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Creatine

by Piotr Drabik

Creatine supplementation recently has become a common practice in various sports.

There is strong evidence that creatine is one of the most effective supplements. It is the most thoroughly studied supplementary molecule (investigated for over 150 years). Even so, all the studies lasted at most a few months and none meet standards for a proof of safety—see the article “Supplements and Common Sense” beginning on this same page.

About 5 % of one’s total creatine is in the heart, brain, and testicles, with the remaining 95 % found in the skeletal muscles. An individual weighing 70 kg (154 lbs.) has about 120 g of creatine, of which about 2 g are recycled. A person replenishes resources from creatine in food and from biosynthesis. Creatine is synthesized from the amino acids glycine, arginine, and methionine. Major food sources of creatine are fish, beef, and pork.

The mechanism by which supplementary creatine could have performance-enhancing effects would be in increasing muscle creat-

ine and phosphocreatine (creatine phosphate) concentration, leading to a higher rate of ATP (adenosine triphosphate, a carrier of free energy in most biological processes) resynthesis, a delay in the onset of muscular fatigue, and improved recovery during repeated bouts of high-intensity exercise. The amount of ATP in a muscle suffices to sustain contractile activity for less than a second. Muscle contains a reservoir of high-potential phosphoryl groups in the form of phosphocreatine. The phosphoryl transfer potential of creatine phosphate is higher than that of ATP. Creatine kinase catalyzes the reversible transfer of a phosphoryl group from creatine phosphate to ADP to form ATP. Creatine phosphate maintains a high concentration of ATP during periods of muscular exertion. Indeed, creatine phosphate is the major source of orthophosphate during the first few seconds of the most intensive efforts.

Many studies demonstrate that creatine supplementation has beneficial effects on

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Supplements and Common Sense

by Thomas Kurz

The more radical the improvement in performance caused by an ergogenic (performance-enhancing) aid such as a supplement or a drug, the more unnatural the aid and so the more severe the downside may be. (I do not like to use here the term *side effects* because it diminishes the significance of these effects and, as used in

medicine, suggests effects that may affect some users but not the majority. The term *downside* is like an inseparable companion of every “upside”—like the obverse and reverse of a coin.) In addition to knowing this general rule, one has to realize that little is known about most artificial substances used to enhance performance, and about the

long-term effects* of all supplements nothing is known.

Proof of Safety

Supplements are subjected to even less scrutiny than prescription drugs—some of

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* In the case of foodstuffs to learn their long-term effects may take thousands of years—not tens. After all hydrogenated oils were introduced 50 or so years ago, considered safe, and only recently their harmful effects are revealed, somewhat reluctantly, to the public. Another example—humans started to eat grains in the processed, high-glycemic forms about 9,000 years ago and only recently these have been implicated as a cause of adult-onset diabetes and syndrome X.

Supplements and Common Sense

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which get withdrawn after a few years due to unforeseen damage they have done.

For example, it turned out that estrogen replacement therapy, deemed safe and wise by scientists, increases the risk of ovarian cancer. Women who were getting estrogen therapy for 10 years had double the risk of dying from ovarian cancer than women who never got estrogen replacement. The risk persisted for 29 years after cessation of the postmenopausal estrogen use (Rodriguez et al. 2001).

Some drugs approved by FDA after a supposedly thorough evaluation are withdrawn later, after they harm or kill too many people for the danger to be dismissed—for instance, the diabetes drug Rezulin and the diet drug Fen-Phen. Some pharmaceutical companies, with the FDA's cooperation, release dangerous drugs while knowing the extent of damage they can cause (see the Associated Press report on Warner-Lambert's knowledge of the diabetes drug Rezulin's life-threatening damage to liver). Some drugs such as the diet drug Fen-Phen were approved by the FDA even though the FDA had evidence the drug causes heart-valve disease (Sen. Patrick Leahy 2001).

Why these blunders? Because it is harder to prove that a substance is safe than to prove it is dangerous. Irwin D. Bross (1985) showed that "the quantity of data required for a valid assurance of safety is of the order of 30 times greater than that required for a valid proof of hazard. . . . The size of the sample needed so far exceeds what is ordinarily attainable in biostatistical-epidemiological studies that official assurances supposedly given on the basis of such studies can have no scientific validity."

Regardless of sound science however, a lack of proof of hazard is often presented to the public as a proof of safety.

Natural, Isolated, and Synthetic

Laboratory studies on supplements are done on very pure substances but for the general public the standards of purity may be less rigorous. A few years ago tryptophan was pulled out of the market because of illness caused by impurities introduced in the process of industrial production.

Another issue is that of naturalness. All supplements, amino acids, vitamins, and minerals in nature occur combined with

several other substances in natural food-stuffs. It is best to take them in their natural form—as fruits, vegetables, grains, meat, fish, eggs, and in the case of salt as unprocessed sea salt.

A good example of why an isolated supplement is worse than consuming it in its natural source is the seemingly innocuous vitamin C.

The first reason for the inferiority of isolated vitamin C is poor absorption.

Isolated vitamin C is typically taken in two forms: a pill or a solution (dissolved in water). Taken in the form of a pill, it lands on the mucous lining of the stomach and dissolves. Vitamin C is an organic acid (ascorbic acid) that crystallizes, which causes a very high local concentration of this acid. This in turn causes a local but very high increase in acidity. This high acidity leads to ulceration of the stomach's mucous membrane.

Vitamin C dissolved in water reacts with air, which leads to several chemical reactions producing toxic organic acids (mainly formic acid) that when ingested may adversely affect metabolism.

The second reason is the likelihood of chronic harm to all body's systems. A recent *in vitro* study has shown that isolated vitamin C may cause genetic damage as well as destruction (apoptosis) of cells (Lee et al. 2001). Vitamin C in a fruit or a vegetable is just one of an uncounted number of chemical compounds. All these chemicals interact in countless ways that are experimentally unsearchable—perhaps keeping the vitamin C from doing harm to both the plant that contains it as well as to the creature that eats it. These other chemicals may also be beneficial on their own.

Individual Reactions

Apart from the issues of purity and long-term experience and knowledge of the effects of a given substance on the majority of people, there is also the issue of individual reactions.

There are substances that are beneficial to some people and harmful to others—for example, chocolate. Dark chocolate is rich in antioxidants, raises HDL cholesterol (the good cholesterol), detoxifies LDL cholesterol (the bad cholesterol) better than vitamin C, reduces blood clotting, and re-

laxes blood vessels.

But in some people chocolate, cocoa, and caffeine disturb the function of the ileocecal valve (a sphincter muscle between the small and large intestine) and make these people sick. They get any assortment of the following symptoms:

- Nausea
- Shoulder pain
- Headache
- Dark circles under the eyes
- Sudden low back pain
- Tension of the right quadriceps
- Dizziness
- Flu symptoms
- Pseudo sinus infection

These symptoms are caused by the effect of chocolate, cocoa, and caffeine on the ileocecal valve. This valve is supposed to stay closed when food is digested and absorbed in the small intestine, to open when digestion and absorption is completed so the waste can be moved into the large intestine, and then to close again. Malfunction of this valve causes absorption of toxins and the previously enumerated symptoms (Walther 2000). More on this is in *Stadion News* Fall 1997.

Conclusion

Once the possible benefits of a given supplement have been established in a laboratory, common sense suggests obtaining this supplement by consuming its natural sources with all the other substances that augment its positive and suppress its negative effects.

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Creatine

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performance of short-duration exercises, including sprinting, jumping, throwing or weight lifting. Creatine ingestion could delay the onset of muscular fatigue during repeated bouts of high-intensity exercise.

In addition to affecting energetic reactions, supplemented creatine increases muscle mass and strength via inducing protein biosynthesis. Subjects taking creatine experience a significant increase of maximal muscle power together with an increase of maximal muscle work. Additionally, the supplementation of creatine causes an increase of the general body mass, fat-free body mass, and the water content in the body. Creatine supplementation is not justifiable in disciplines where aerobic training dominates, but it has a strong impact on disciplines where muscle mass, strength, and speed are desired.

The improvement in performance following creatine supplementation is dependent on the fitness of the user. It has been suggested that human skeletal muscles have an upper limit for total creatine concentration. In contrast to sedentary subjects, athletes and well-trained subjects who have a high initial total creatine concentration in their skeletal muscle exhibit only a slight improvement in exercise performance. A critical review of the literature reveals that beneficial effects, when found, have been generally shown in untrained subjects performing several exercise bouts under laboratory conditions. The limited body of scientific data available concerning highly trained athletes—national- and international-level competitors—performing single maximal efforts separated by long breaks (track-and-field throwers and jumpers, weightlifters) indicates that this population does not benefit much from creatine supplementation. Therefore the widespread use of creatine ingestion to improve competition performance does not seem to be justified. The potential benefit of creatine supplementation for elite athletes in sports in which repeated efforts are required (e.g. soccer, basketball) could be related to an increased ability to perform repeated high-intensity exercise bouts, either during training or during competition, but this possibility needs scientific confirmation.

Taken together, the results of most stud-

ies published to date suggest that only the performance of repetitive high-intensity exercise bouts in athletes of low fitness is positively affected by creatine supplementation. During this type of exercise, in the case of low-fitness athletes, the increase in total creatine contributes to the fast resynthesis of phosphocreatine during recovery.

That supplementation helps most the low-fitness athletes is a typical occurrence in biology: The lower the initial level of a given substance, the more intensive is the response to supplementation of that substance. When the initial level of a given substance is very high the response to supplementation may be too small to be noticed. The similar applies to sports training—highly trained athletes may not respond at all to exercises that improve fitness of less trained athletes.

Insulin can act as an activator of creatine transport to muscle cells. Thus, it is reasonable to take creatine with glucose dissolved in water to increase one's insulin blood concentration. It should be kept in mind that caffeine nullifies the effect of supplemental creatine. Thus, diluting this supplement in coffee, tea, or other caffeinated drinks is not advisable.

Creatine is taken orally as a water solution of creatine monohydrate and glucose. Recent studies have shown that ingestion of about 20 g of creatine monohydrate per day is enough to modulate total muscle creatine, free creatine, and phosphocreatine. Supplementation should be done in two phases. In the first one (called "loading") lasting 5 days, one should take 5 g of creatine 4 times per day (in equal time periods). In the second stage (called the "maintaining phase") lasting 4 or 5 weeks, one can decrease dosage to 2 g per day. The whole cycle may be repeated many times in the course of training. On the day of competition the last dose should be taken about one hour before the warm-up for the start. This time interval is crucial due to the glucose ingested together with the creatine. Eating high glycemic index carbohydrates such as glucose less than one hour before beginning an event or an exercise inhibits glycolysis (breakdown and utilization of glucose for energy) and increases gluconeogenesis (conversion of protein and

fat into glucose) during the exercise. The result is impaired resynthesis of ATP from carbohydrates.

The method of creatine supplementation described in this article will most likely work well only for athletes of low fitness. It is not known whether drastically increasing the dosage would cause noticeable improvements in highly trained athletes.

There are no studies indicating any negative side effects of creatine supplementation. In some sports, however, mass gain (about 1–2 kg, or 2.2–4.4 lbs.) due to taking creatine may be undesirable. The mass gains may be very rapid. In one study the average gain was 1.4 kg (3 lb.) in a week (Volek et al. 1997).

In that study by Volek, in the same week of creatine supplementation subjects showed significant gains in power output and strength-endurance (muscular endurance). Such a rapid increase of strength-endurance and power output due to taking creatine may cause injuries in poorly supervised athletes. The potential for injuries has to do with the athletes suddenly raising the intensity of exercises to a level their tendons, ligaments, and joints are not ready for. Further, thanks to this higher intensity of exercises, muscles grow stronger at a faster pace than the structural strength of their tendons and the joints these muscles move. The end result may be strained or completely torn tendons, torn joint cartilage, and sprained ligaments. All these dangers are more likely for low-fitness athletes, the ones whose performance is most improved by taking creatine.

Creatine is extremely effective, but it is not a panacea. Although harmful metabolic side effects are unknown even if it is taken in big doses, so far the evidence shows that creatine may help only athletes of relatively low fitness who perform very intensive brief efforts, and that its dosage should not exceed 20 grams per day. In other cases it is just waste of money.

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Q and A on STRETCHING and TRAINING (continued from previous issue)

Study these typical questions on stretching and training carefully. You may find information that relates to questions of yours. Questions are in *italic boldface*.

■ *Sometimes when I try to do isometric stretching to my maximum reach, my leg starts to shake automatically. You have any idea why that might happen?*

Perhaps the shaking is caused by impaired inter- and intramuscular coordination due to fatigue. If so, then it might be remedied by improved muscular strength or muscular endurance.

■ *My height on the leg raises to the side is very poor--barely over waist high. I use your technique as shown in January 2000 issue of Taekwondo Times. I have difficulty getting in correct position sometimes, usually the first two raises are low until it feels right.*

It takes some practice to get any technique right on the first attempt.

■ *I'm 45 and getting back into TKD after a 20+ year layoff (red belt then). I'm in good shape, but even 20 years ago my flexibility wasn't that great. My goal of course is to do the side split.*

My workout week: morning warm-up 50-60 jumping jacks. Then 1-2 sets leg raises all three directions, some kicking practice, 2 wall squats (lean back against wall, lower down and hold for 60 seconds). Then relaxed static stretches in this order each held for 30-40 seconds sometimes two sets. Quad stretch, inner thigh or butterfly stretch PNF and relax on this one, lower back stretch, calf and hamstring stretch PNF and relax style on this also. Then I try doing side split without hunching my back, holding on to the bottoms of my feet while trying to get my chin on the ground--a long ways away. I can get my forearms and elbows on the ground with slight help or a 13 pound weight resting on my forearms. Some light jogging and I'm on my way to work as a mailman.

During breaks at work I stretch arms and shoulders, do 2 wall squats lean-

ing against my truck for 60 seconds each, then I do 2 sets of lower back and hamstring stretches. I also do 2 sets leg stretch by putting one leg on drivers seat door open and supporting leg on sidewalk, each about 40 sec. After I get home, eat, and shower I do at least one set of 12 dynamic leg raises all three directions. Twice a week I have TKD class (usually Monday and Thursday), Wednesday I do Tae Bo aerobics class. Friday, Saturday, and Sunday light workout days no classes but same routine otherwise. I don't work on Sunday and on one other day, it rotates. On my light days I try and squeeze in what I need to know for Tae Kwon Do besides kicking, forms, self defense, Ho-Sin-Sul.

Regarding your first exercise in a day: I would not do jumping jacks. Some of the reasons are explained in the book *Science of Sports Training* and in the twelfth article of my column on stretching and training at <http://www.stadion.com/column.html>.

Regarding all the other exercises: I think you do too much. A morning stretch should consist of dynamic stretches, perhaps one or two relaxed stretches for some particularly inflexible muscle group but no isometric or PNF stretches—especially before long physical efforts.

You do too many isometric stretches for too many muscle groups—five muscle groups just in the morning. One isometric stretch per one muscle group, up to three muscle groups stretched per workout is plenty. Change the stretch for a more effective one once it no longer increases range of motion. See pages 70-72 and 89-90 in *Stretching Scientifically* for a selection of stretches leading to side split. To reach your goal you have to do exercises that are specifically designed for reaching it. You also have to observe your reaction to these exercises and adjust your training accordingly.

You workout every day of the week as if you did not know that rest is an integral and necessary part of training. All the information you need, including specific stretches for side splits, is in the book *Stretching Scientifically* as well as on the video *Secrets of Stretching*.

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