Report of the Scientific Committee on Food on composition and specification of food intended to meet the expenditure of intense muscular effort, especially for sportsmen

CAFFEINE

Caffeine is known as one of the most widely used non-nutritive components in beverages in the Western world and is therefore already present in the diet of many athletes. Already for a long time caffeine is considered as a nutritional ergogenic aid in physical performance. However, only in the last decade have a number of well-controlled studies clearly demonstrated its efficacy in relation to prolonged endurance exercise as well as short term intense exercise.

At present, the mechanism by which caffeine acts is not well known. Three major theories for the ergogenic effect have been suggested.

The first theory involves a direct effect on the sympathetic nervous system (SNS), leading to a stimulatory effect on the neural signals between brain and neuromuscular junction.

The second theory proposes a direct effect on the skeletal muscle metabolism by increasing, among others, cyclic AMP.

The third and most accepted theory involves an increase in fat oxidation, sparing endogenous carbohydrate stores and thus improving performance especially in exercise where CHO availability limits performance. The evidence demonstrating that caffeine is an ergogenic substance has forced the IOC to set a limit to prevent extreme use of this component. Caffeine is a restricted substance for athletes in competition that allows up to 12-ug caffeine/ml urine. This level would only be approached by an excessive intake of more than 6 regular cups of drip-percolated coffee. There is no restriction in training. In a well-controlled study, intake of 9 and 13 mg/kg body weight caffeine resulted in urine levels above the doping limit in some individuals.

However, caffeine ingestion even at low levels i.e. 3-8 mg/kg body weight prior to exercise, enhances performance of both prolonged endurance exercise and short-term intense exercise lasting approximately 5 minutes in the laboratory. Recently it was also demonstrated that carbohydrate-electrolyte solutions with low concentrations of caffeine (2.1, 3.2 and 4.5 mg/kg BW respectively) improve endurance performance with low post-exercise urinary caffeine concentrations (1.3; 1.9 and 2.5 ug/ml respectively).

CREATINE

Creatine is a non-essential dietary compound found in high abundance in meat and fish. It is synthesized within the body, primarily in the liver, from the amino acids arginine and glycine. Diet and endogenous synthesis each contribute about half in subjects on a normal diet.

Creatine phosphate (CrP) serves as a readily available source of energy in skeletal muscle and other tissues. The rapid re-phosphorylation of ADP from CrP via the Creatine kinase reaction buffers changes in ATP during transitions between rest and exercise, and contributes a substantial fraction of ATP synthesis during short duration, high intensity exercise.

The relative importance of CrP during exercise is dependent on the nature of the exercise. For most exercise situations, the demand for ATP is predominantly provided through oxidative phosphorylation in the mitochondria. However, when aerobic energy production cannot meet the demand for ATP, anaerobic energy production from CrP hydrolysis and glycogenolysis/glycolysis is required to assist in the provision of ATP. Such cases include the transition from rest to exercise, the transition from one power output to a higher power output, and power outputs above 90-100% maximal oxygen consumption (VO2max). During a bout of high intensity exercise the relative importance of CrP hydrolysis to ATP synthesis falls off dramatically as the exercise duration is increased beyond a few seconds.

Research has shown that creatine ingestion increases the total creatine content in human muscle by approximately 15-20% (mean value). Such increases can be achieved by ingestion of 20 gram per day for 4-5 days, but also by ingestion of 3 gram per day over a period of 1 month. The increased creatine content is maintained when the ingestion is reduced to 2 gram per day after the original loading period. The increase in creatine content is rather variable between subjects, ranging from zero to up to 40%. Thus, there are ‘responders’ and ‘non-responders.’

Sub-maximal exercise performed prior to creatine ingestion can augment muscle creatine accumulation by approximately 10%, but again the variation in response is marked among individuals. Muscle creatine accumulation can be substantially augmented by ingesting creatine in combination with large quantities of simple carbohydrates. Coincident with the retention of creatine, there is a substantial reduction in urine production on the first 3 days of the loading period. This retention of water is thought to be related to an osmotic load caused by creatine retention and to account for the rapid-onset weight gains experienced by many individuals ingesting creatine. Many studies have reported increases in body mass of 1-3 kg following short-term (5-7 days) creatine supplementation.

Short-term creatine supplementation (5-7 days of ~20 g/d) can lead to an improvement in performance. Most but not all of the studies indicate that creatine supplementation significantly enhances the ability to produce higher muscular force and/or power output during short bouts of maximal exercise in healthy young adults. At present, exercise performances that are improved include: various protocols of short-term, all-out cycling, sprinting, repeated jumping, swimming, kayaking/rowing, and resistance exercise performance. Interestingly, the greatest improvements in performance seem to be found during a series of repetitive high power output exercise bouts. Exercise performance during the latter bouts of a series (e.g., third, fourth, fifth) can be increased by 5-20% over that measured for the placebo group. These experimental protocols employed exceptionally high power output efforts (e.g., maximal cycling and/or power jumping that can be maintained for only a short period, usually seconds) separated by fairly brief periods of rest (e.g., 20-60 seconds). These are the exercise conditions where the transitional energy contribution from CrP is likely most significant; further, the short-term rest periods between bouts are apparently sufficient to permit an enhanced recovery of the muscle CrP concentration in those individuals with a greater total creatine concentration as was shown in an in vivo magnetic resonance spectroscopy study. It, therefore, is likely that creatine supplementation improves exercise performance in sport events that require explosive, high-energy output activities especially of a repeated nature.

In some but not all studies, creatine supplementation increased maximal isometric muscle strength and not alter the rate of maximal force production. Creatine supplementation also did not appear to enhance aerobic-oriented activities.

Few data exist on the long-term effects of creatine supplementation.A number of studies indicate that creatine supplementation in conjunction with heavy resistance exercise training (e.g., 4 to 12 weeks in duration) enhances the normal physiological adaptations to a weight training program. Typical training adaptations including, increases in body mass fat-free mass, maximal strength and power, lifting volume, and muscle fiber hypertrophy, are all significantly enhanced concurrent with creatine supplementation.

The loading doses suggested by the manufacturers are 10-20 g/day for 5-7 days and then 2-5 g/day as a maintenance dose.

There are numerous anecdotal reports of creatine supplementation causing gastrointestinal, cardiovascular and muscular problems. There is no scientific evidence to support these reports. However, at this moment in time it also cannot be concluded (documentation is lacking or incomplete) that creatine supplementation is free from health risks. Creatine ingestion prior to competition in the heat should be discouraged as it may interfere with water absorption and as there is no rationale for intake immediately before competition (despite such claims on some commercial preparations). Creatine supplementation increases urinary creatine and creatinine excretion. Thus, it would be expected that creatine supplementation will increase plasma creatinine concentrations in healthy individuals; there is no a priori reason to expect that acute and long-term creatine ingestion impairs kidney function. This has been confirmed recently in experimental studies.