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Commentary on *The Optimum Composition for Endurance Sports Drinks*

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Sports drinks containing carbohydrate, electrolytes, and fluid are widely recommended for use by endurance athletes during competition and training. Fluid replacement probably improves performance by off setting the disturbances to cardiovascular function associated with dehydration (e.g. elevated blood pressure and modified distribution, impaired thermoregulation), while carbohydrate ingestion may aid performance by attenuating liver and skeletal-muscle glycogen depletion. Carbohydrate and fluid have been found to independently improve endurance performance, and there appears to be some synergism in their action (Coombes and Hamilton, 2000). The electrolyte sodium may enhance water and glucose intestinal absorption, and help to replace sweat losses by retention of extracellular-fluid sodium homeostasis. Hopkins and Wood provide an up-to-date summary of the physiological rationale for sports drinks and present the likely best average composition for most events of about one hour duration or more: composite carbohydrate (fructose or sucrose and glucose polymers), sodium chloride at a palatable concentration, and fluid.

In the absence of hard data to the contrary, we can assume that more is better, so the carbohydrate composite could be ingested at a rate aimed at maximizing delivery to the circulation, oxidation, and subsequent endogenous-carbohydrate sparing; there is evidence, although variable, for the latter (e.g., Jentjens et al., 2006; Jentjens and Jeukendrup, 2005; Jentjens et al., 2004). Oxidation rates for ingested carbohydrate of up to 1.5 g per minute can be expected with the ingestion of around 72 g glucose polymer (maltodextrin) and 36 g fructose per hour (Wallis et al., 2005). The ingestion scheme will approximately double carbohydrate delivery compared with even the high-end previous recommendation of 50-60 g per hour, and retain drink osmolality around isotonic levels (280-300 mOsm) avoiding the reduction in gastric emptying, fluid uptake, and risk of GI distress with osmolalities >500 (Brouns and Kovacs, 1997).

While the ingestion of fluid or carbohydrate-containing beverages compared with nothing or water only generally improves endurance performance (for reviews see Brouns and Kovacs, 1997; Coombes and Hamilton, 2000), there is no conclusive evidence to date that one drink formulation is better than another. This uncertainty is due largely to a lack of appropriately designed and controlled studies specifically aimed at determining the effect of drink composition on performance. Additionally, there is no performance data I have been able to find on the effects of composite carbohydrate formulations ingested at high rates and concentrations vs appropriate controls. Consequently, both those of Hopkins and Wood and the pool of present guidelines for sports drink formulations (e.g., Brouns and Kovacs, 1997; Coombes and Hamilton, 2000; Coyle, 1994; Gisolfi and Duchman, 1992) are based largely on interpolation of a performance benefit based on physiological correlates. With the exception of a negative effect of fructose in isolation and in high concentrations (e.g., Maughan et al., 1989), as far as we know there is no difference in the effectiveness of one formulation over another. More publications would be welcomed in this area.

Hopkins and Wood, citing Nancy Rehrer (2001), propose that in events of increasing duration from 2 to 8 hours, sodium concentration might be increased from 20 to 40-50 mM. This recommendation is due in part from the concern about the (rare) occurrence of hyponatremia (plasma [Na^+] <130 mM) during prolonged exercise with high levels of fluid ingestion. Commercial sports drink formulations promote greater voluntary consumption than that of water, which is viewed as positive under the paradigm where any dehydration is negative. Under circumstances of high sweat rates sustained for several hours or more, the consumption of large amounts of sports drinks to meet fluid needs containing 20 mM NaCl (1.17 g/L) may, however, be insufficient to maintain plasma sodium concentrations, which might increase the chance of hyponatremia. In this instance, the higher sodium intake may be better (Rehrer, 2001), or perhaps more simply consuming *less* sports drink which can have the added benefit of increased power-to-weight ratio. Such *functional dehydration* with intakes less than that required to maintain body weight is common in elite endurance athletes such as marathon runners and triathletes and is rarely a health risk (Noakes, 1995). Tolerance to dehydration is probably improved through exposure during training and may have downstream benefits to haematology–plasma volume expansion and erythropoiesis, as alluded to in the article.

The main function of sodium in sports drinks is not to prevent hyponatremia, but rather to enhance palatability and promote water and glucose absorption (Gisolfi and Duchman, 1992). Many commercial sports drinks also contain other salts, such as, potassium chloride and magnesium sulphate. Hopkins and Wood did not include other electrolytes in their *optimal drink*. As far as I am aware, there is presently only a theoretical argument for the inclusion of potassium. Interested readers are referred to Cunningham (1997). The most attractive justification for the inclusion of potassium in sports drinks (usually 2-5 mM) is that losses in sweat contribute to a *relative* exercising plasma hypokalemia (low potassium). Normally potassium concentration in the extracellular fluid (at rest 4.0-4.5 mM) increases during heavy exercise (Sejersted, 1992), owing to efflux of potassium from muscle fibers exceeding the capacity the sodium-potassium pump to restore ion gradients. This exercise-induced hyperkalemia (e.g., 5-7 mM) may stimulate sodium-potassium pump activity and is probably a key regulator of breathing during exercise. Hence, potassium losses in sweat coupled with dilution of extracellular-fluid potassium concentration with low-potassium beverages may be linked to physiological processes that act to hinder endurance performance.

So while Hopkins and Wood propose an optimal formulation, which is not too dissimilar to most commercially-available products, we still do not know what combination of ingredients are actually better for performance. Nor do we know if the quantity and quality of carbohydrate, salt, and fluid actually matters. With evidence of a possible oral sugar sensor facilitating performance in response to a mouthwash (Carter et al., 2004) and the lack of any consistent pattern as to the effects of carbohydrate type or electrolytes in the studies that have made it to publication (Coombes and Hamilton, 2000), it may not matter what carbohydrate-electrolyte beverage the athlete ingests, providing it contains a reasonable amount of fluid to offset dehydration to a level that does not adversely affect performance (probably <2% body weight loss) and some carbohydrate. Whether salts are a necessary component of sports drinks to enhance performance remains to be determined.

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Back to article/homepage

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