The effect of fructose and maltodextrin vs glucose and maltodextrin formulated sports beverages on mountain-bike race performance

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Abstract

Background: Exogenous carbohydrate improves performance during prolonged high-intensity exercise. When ingested together, fructose and glucose polymers are oxidised at rates 1.5-1.7 higher than isocaloric glucose solutions. As fructose and glucose are transported across the intestine via different mechanisms, the capacity for exogenous-carbohydrate absorption is greater with composite carbohydrate mixtures. Therefore, since the effect of ingesting multi-transportable carbohydrate on field-based performance has to our knowledge not been investigated, we examined their effect on mountain bike race performance. Finishing time was expected to be substantially reduced when multi-transportable carbohydrates were ingested.

Method: Ten; male (7) and female (3), mountain bikers aged 32.9 ± 8.7 years, weighing 68.8 ± 9.4 kg and training for at least 8 hours per week and racing regularly participated in a double-blind crossover study. Following a standardised training and diet regimen cyclists completed two Olympic-distance (target winning time of 2h 15m), cross-country mountain bike races during which they ingested either a 11.25% maltodextrin and fructose solution (MF) or an isocaloric, equi-volumetric, isosmotic control solution containing maltodextrin and glucose (MG). Performance times, ratings of perceived exertion, gastro-intestinal discomfort and measurements of hydration status were recorded and compared. Data was analysed using appropriate mixed models in SAS.

Results: Cyclists were 1.8% (2mins 31s) faster in MF compared to MG (90% confidence interval: ±1.8%; 72% likelihood of a substantial benefit). The effect solution composition on the increase in time from the first the final lap (fatigue) was 9.7% (±2.8%) in MF and 10.7% (±2.8%) in MG; which corresponded to a 0.9% reduction (±3.5%; unclear) in the fatigue in MF. Abdominal cramps were reduced by 8.1% in MF relative to MG (±6.6%; likely benefit) and for every 1% change in abdominal cramp rating, lap time increased by 0.14% (±0.10%). There we no clear effects of MF on ratings of perceived exertion and hydration status compared with MG.

Conclusion: Cross-country mountain bike race performance was substantially enhanced following ingestion of a maltodextrin and fructose solution. This outcome was related to reduced gastro-intestinal distress supporting the theory that solutions containing multiple-transportable carbohydrates increase the availability of carbohydrate for metabolism. Further investigation with a larger sample size is recommended to establish whether the performance effect is genuinely beneficial or trivial.

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Introduction

Fluid and carbohydrate both independently and together improve exercise performance (Below, et al., 1995). According to Williams, (1989), exercise performance refers to the time taken to perform a set task or distance, whereas exercise capacity refers to the time taken to exercise to exhaustion at a constant intensity. A lack of fluid intake during exercises causes dehydration which may impair thermoregulation (Fortney, et al., 1981; Nadel, et al., 1980; Sawka, et al., 1985), cardiovascular function (Hamilton, et al., 1991; Montain and Coyle, 1992b; Walsh, et al., 1994) and exercise performance (Armstrong, et al., 1985; Barr, et al., 1991; Walsh, et al., 1994); however, when fluid is ingested these impairments can be attenuated (Barr, et al., 1991; Below, et al., 1995; Hamilton, et al., 1991; Maughan, et al., 1996).

Under normal post-absorptive metabolic conditions, exercise at a high intensity relies heavily on endogenous-carbohydrate stores (Gollnick, 1985; Saltin and Karlsson, 1971). As muscle glycogen is depleted, more glucose is extracted from the blood (Gollnick, et al., 1981) and there is an increase in hepatic-glucose output to maintain blood-glucose concentrations (Astrand and Rodahl, 1986). Depleted muscle- and liver-glycogen and an inability to maintain blood glucose are considered to be primary causes of fatigue under these circumstances (Coggan and Coyle, 1987; Coyle, et al., 1986; Coyle, et al., 1983). Ingestion of carbohydrate during prolonged exercise, however, can delay fatigue and improve both endurance capacity (Coggan and Coyle, 1987; Coyle, et al., 1986; Coyle, et al., 1983; Fielding, et al., 1985; Hargreaves, et al., 1984; Maughan, et al., 1989; Mitchell, et al., 1989; Tsintzas, et al., 1996b; Yaspelkis, et al., 1993) and the performance of constant-work tasks (Tsintzas, et al., 1995b) by reducing endogenous-carbohydrate oxidation (Bosch, et al., 1996; Coyle, et al., 1983; Hargreaves, et al., 1984; Jeukendrup, et al., 2006; Jeukendrup, et al., 1999b; McConnell, et al., 1994; Nicholas, et al., 1999; Palmer, et al., 1999; Tsintzas, et al., 1995a, 1996a; Yaspelkis, et al., 1993). Carbohydrate ingestion may also improve performance by reducing central fatigue (Dalsgaard, et al., 2002; Davis, et al., 1992; Nybo, et al., 2005; Nybo, et al., 2003; Snow, et al., 2000). The peak oxidation rates of different types of exogenous carbohydrate vary with the highest rates of ~1.0 g·min^{-1} (Jeukendrup, et al., 1999b; Rehrer, et al., 1992b; Wagenmakers, et al., 1993) observed following ingestion of glucose or glucose polymers at a rate of 1.2 g·min^{-1} or greater (Hawley, et al., 1992a; Jentjens, et al., 2004c; Jentjens, et al., 2004a; Jentjens, et al., 2004b; Jeukendrup, et al., 1999b; Wagenmakers, et al., 1993; Wallis, et al., 2005). Fructose is oxidised at lower rates than glucose (Adopo, et al., 1994; Guezzenec, et al., 1989; Massicotte, et al., 1986; Massicotte, et al., 1989) when ingested alone. However, fructose absorption appears to be facilitated when it is co-ingested with glucose (Adopo, et al., 1994; Jentjens, et al., 2004c; Jentjens and Jeukendrup, 2005; Jentjens, et al., 2004a; Jentjens, et al., 2004b; Shi, et al., 1997; Shi, et al., 1995; Wallis, et al., 2005). Exogenous-carbohydrate oxidation rates are 40-65% higher following co-ingestion of glucose or maltodextrin and fructose at rates of 1.2 g·min^{-1} and 0.6-1.2 g·min^{-1} respectively, relative to an isocaloric quantity of glucose or maltodextrin (Jentjens and Jeukendrup, 2005; Wallis, et al., 2005). However, ingestion of large quantities of carbohydrates without increasing fluid intake increases the solution concentration and osmolality which may reduce fluid uptake (Brouns and Kovacs, 1997; Rehrer, 1994) and increase the likelihood of gastro-intestinal discomfort (Tsintzas, et al., 1995b; Wagenmakers, et al., 1993).

Most studies into the performance effects of carbohydrate supplementation during prolonged endurance exercise have been completed in the laboratory when the athlete has fasted for a prolonged period of time (Jeukendrup, 2004) giving them initially depleted liver-glycogen stores. These conditions do not accurately represent the demands and preparation surrounding competition. Furthermore, to my knowledge no research has looked at the affect of co-ingestion of fructose and glucose-based carbohydrate at high rates on performance. Therefore, the first aim of this study is to investigate the effect of ingesting maltodextrin and fructose at high rates during prolonged, high-intensity exercise performance in the field under normal competition conditions compared to an equicaloric maltodextrin and glucose solution. Performance will be evaluated during an Olympic-distance, cross-country mountain bike race which due to its intermittent and high-intensity nature (Impellizzeri, et al., 2002;

Lee, et al., 2002; Stapelfeldt, et al., 2004) likely relies on carbohydrate as the predominant fuel source (Saltin and Karlsson, 1971). Carbohydrates will be ingested at rates similar to those used previously in laboratory studies to attain high exogenous-carbohydrate oxidation rates (Jentjens, et al., 2004c; Jentjens and Jeukendrup, 2005; Jentjens, et al., 2004a; Jentjens, et al., 2004b; Wallis, et al., 2005) and mixed with a quantity of fluid that meets normal recommended rates of fluid ingestion for prolonged exercise (Noakes, 1995; Speedy, et al., 2000). An appropriate quantity of salt will also be included to aid in the stimulation of thirst (Astrand and Rodahl, 1986) and increase both fluid (Wemple, et al., 1997) and carbohydrate (Leiper, 1998; Olsen and Ingelfinger, 1968) uptake. A second aim will be to examine any effect of the different drink compositions on ratings of perceived exertion and gastro-intestinal discomfort. Thirdly, we will investigate whether ingestion of these drink formulations affects dehydration by recording measurements of hydration status (urinary indices and change in body mass). Urine colour has been shown to correlate to more accurate urinary indices of hydration status (Armstrong, et al., 1994) and can be used to monitor hydration in the field to help prevent dehydration. Therefore the final aim is to compare the validity of measurements of urine colour, urine specific gravity and urine osmolarity with those of a previous benchmark study (Armstrong, et al., 1994).

We expect to observe a reduction in performance time and less symptoms of gastro-intestinal discomfort with ingestion of the maltodextrin and fructose drink compared to the maltodextrin and glucose drink. Additionally, we do not expect the cyclists to become unusually dehydrated.