Finding your carbohydrate and fluid sweet-spot - practical and academic considerations

Cox, Gregory R.

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Chapter

FINDING YOUR CARBOHYDRATE AND FLUID SWEET-SPOT – PRACTICAL AND ACADEMIC CONSIDERATIONS

Gregory R. Cox*

Australian Institute of Sport, Queensland, Australia

ABSTRACT

The ultimate goal in the pursuit of athletic excellence is to perform optimally on a nominated day at major championship events including World Championships and Olympic Games. To compete to their full potential, endurance athletes undertake years of training to facilitate physiological adaptations that increase their ability to sustain the highest possible average power output or speed of movement for a given distance or time. [13] Apart from an athlete's genetic make-up and optimised training programme, perhaps the largest single determinant of ensuring an optimal performance during an endurance event is through the intake of carbohydrate and fluid on race-day. However, the potential advantages associated with a strategic intake of carbohydrate and fluid during exercise [14] need to be balanced with the possibility of gastrointestinal upset associated with their intake. [22]

This brief commentary will describe recommendations for carbohydrate and fluid intakes during endurance exercise. Recommendations for carbohydrate and fluid need to be integrated as athletes typically consume carbohydrate during exercise by way of consuming sports drinks which simultaneously provide both carbohydrate and fluid. In fact, a study investigating race-day intakes of elite Olympic distance triathletes, found that carbohydrate intakes were increased during hot races as triathletes consumed more sports drink. [7] Conversely, in cooler weather conditions triathletes consumed less carbohydrate as a direct result of consuming less sports drink. The findings of this study highlight the importance of developing a race nutrition plan which integrates carbohydrate and fluid intake strategies so that carbohydrate and fluid intake goals are independently met.

* Contact: Gregory R. Cox, Sports Nutrition, Australian Institute of Sport, Gold Coast, Queensland, Australia. Email: greg.cox@ausport.gov.au.

INTRODUCTION

Carbohydrate Intake Recommendations for Exercise

Although evidence for carbohydrate ingestion during exercise was established nearly a century ago, [10] it is only in the last 20 years that the benefits of carbohydrate intake during exercise have been fully recognised in formal sports nutrition guidelines. [5] The absence of carbohydrate intake recommendations within formal guidelines was largely based on the observation that carbohydrate added to water temporarily slowed gastric emptying rates. [8]

Recently, carbohydrate intake guidelines for competition have been updated in light of new information which has changed our understanding of the needs of athletes and the advice offered. [3] The amount, type and carbohydrate intake strategy associated with performance benefits vary according to the duration of exercise, which suggests that several overlapping mechanisms may be responsible for the performance enhancement associated with carbohydrate ingested during exercise. [17] The two major mechanisms that primarily explain why carbohydrate supplementation during exercise improves performance are: 1) a mental/cognitive stimulation of the central nervous system by oral exposure of carbohydrate during shorter exercise durations (e.g. < 1 h) when muscle glycogen stores are not limiting; and 2) direct contribution of carbohydrate energy and exogenous carbohydrate oxidation during muscle glycogen limiting exercise situations (e.g. > 2 h). As a sports nutrition practitioner, it is important to consider these mechanisms when consulting athletes as carbohydrate intake strategies should be individually tailored to the athlete and event.

Previous carbohydrate intake guidelines favoured a simplistic, "one size fits all" approach. Specifically, for sports of > 60 min duration in which fatigue would occur due to depletion of muscle glycogen stores or a decrease in blood glucose levels, athletes were encouraged to develop a nutrition plan which provided carbohydrate intakes of 30-60 g/h in conjunction with adequate hydration during the event. [24] However, new guidelines now recommend the amount of carbohydrate during exercise to be modified according to the duration of the event (see Table 1).

There is now robust evidence that in high intensity endurance exercise situations lasting ~ 45-75 min frequent mouth rinsing or intake of very small amounts of carbohydrate can enhance performance by 2-3%. [16] In these exercise situations where muscle glycogen is not-limiting, the type and/or amount of carbohydrate and its ability to be absorbed and oxidized appears irrelevant. In fact, the frequency of exposure to carbohydrate (either mouth rinse or ingested), the amount of time the mouth is exposed to carbohydrate and whether the athlete starts exercise fed or fasted are more likely to influence the potential benefit of ingested carbohydrate during high intensity endurance exercise. Whether the effect of consuming small amounts of carbohydrate or mouth rinsing with carbohydrate is washed out by pre-exercise feeding [1] or has an additive benefit to providing a pre-exercise meal [19] remains unclear. Endurance athletes competing in half marathons, sprint distance triathlons, 5km open water swims or 40 km cycle time-trials should consume small amounts of carbohydrate at regular intervals throughout strenuous training sessions and racing to optimise performance.

Table 1. During exercise carbohydrate intake recommendations for athletes (adapted from Burke et al. 2011)

	Situation	Carbohydrate targets	Comments on type and timing of carbohydrate intake
During brief exercise	• < 45 min (e.g. 10 km track event)	Not needed	
During sustained high intensity races	• 45-75 min (e.g. half marathon, road cycling time trial)	Small amounts including mouth rinse	• A range of drinks and sports products can provide easily consumed carbohydrate
During endurance events	• 1-2.5 h (e.g. marathon)	30-60 g/h	• Most endurance events require the athlete to refuel/rehydrate while they are actually racing. The availability of foods and fluids varies according to the race ranging from the athlete carrying their own supplies to access to a network of feed/aid stations • A range of everyday dietary choices and specialised sports products ranging in form from liquid to solid may be useful • The athlete should practice to find a refuelling plan that suits their individual goals including hydration needs and gut comfort
During ultra-endurance exercise	• > 2.5-3 h (e.g. ultramarathons, Ironman triathlons, cycling stage races)	Up to 90 g/h	• As above • Higher intakes of carbohydrate are associated with better performance • Products providing multiple transportable carbohydrates (glucose:fructose mixtures) will achieve high rates of oxidation of carbohydrate consumed during exercise • Multiple transportable carbohydrates should be utilized when intakes exceed 60g/h • For slower athletes undertaking various tasks in extended events (i.e. adventure racing), moderate carbohydrate intakes may be adequate (i.e. 30-60g/h)

In longer endurance events (> 3 hours) that require sustained moderate-high intensity exercise, athletes become increasingly reliant on ingested carbohydrate as a fuel source as muscle glycogen stores deplete. Despite the obvious requirement to encourage greater carbohydrate intakes during exercise, previous intake guidelines were capped at 60 g/h due to the prevailing belief that larger amounts of carbohydrate would cause gastrointestinal distress or require drink concentrations that compromised the delivery of fluid. Contrary to these guidelines, there are several accounts within the literature that report high intakes of carbohydrate by successful endurance athletes. Carbohydrate intake rates as high as ~ 90 g/h have been observed during multi-day cycling events [23] and Ironman triathlons. [18] Recently, a series of studies that tracked the oxidation rates of various carbohydrates in different combinations during exercise, revealed that the rate limiting step in the oxidation of ingested carbohydrate was its intestinal absorption, with a limit to the absorption of glucose in its various forms to ~ 1 g/min. [15] However, when glucose is consumed in combination with a carbohydrate that uses a different carbohydrate transporter across the gut (e.g. fructose), rates of oxidation of ingested “multiple transportable carbohydrates” can exceed 1.5 g/min and further enhance performance. [9]

Recent carbohydrate intake guidelines for extended endurance exercise (> 3 hours) encourage athletes to consume carbohydrate up to 90 g/h from multiple transportable carbohydrate sources (Table 1). Selecting drinks and foods that contain multiple transportable carbohydrates (glucose and fructose) becomes important when carbohydrate intake rates exceed 60 g/h. There is now a wide range of sports drinks, energy bars, carbohydrate gels and sports confectionery which have been specifically developed with unique blends of carbohydrate to allow for maximal rates of carbohydrate oxidation at high hourly carbohydrate intake rates. Furthermore, the carbohydrate content of the habitual diet or intake of carbohydrate during daily training sessions [6] may play a role in determining the capacity for oxidising carbohydrate ingested during exercise. Practitioners and athletes alike, are encouraged to rehearse race-day carbohydrate intake strategies routinely in key competition simulation sessions to minimise the risk of gastrointestinal upset and discomfort on race-day. This is particularly important for athletes competing in marathons, half ironman and ironman triathlons, and endurance cycling events where aggressive carbohydrate intake strategies are warranted.

Fluid Intake Recommendations for Endurance Sports

The other aspect that requires careful consideration when developing a nutrition plan to support athletes undertaking endurance events is the amount of fluid that should be consumed. Fluid and carbohydrate intakes are intertwined and need to be considered simultaneously as athletes regularly consume carbohydrate containing sports drink; a source of both fluid and carbohydrate. [7] Fluid intake can help to offset the dehydration incurred through the loss of sweat during exercise. Typically, as the fluid deficit increases it gradually increases the physiological (i.e. heart rate) and psychological (i.e. perception of effort) stress associated with exercise. [20] The effects of dehydration on performance are hotly debated particularly in field settings, with evidence of performance decrements [4] but suggestions that it may be less than previously thought. [11] It’s important to note, that dehydration is a process (a loss of body fluid), not a state of hydration as such. In a practical sense, the effects of dehydration on an athlete who starts exercise euhydrated (i.e. well hydrated) will differ considerably to that of an athlete who starts exercise hypohydrated. Furthermore, the point at which the effects become detectable will depend on the individual athlete and the environment (effects are greater in the heat or at altitude) in which they compete.

Nevertheless, endurance athletes should utilise the opportunities that are specific to their race to drink fluids at a rate that keeps their accumulating fluid deficit below 2-3% of body mass. This is particularly important in stressful environments where athletes have limited opportunity to optimise their hydration before the event. [12] As drinking in endurance races generally requires a reduction in pace to obtain and consume fluids, advice needs to be tailored to each individual athlete, the event and the environmental conditions (Figure 1).

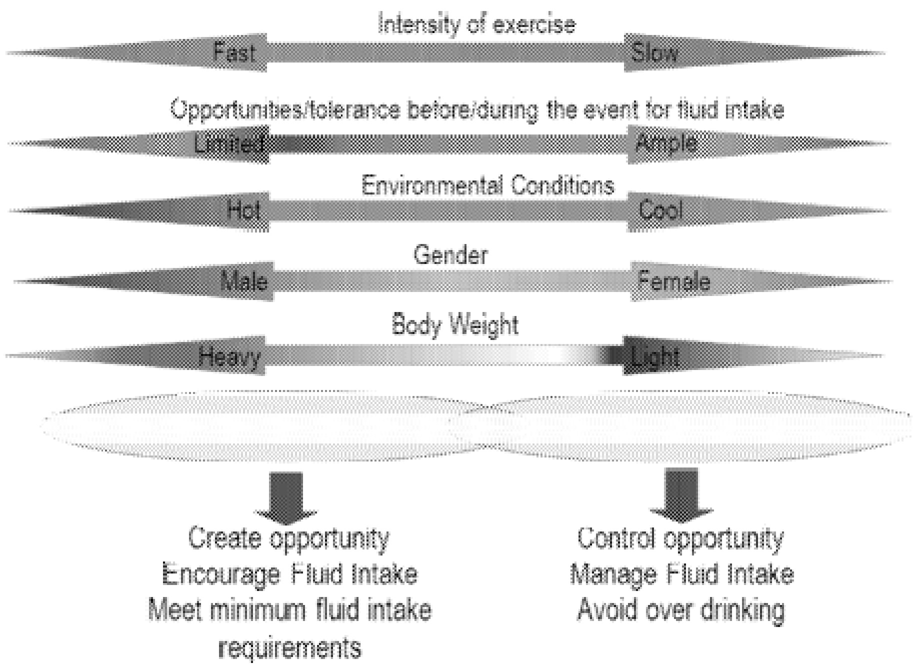

Figure 1. Fluid intake advice for endurance exercise. Adapted from Burke and Cox (2010). [2]

For instance, a highly competitive male triathlete racing at high speeds in the heat of the Ironman Triathlon World Championship in Kona, Hawaii will need to create opportunities to maximise fluid intake. This athlete is likely to have high sweat rates, but have limited opportunity and access to fluid, as well as a lower tolerance for fluid in the gut. While most endurance athletes are likely to incur a fluid deficit during a competitive event, it is possible for some athletes to overhydrate if they drink ahead of their actual sweat rates. While less common, over drinking can lead to the potentially fatal condition of hyponatremia (low blood sodium concentration; often known as water intoxication). In contrast to a faster runner, a recreational marathoner who runs/walks in a cool weather race like the New York Marathon, is likely to have lower sweat rates and plenty of opportunity to drink fluids. They may even have the luxury of walking through drink stations, in direct contrast to the winners as they run through drink stations at paces reaching 20km/h. In the situation of the slower athlete, they are at risk of over drinking and should be advised to manage opportunities available for fluid intake against likely fluid losses (Figure 1). Satisfying thirst may be an appropriate message for slower athletes competing in endurance events in the absence of an individually formulated hydration plan. [21] To develop a race fluid intake plan athletes should undertake fluid balance assessments during event-simulating sessions in similar environmental conditions to gauge their typical sweat rates in comparison to their opportunity/ability to rehydrate. It's paramount to assess pre-exercise hydration status (e.g. assessment of waking urine specific gravity) when undertaking a fluid balance assessment to ensure results are interpreted appropriately.

Suitable drink choices will be specific to the athlete and will depend on the event, which dictates the requirement to fulfill other nutritional goals. Clearly, to encourage fluid intake, fluids on offer need to be palatable and accessible. Athletes should experiment with different sports drinks to find a drink they like as well as investigate equipment choices to ensure easy access to fluids (e.g. drink bottle set-up on a bike). While cool drinks are typically preferred, it's challenging for athletes and race organisers to have access to cool fluids in hot, humid race conditions. Insulated drink bottles or freezing drink bottles ahead of time are simple, yet effective strategies of providing cool fluids in hot, humid conditions. Furthermore sports drinks are formulated to simultaneously meet a range of needs in sport and generally contain electrolytes (to encourage fluid intake by maintaining thirst, and possibly to replace large sweat sodium losses in salty sweaters) and carbohydrates (to provide an additional fuel source during the event).

A final an important issue to consider when developing a race nutrition plan is how to integrate fluid and carbohydrate requirements. In essence, a well structured race nutrition plan will allow hourly carbohydrate intake to be adjusted independently to that of hourly fluid intake. The plan should be easy for an athlete to implement and allow for adjustments given the dynamics of race-day. As a general rule, the intake of sports drinks (which provides fluid and carbohydrate) should be controlled to ensure carbohydrate intake is managed within the overall fuild intake strategy. Additional fluid requirements can be met by adjusting hourly water intake, while additional carbohydrate can be consumed by including non-fluid carbohydrate choices (i.e. carbohydrate gels, energy bars and foods such as bananas and sandwiches). Obviously, the variety and texture of food choices and balance between sweet and savoury options will be influenced by the athlete's preferences, tolerance and opportunities for intake. Likewise, fluid and carbohydrate targets will differ between athletes, for different race durations and environmental conditions.

CONCLUSION

Practically speaking each athlete will have a unique carbohydrate and fluid intake "sweet spot" that will optimise race-day performance versus a mismatch of fluids and carbohydrate, which will cause gastrointestinal distress resulting in decreased performance. It is likely that an individual's sweet spot for carbohydrate and fluid will need to be adjusted for changes in environmental conditions, exercise intensity and exercise mode. Hence, it's paramount that race nutrition strategies are seen as dynamic recommendations, that are adapted for the specifics of racing. An experienced sports nutrition professional is well positioned to incorporate current guidelines that reflect the opportunities presented to individual athletes and the athletes tolerance for carbohydrate and fluid intake during exercise.

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