A–Z of nutritional supplements: dietary supplements, sports nutrition foods and ergogenic aids for health and performance—Part 26

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INTRODUCTORY REMARKS

Part 26 provides an overview of three supplements with different characteristics of potential contribution to exercise performance and different levels of scientific support for this potential. Methionine is an amino acid with an important role, in addition to its contribution to protein metabolism, namely, as a precursor of creatine. N-acetylcysteine has an important role in glutathione resynthesis and therefore contributes to antioxidant status. Finally, we discuss a new approach to providing carbohydrates in sports supplements – known as multiple transportable carbohydrates (MTC) – which overcomes the usual intestinal absorption limits to allow higher rates of carbohydrate consumed during exercise to be available as a muscle fuel.

METHIONINE

N A Burd

Methionine is an indispensible amino acid that acts as a substrate, much like the other indispensible amino acids, for building functional muscle proteins. It is clear, however, that methionine also holds a unique role, when compared against the other indispensible amino acids, as it serves as a methyl group donor for DNA/RNA intermediates and for the synthesis of cysteine.[1] Daily methionine requirement, reported as a constituent of the requirement for total sulphur amino acids, is 13–15 $mg/kg^{-1}/day^{-1}$ with the risk for toxicity manifesting only at levels exceeding >10-fold excess in humans.[2 3] Daily requirements of methionine are easily obtained in the diet due to its widespread abundance in meats, eggs, cheeses, fruits and vegetables. However, vegan athletes may need increased self-awareness of daily methionine intake.[4]

What purpose does supplemental methionine have in an athlete's diet for enhancing performance/recovery? Very little, provided the athlete is healthy and consuming a mixed diet containing an adequate amount of energy to meet training needs. Indeed, methionine is fundamental, together with arginine and glycine, for the endogenous synthesis of creatine. However, there is no evidence to suggest that additional crystalline methionine to normal dietary intake would be more beneficial or even helpful, than oral intake of creatine monohydrate; a supplement that has been shown to increase muscle strength and hypertrophy after resistance training.[5]

MULTIPLE TRANSPORTABLE CARBOHYDRATES

A Jeukendrup

Since the 1980s, it has been known that carbohydrate intake during exercise can improve exercise performance lasting 2 h or longer. Soon after this discovery, it was established that not all carbohydrates are equal and carbohydrates ingested during exercise may be utilised at different rates.[6] Until a landmark publication in 2004,[7] it was believed that carbohydrate ingested during exercise could only be oxidised at a rate not higher than 1 g/min (60 g/h) independent of the type of carbohydrate. This is reflected in the guidelines published by the American College of Sports Medicine, which recommend that athletes should take between 30 and 60 g of carbohydrates during endurance exercise (>1 h)[8] or 0.7 g/kg/h.[9]

Exogenous carbohydrate oxidation appears limited by the intestinal absorption of carbohydrates.[6] It is believed that glucose uses a sodium-dependent transporter (SGLT1) for absorption, which becomes saturated at a carbohydrate intake around 60 g/h (or 1 g/min). When glucose was ingested at this rate and another carbohydrate (fructose) that uses a different transporter was ingested simultaneously, oxidation rates well above 1 g/min (1.26 g/min)[7] were observed. At present only two different intestinal carbohydrate transporters have been identified (SGLT1 for glucose or glucose polymers and galactose, and glucose transporter type 5 for fructose). Interestingly, sucrose (a disaccharide of glucose and fructose), which is said to have its own disaccharide transporter, appears to behave more like glucose than glucose:fructose.[10] Studies suggest that exogenous carbohydrate oxidation from sucrose is similar to glucose and does not reach the high oxidation rates observed with glucose and fructose (or other MTC).

With the knowledge that a single carbohydrate could only be oxidised at a rate of 1 g/min, a series of studies was initiated in an attempt to find the combination that would result in the highest oxidation rates. In these studies, the rate of carbohydrate ingestion as well as the combinations of carbohydrates varied. All studies confirmed that MTC resulted in higher (up to 75%) oxidation rates than carbohydrates that use the SGLT1 transporter only (for reviews see [6 11]). Combinations of maltodextrin and fructose, and glucose and fructose or glucose, plus sucrose and fructose, seemed to produce the most favourable effects.[6 10–12]

From a practical perspective, it is important to note that such high oxidation rates can not only be achieved with carbohydrate ingested in a beverage but also as a gel[13] or a low fat, low protein, low fibre energy bar.[14]

Strong evidence is now emerging of a dose–response relationship between carbohydrate intake and endurance performance. Studies have demonstrated that MTC can result in improved performance over and above the performance enhancing effect of a carbohydrate drink with one single carbohydrate.[15 16] It has also been demonstrated that MTC may have advantages in fluid delivery[17–19] and studies suggest less gastrointestinal discomfort. Recently published recommendations take these findings into account, acknowledging that there may be different carbohydrate needs for different durations of exercise as well as for different levels of athletes.[20] MTC can be recommended at all durations but are most effective when the exercise is 2.5 h or longer. In those conditions, carbohydrate intakes of up to 90 g/h are recommended and these would only be oxidised to any significant degree if they are MTC in which glucose makes up no more than about 60 g.[20]

N-ACETYLCYSTEINE

M B Reid

N-acetylcysteine (NAC) is a reduced thiol donor that supports cellular resynthesis of glutathione, a major antioxidant in skeletal muscle and other human tissues. As reviewed elsewhere,[21] glutathione buffers reactive oxygen species (ROS) produced by muscle. ROS levels increase substantially during strenuous exercise, overwhelming glutathione buffering and depressing contractile function. This contributes to the development of muscle fatigue. NAC opposes this process. By supporting glutathione resynthesis, NAC slows the rise of ROS activity in exercising muscle and delays fatigue. This was first demonstrated in humans by our group[22] in studies of tibialis anterior, an ankle dorsiflexor muscle, during repetitive electrical stimulation. Subsequent studies confirmed that NAC inhibits fatigue during volitional exercise tasks, for example, loaded breathing[23] and handgrip exercise.[24] The studies of greatest physiological relevance were conducted by McKenna and colleagues who showed that NAC delays fatigue of trained athletes during strenuous cycling exercise.[25] Despite performance benefits in the laboratory, several issues limit NAC use as an ergogenic aid. First, only pharmacological doses of 140–150 mg/kg have been shown to limit fatigue. We do not know if lower doses are effective. Secondly, doses that delay fatigue are safe but can have uncomfortable side effects including nausea and diarrhoea.[26] Finally, NAC may have negative effects on athletic training. Data are emerging to suggest that chronic antioxidant supplementation blunts the positive effects of transient oxidative stress, a signal that appears to be essential for muscle adaptation to exercise. Thus, while effects of high-dose NAC are intriguing, it is too soon to conclude that NAC supplementation is beneficial for athletes. Future directions for research include studies to optimise NAC dosage, balancing efficacy versus side effects, and to evaluate novel thiol donors for their effects on fatigue.

CONCLUDING COMMENTS

Of the products reviewed in this part, it is clear that the MTC have the strongest evidence to support a beneficial role in sports performance. In fact, they add a further chapter to the carbohydrate story which already provides a major theme in the nutritional plans of most athletes. NAC enjoys some evidence of potential benefits but the practical implications of this evidence seem small. Finally, methionine plays a cameo role as a precursor of the important muscle fuel creatine, but supplementation will not enhance this role.

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Notes