Anabolic-androgenic steroids (AASs) have been used by athletes for decades to increase lean body mass, strength, and overall athletic performance. The legal issues and dangers associated with AASs, however, have resulted in a reluctance to use them by many athletes and a search for a more natural method for improving performance. This has led to an increase in the popularity of nutritional supplements marketed as ergogenic aids. Because they are considered natural and are available without a prescription, there is a misconception that these supplements are all healthy and safe, which is not always true. Although there are numerous supplements currently marketed as ergogenic aids, the more popular ones are those containing creatine, ephedra, and AAS precursors.

**Creatine**

The use of creatine (Cr) as a performance enhancer was first popularized after the 1992 Olympic Games in Barcelona, and testimonies by Mark McGuire and many other professional athletes helped make it extremely popular in the United States and Canada. Approximately 95% of the body’s Cr pool is found in skeletal muscle, with 60% of that in the form of phosphocreatine (PCr). Cr plays a primary role in the phosphagen energy system; PCr is the primary substrate for adenosine-triphosphate (ATP) resynthesis. The theory behind its use is similar to that of carbohydrate loading; increased muscle Cr and PCr content would conceivably enhance the capacity of the phosphagen energy system, providing greater resistance to fatigue, and improve performance. This has been partially supported; several reports indicate that muscle Cr and PCr can be elevated when a normal diet is supplemented with oral Cr. Its efficacy as a performance enhancer, however, remains in question.

**Ergogenic Effects**

Literally hundreds of scientifically controlled studies have been performed investigating the effects of Cr on performance, and anecdotal reports of ergogenic value have been supported by improvements in strength, power, speed, and fatigue. Not all studies, however, support ergogenic claims. Reports of weight gain after supplementation are a bit more consistent than other measures of performance. What is not known is the source of the weight gain, with protein synthesis and water retention
being the more popular theories. Because the weight gain is observed over a short period of time, it cannot be explained by protein synthesis alone. Thus, water retention is a more likely cause. This theory has been supported because increases in both total body water and intracellular water volumes have been observed after supplementation.\textsuperscript{15,16} There is also evidence, however, supporting the theory of increased protein synthesis after increases in muscle Cr.\textsuperscript{17}

At this time, the efficacy of Cr as a performance enhancer remains inconclusive. There are a number of factors that can affect the potential for performance improvements, such as the type of training and performance testing, training level, diet, and initial Cr levels. To achieve a performance effect from supplementation, one must first experience an increase in muscle Cr levels when it is ingested. As mentioned previously, this has been shown to occur,\textsuperscript{1,4} but a large amount of variability has been observed regarding the change in muscle Cr after supplementation.\textsuperscript{1-5} This might explain why some individuals do not experience an ergogenic effect.\textsuperscript{3,13-16} It has been reported that 20–30\% of those ingesting Cr do not respond, meaning they experienced less than a 10-mmol/kg increase in the muscle concentration.\textsuperscript{18} It has also been reported that only 20\% of individuals achieved concentrations of approximately 150–160 mmol/kg after supplementation.\textsuperscript{15} This concentration is considered the upper limit of muscle Cr stores, although some individuals have been observed to achieve higher levels.\textsuperscript{1,2}

**Side Effects**

There have been numerous anecdotal reports of muscle cramping, spasm, strains, gastrointestinal distress, kidney dysfunction, and heat illness associated with Cr supplementation. Many of these are based on isolated cases. At this time, however, the only side effect directly associated with supplementation is weight gain.\textsuperscript{5,7,9,11,14-16} Creatine use over the past decade has been so high that an obvious causal relationship would have been noted if serious side effects were actually associated with it, but this has not occurred. In fact, a number of studies have specifically investigated the occurrence of side effects.\textsuperscript{19-22} The general conclusion from these studies was that Cr is not associated with any negative side effects. Thus, a causal relationship between Cr supplementation and negative side effects cannot be established at this time.

**Ephedra**

The ephedra plant species, collectively known by their Chinese name ma-huang, have two primary active ingredients, ephedrine and pseudoephedrine.\textsuperscript{23-25} Ephedrine and pseudoephedrine are classified as sympathomimetic alkaloids because they directly stimulate the sympathetic nervous system. They are structurally similar to amphetamines and have direct alpha- and beta-agonistic properties, as well as catecholamine-releasing actions.\textsuperscript{24,26} These alkaloids also function as indirect adrenoreceptor agonists, because they augment the availability and action of norepinephrine in the brain and in the heart.\textsuperscript{24,27} Unlike pseudoephedrine, however, ephedrine also mediates its effects via circulating epinephrine.\textsuperscript{27,28} Based on these properties, ephedra is currently marketed as a central-nervous-system (CNS) stimulant and a thermogenic and lipolytic agent.

**Ergogenic Effects**

Interest in ephedra supplementation originated from early reports of enhanced thermogenesis and lipolysis after ephedrine ingestion.\textsuperscript{29-30} These were clinical trials involving subjects seeking treatment for obesity, however, so it is likely that the participants were deficient in metabolic rate or fat metabolism. Although the research concerning ephedrine and performance in an athletic population is limited, most of it does not support ergogenic claims.\textsuperscript{31-33} Ephedrine ingestion has failed to improve muscle strength, endurance, and power; lung function; reaction time; hand–eye coordination; anaerobic capacity; speed; cardiorespiratory endurance; ratings of perceived exertion; and recovery.\textsuperscript{32} Similar observations have been made after pseudoephedrine ingestion; a single 120-mg dose had no effect on 40-km cycling time, maximal muscle force, or muscle endurance during repeated isometric contractions.\textsuperscript{31} Likewise, pseudoephedrine ingestion has also failed to improve VO\textsubscript{2} max, time to exhaustion, and ratings of perceived exertion in comparison with placebo conditions during exercise.\textsuperscript{33,34}

It is quite common to find products combining ephedra with garana or other sources of caffeine. The primary reason for combining the two drugs is to potentiate the effects of the ephedrine.\textsuperscript{28} Ephedrine exerts its ergogenic effects via catecholamine release. Increased catecholamine levels after ephedrine...