creatine products have been marketed as a more optimal means of ingesting creatine because they theoretically enhance the suspension and solubility of the creatine in liquid; optimize pH levels to prevent degradation of creatine to creatinine; and reduce purported gastrointestinal problems that may interfere with creatine transport in the gut.

According to FSI Nutrition, “Pilot studies using FSI effervescent creatine demonstrated that the AWC [anaerobic work capacity] is significantly enhanced compared to powder creatine monohydrate and a commercially available creatine monohydrate/carbohydrate blend... The improvement in AWC shown in the pilot study performed at Creighton University by Dr. Jeff Stout was 195 percent over a creatine monohydrate and 84 percent over a creatine monohydrate/carbohydrate blend.”

However, Dr. Greenwood and colleagues recently reported that effervescent creatine supplementation (creatine citrate + dextrose + sodium + potassium) appears to be no more effective than ingesting creatine monohydrate alone.

Creatine Serum
According to Muscle Marketing USA, "A recent article in an independent and widely-respected journal of naturopathic medicine has acknowledged that Creatine Serum, manufactured by Muscle Marketing USA (MMUSA), is the safest and most effective form of creatine for athletic supplementation. The article appeared in the February/March issue of The Townsend Letter for Doctors & Patients... It outlines the different forms of creatine available and details the rising safety concerns around supplementation with large doses of creatine powder. These safety concerns include the osmotic effect of dehydration resulting from creatine monohydrate’s insolubility and the suppression of natural creatine production in the body... The article also points out several other important concerns around creatine monohydrate powder supplementation. For example, an unknown amount of powder remains unaccounted for in the digestive system. Furthermore, it may cause complications in stomach acid deficiency and an increase in the body’s production of formaldehyde. Both of these could lead to potentially serious complications."

However, there is no scientific evidence supporting these claims and the Townsend Letter is certainly not a peer-reviewed scientific journal. I just read this paper (Gina L. Nick, Ph.D., N.D.: Creatine phosphate complex and creatine serum) and I was stuck by the following statements: "Creatine monohydrate is less than one percent soluble in water (0.7 percent), and therefore most preparations come in powdered form or suspended
in a variety of viscous proprietary compounds. Only the soluble one percent is absorbable through the stomach lining. Of the remaining 99 percent of the ingested monohydrate, roughly 90 percent will be hydrolyzed to creatinine by stomach acid, leaving about 10 percent to enter the bloodstream and be taken by muscle cells."

Although creatine is not subject to first-pass metabolism, other routes are possible for decreasing systemic creatine exposure after oral administration. The rate of formation of the degradation product creatinine, is increased in the presence of acid and therefore accelerated degradation is possible in the lower pH of the stomach. However, creatine degradation to creatinine occurs at its maximal rate at pH 3-4. The degradation half-lives for the conversion of creatine to creatinine at pH values 1.4, 3.7 and 6.8 are 55, 7.5 and 40.5 days, respectively. At these rates, less than 0.1 gram of a five-gram dose would be lost in one hour.

Therefore, conversion to creatinine in the gastrointestinal tract is probably minimal regardless of transit time. Dr. Richard Kreider and colleagues examined whether creatine serum supplementation has any effect on muscle adenosine triphosphate (ATP) or creatine levels. Results revealed that creatine monohydrate significantly increased muscle creatine content while no significant differences were observed in liquid placebo or creatine serum in pre- and post-ATP or creatine levels. These findings indicate that creatine serum has no effect on muscle ATP or creatine stores even when taken at eight times the recommended dosage for five days.

**Caffeine and Creatine**
Caffeine is the most commonly consumed drug in the world and athletes frequently use it as an ergogenic aid. It improves performance and endurance during prolonged, exhaustive exercise. To a lesser degree it also enhances short-term, high-intensity athletic performance. It is relatively safe and has no known negative performance effects, nor does it cause significant dehydration or electrolyte imbalance during exercise.

Vandenberghe and coworkers compared the effects of creatine supplementation with creatine supplementation in combination with caffeine on muscle phosphocreatine level and performance in healthy male volunteers. Creatine and creatine + caffeine increased muscle phosphocreatine concentration by four to six percent. Dynamic torque production, however, was increased by 10-23 percent by creatine, but was not changed by creatine + caffeine. Authors concluded that creatine supplementation elevates muscle phosphocreatine concentration and markedly improves performance during intense intermittent exercise. This ergogenic effect, however, was completely eliminated by caffeine intake. Additional research is needed to confirm these preliminary findings.

**Bottom Line**
Creatine ingested in combination with simple carbohydrates substantially increases muscle creatine accumulation compared with the ingestion of creatine alone. However, creatine supplements would need to be ingested with very large quantities of simple carbohydrates to achieve an insulin-mediated stimulation of muscle creatine transport. The results of a recent study indicate the ingestion of creatine, in conjunction with about 50 grams of protein and about 50 grams of carbohydrates, is as effective in stimulating insulin release and whole body creatine retention as ingesting creatine in combination with almost 100
grams of carbohydrates. However, authors proposed that ingestion of carbohydrates alone, or in combination with protein, in an effort to augment muscle creatine accumulation will probably only be highly effective on the first day of supplementation.

Results of a pilot study indicate that co-administration of creatine with low-doses of D-pinitol may offer a non-caloric means of augmenting whole body creatine stores. Effervescent creatine supplementation appears to be no more effective than ingesting creatine monohydrate alone. Creatine serum has no effect on muscle ATP or creatine stores, even when taken at eight times the recommended dosage for five days. Caffeine has been reported to adversely affect the efficacy of creatine supplementation.

According to a recent review by Dr. A.M. Persky and coworkers, “A short loading phase of two to three days taking 0.071 grams per kilogram body weight (equivalent to five grams for a 70-kilogram person) four times a day is suggested. Creatine should be taken with a high-carbohydrate meal or beverage, but high-fructose components (e.g. fruit juice) should be avoided because fructose does not elicit a significant insulin response. After the loading phase, creatine can be taken once daily at a dosage of 0.029 grams per kilogram body weight to maintain muscle levels. This regimen should cause rapid increases in muscle creatine without overuse of the supplement.”

References