Race-day carbohydrate intakes of elite triathletes contesting olympic-distance triathlon events

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Key words: competition, carbohydrate guidelines, nutrient intakes

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Abstract

The aim of this study was to investigate the pre-race and during-race carbohydrate intakes of elite level triathletes contesting draft-legal Olympic Distance Triathlon (ODT) events. Self reported pre-race and during-race nutrition data were collected at three separate ODT events from fifty-one elite senior and Under 23 triathletes. One-hundred and twenty-nine observations of food and fluid intake representing actual pre-race *(n=62)* and during-race *(n=67)* nutrition practices from 36 male and 15 female triathletes, were used in the final analysis of this study. Female triathletes consumed significantly more carbohydrate on the morning before race start when corrected for body mass and race start time compared with their male counterparts ($p<0.05$). Male and female triathletes consumed 26% more energy ($kJ.kg^{-1}$) and 24% more carbohydrate ($g.kg^{-1}$) when commencing a race after mid-day (1.00-1.30pm) compared to a late morning (11.00-11.15am) race start. During the race, triathletes consumed less than 60 g of carbohydrate on 66% of occasions, with an average total race intake of 48±25 g, and 49±25 g carbohydrate for males and females, respectively. Given average race times of 1:57:07 h and 2:08:12 h, hourly carbohydrate intakes were ~25 g and ~23 g for males and females, respectively. Whilst most elite ODT triathletes consume sufficient carbohydrate to meet recommended pre-race carbohydrate intake guidelines, during-race carbohydrate intakes varied considerably with many failing to meet recommended carbohydrate intakes.

Introduction

Triathlon events are held over a variety of distances; the four most common events are Sprint (750 m swim, 20 km bike, 5 km run), Olympic (1.5 km swim, 40 km bike, 10 km run), 70.3 (1.9 km swim, 90 km bike, 21.1 km run) and Ironman (3.8 km swim, 180 km bike, 42.2 km marathon run) races. Event finishing times range from 50-60 minutes for Sprint distance triathlons through to 8-17 hours for Ironman triathlon events. This range in race duration has significant physiological and nutritional implications for the triathlete, which in turn influences race day dietary practices.

Elite triathletes contest Olympic Distance Triathlon (ODT) events according to the regulations set by the International Triathlon Union (ITU) in a "draft-legal" format that permits competitors to ride in the slipstream of other triathletes during the cycling portion of the race. Typical race times for top finishers are approximately 1h 45min-2h 05min depending on gender (males are typically ~10 min faster than females), the environmental conditions, terrain of the cycle and run segments, and race tactics adopted by competitors.

Athletes who compete in endurance events greater than 90 minutes are actively encouraged to plan a pre-exercise meal and consume carbohydrate during exercise (Rodriguez, DiMarco, & Langley, 2009). Guidelines for a pre-exercise meal or snack recommend that athletes consume 1-4 g carbohydrate.kg^{-1} body mass, 1-4 h before exercise (Burke, Cox, Cummings, & Desbrow, 2001). Some sports nutrition experts encourage rates of carbohydrate ingestion during prolonged activities based on observations of maximal rates of exogenous carbohydrate oxidation; for example, Jeukendrup & Jentjens (2000) recommend that endurance athletes consume 1.0-1.1 g carbohydrate.min^{-1} or 60-70 g carbohydrate.h^{-1}. However, most official guidelines for endurance activities typically encompass a range of carbohydrate intakes starting at about 50% of this rate [e.g. 30-60 g carbohydrate.h^{-1}] (Coyle, 2004; Mora-Rodriguez, Del Coso, Aguado-Jimenez, & Estevez, 2007; Sawka et al., 2007) in recognition that benefits can be seen at lower intakes (Maughan, Bethell, & Leiper, 1996).

There is limited literature on how well these guidelines are incorporated into the race-day fuelling practices by elite triathletes. An early study investigating the nutritional habits of elite male triathletes found that only two triathletes (n=25) reported consuming a carbohydrate rich meal on the morning of competition (Burke & Read, 1987). Furthermore, subjects reported drinking sugary (carbohydrate) fluids only during longer triathlon events (70.3 events and above). Kimber et al. (2002) assessed food and fluid intakes of 18 triathletes competing in the 1997 New Zealand Ironman triathlon. Hourly carbohydrate intake was higher during the cycle (1.5±0.6 g.kg^{-1}.h^{-1} and 1.2±0.3 g.kg^{-1}.h^{-1}) compared to the run (0.6±0.2 g.kg^{-1}.h^{-1}, $p<0.001$ and 0.8±0.3 g.kg^{-1}.h^{-1} $p<0.05$) for males and females, respectively. Of interest, a positive relationship was observed for total carbohydrate intake and cycle carbohydrate intake with finishing time for female triathletes, whereas run carbohydrate intake relative to body weight and time showed a negative relationship with finishing time for males.

To date, little is known about the pre-competition race day and race nutrition intakes of elite level (professional) triathletes contesting draft-legal ODT events. Athletes contesting these events face an increased possibility for gastrointestinal discomfort or distress associated with the ingestion of carbohydrate before or during exercise (Davis, Burgess, Slentz, Bartoli, & Pate, 1988; Rehrer, van Kemenade, Meester, Brouns, & Saris, 1992; Sullivan, 1988; Wagenmakers, Brouns, Saris, & Halliday, 1993). In addition, the lack of opportunities for consuming carbohydrate containing fluids (i.e. sports drink) or foods (i.e. sports gel or sports bar) while exercising (Jeukendrup, Jentjens, & Moseley, 2005), may prevent triathletes from meeting suggested recommendations for carbohydrate before or during a race. This may be particularly evident in draft-legal ODT events where nutrition strategies during the cycling leg are likely influenced by race tactics rather than the discretion of the individual athlete. Therefore, the purpose of this study was to investigate race day pre-race and during-race dietary intakes of food and fluid by male and female elite level triathletes contesting draft-legal ODT events, with specific interest to determine carbohydrate intakes before and during exercise.

Methods

Data were collected at three separate ODT events that were part of the official Australian triathlon series. Two of the races were part of the National Accenture Triathlon series, while the third race was an ITU World Cup event. The first of the three races, doubled as the final selection race for the 2004 Australian Olympic Games Triathlon team. Races were held over a two-month period throughout February and March, 2004, in Perth, Western Australia; Devonport, Tasmania; and Mooloolaba, Queensland. Race start times were 11.00am and 1.30pm in Perth; 1.00pm and 11.15am in Devonport; 11.00am and 1.15pm in Mooloolaba for females and males, respectively. Temperature and humidity was measured at the start of each male and female race. Mean race day temperature and humidity were 28.4^{o}C and 38.5%; 17.2^{o}C and 44.0%; 26.3^{o}C and 63.0% for Perth, Devonport and Mooloolaba, respectively.

Description of subjects and subject recruitment process

We recruited elite senior and Under 23 Australian triathletes entered in the abovementioned races to participate in this study. Although contesting elite races, athletes had varied experience in racing ODT events. No attempt was made to influence or alter their race nutrition practices throughout the course of this study. Athletes were approached at race briefings on the day prior to the race. The purpose of the study was briefly explained and a plain language statement outlining subject commitments was provided. The study was undertaken with the approval of the Human Research Ethics Committee of the Australian Institute of Sport and all subjects provided their written consent prior to their involvement in the study.

Fifty-one elite senior and Under 23 male and female triathletes contesting the chosen ODT events, agreed to participate in this study. A combined total of 129 observations of food and fluid intake representing actual pre-race *(n=62)* and during-race *(n=67)* nutrition practices from 36 male and 15 female triathletes, were used in the final analysis of this study. Forty-five complete sets (observations of both pre-race and during-race food and fluid intake) of data were collected across the three races. During-race carbohydrate intakes were included only from subjects who completed the race, whereas all observations of pre-race food and fluid intake were used in the final dietary analysis regardless if the subject completed the race.

Dietary collection methodology

Subjects were required to complete a food and fluid diary using household measures on the day of competition. Subjects were instructed to record all food and fluids consumed on the day of the race, prior to race start. Verbal and written instructions were provided to each subject to ensure foods were recorded as accurately as possible. Subjects were instructed to provide a detailed description of the food, including brand name, packaging, method of preparation, and the quantity (household measures) of food consumed. On arrival at the race transition area, the food and fluid diary was collected by a Sports Dietitian (GC). The Sports Dietitian reviewed the diary immediately upon collection, and clarified any discrepancies with regards to the types and quantities of foods and fluids recorded. All energy containing foods (i.e. sports gels) and fluids (i.e. sports drink, soda/soft drink) consumed by subjects after completed food diaries were collected (i.e. during the warm-up period before race start), were noted and subsequently added to the food diary and included in the analysis of the pre-race food and fluid intake. Furthermore, subjects were questioned regarding drinks and gels likely to be consumed during the race in order to accurately determine the carbohydrate content of these items and quantify the amount of carbohydrate carried during the race (cycle and run). Commercial brands and mixing procedures of drinks were noted at this time.

Immediately prior to the start of the race, subjects' drink bottles were taken from the bike racks in the transition area and weighed on portable food scales (Salter Microtronic Electronic Kitchen Scale, Model 2001, Salter Housewares Limited., Kent, England), accurate to 2 g. Drink bottles were reweighed at the completion of the race before the athletes were able to consume any further fluid. This information was used to assess during-race intake of carbohydrate provided from sports drinks or other carbohydrate-containing drinks such as soda/soft drink. The brand and quantity of commercial carbohydrate-containing sports gels intended for consumption during the cycle and run legs were noted prior to race start, and triathletes were interviewed immediately post-race in order to determine the amount consumed. Athletes were specifically asked about their during-race fluid and gel intakes in order to determine whether any carbohydrate containing fluid consumed (reflected by a change in drink bottle weight pre/post race) was spilt and the complete contents of carbohydrate-containing sports gels consumed. During the run leg, sports gels carried by the triathletes provided the only opportunity for the intake of carbohydrate, since the race-sponsored aid stations provided water as the sole fluid source.

Total energy (kJ), carbohydrate (g), fat (g), protein (g) and dietary fibre (g) of all foods and fluids described in the pre-race food and fluid diaries were estimated using FoodWorks Professional Edition, Version 3.02, © 1998-2005 (Xyris Software, Brisbane, Australia). Dietary analysis was performed by a Sports Dietitian (GC). All sports foods and dietary supplements were analysed according to the manufacturers' specifications as stipulated on the product labels. Food composition data were compiled from Nuttab 95; AusFoods; Australian AusNut and nutritional information from food manufacturers entered into the standardised Australian Institute of Sport Recipe database. On completion of analysis, data entries were verified against the original records provided and written comments noted by the Sports Dietitian (GC) at the time of collection.

Statistical Analysis

Values are presented as mean ± SD. Independent t-tests were used to compare body weight differences and sex. Restricted maximum likelihood (REML) method was employed using JMP software (Version 7.0.2, SAS Institute, Cary NC, USA) under the Analyse/Fit Model platform. The model allowed comparisons between pre-race and during-race nutrient intakes; with sex, race start times (early or late) and race environmental conditions (Warm race conditions – Perth and Mooloolaba; Mild race conditions – Devonport). Further comparisons were undertaken between during-race carbohydrate intake and carbohydrate carried; and, pre- and during-carbohydrate intakes. Statistical significance was accepted at $p < 0.05$.

Results

Subject Characteristics

Despite the inherent distractions in collecting information immediately prior to a race, the subject pool involved high level athletes including several World Champions at senior, under 23 and junior elite levels. Mean pre-race body mass for male triathletes (68.6 ± 5.5 kg) was significantly higher than that of female triathletes (59.3 ± 6.1 kg) participating in this study ($p<0.01$).

Pre-race and during-race dietary intakes

The results of pre-race food and fluid intakes nutrient analysis (mean ± SD; range) reported by elite male and female Olympic distance triathletes are summarised in Table 1. Reported pre-race intakes reflect all food and fluid consumed on the morning of the race, prior to the race start, including items consumed during and after the warm-up. When corrected for body mass, no differences existed in energy ($kJ.kg^{-1}$), protein ($g.kg^{-1}$), fat ($g.kg^{-1}$) or fibre ($g.kg^{-1}$) of pre-race meal and snack intakes between male and female triathletes. Of interest, female triathletes consumed significantly more carbohydrate when corrected for body mass differences than their male counterparts on the morning of the race ($p<0.05$).

Figure 1 demonstrates the distribution of pre-race carbohydrate intakes expressed relative to body mass ($g.kg^{-1}$) reported by male and female triathletes in this study. Typically, triathletes consumed between 2.1-3.0 $g.kg^{-1}$ of carbohydrate during the day, prior to race start. On two occasions, male triathletes consumed less than 1.0 $g.kg^{-1}$, despite race start times of 11.15am or later.

Reported pre-race intakes of energy ($kJ.kg^{-1}$), carbohydrate ($g.kg^{-1}$) and protein ($g.kg^{-1}$) were significantly higher ($p<0.05$) for late race start times compared with early race start times (Table 2). Athletes consumed 26% more energy ($kJ.kg^{-1}$) and 24% more carbohydrate ($g.kg^{-1}$) when commencing a race after mid-day (1.00-1.30pm) compared to a late morning (11.00-11.15am) race start. No significant differences in fat or fibre intakes were noted.

The triathletes commonly reported the consumption of carbohydrate from sports gels (84% of observations) and drinks (69% of observations) during races. Reported during-race intakes of carbohydrate for male and female triathletes are summarised in Table 3 (mean ± SD; range). Absolute and relative amounts of carbohydrate consumed from carbohydrate-containing drinks and carbohydrate-containing sports gels during the race are presented. Furthermore, the amount of carbohydrate consumed from the available supplies was analysed (i.e. the amount of carbohydrate consumed relative to the total carried by the athlete was calculated as a percentage). Seventy-two percent of carbohydrate carried during the race was consumed, which explained 91% of the variance observed in during-race carbohydrate intakes ($p<0.001$). No sex differences were observed for during-race carbohydrate intakes and the amount of carbohydrate consumed during the race was not influenced by pre-race carbohydrate intake. However, athletes consumed more carbohydrate ($p<0.05$) during races in warm weather conditions (53 ± 25g) compared to races in mild weather conditions (41 ± 21 g). This difference was due to a greater intake of carbohydrate ($p<0.05$) from carbohydrate-containing drinks (25 ± 22 g and 14 ± 17 g for warm and mild conditions, respectively). During warm weather races, athletes carried more ($p<0.05$) carbohydrate (33 ± 25g) from carbohydrate-containing drinks during the cycle compared to races held in milder environmental conditions (19 ± 19 g).

Figure 2 demonstrates the distribution of during-race carbohydrate intakes for male and female triathletes in this study. Triathletes consumed less than 30 g of carbohydrate during the race from carbohydrate containing drinks and sports gels on 25% of observations. One athlete consumed less than 10 g of carbohydrate on two separate occasions.

Discussion

This is the first study to report race-day food and fluid intake practices of elite level triathletes contesting draft-legal ODT events to assess pre-race and during-race carbohydrate intakes. Mean pre-race carbohydrate intakes of male and female triathletes in the current study were approximately 3 $g.kg^{-1}$. Observed pre-race dietary practices ensured athletes met current guidelines, which encourage athletes to consume 1-4 g $carbohydrate.kg^{-1}$, 1-4 h before exercise (Burke et al., 2001). In addition to scheduling breakfast and a snack throughout the morning before the race, triathletes in this study commonly consumed carbohydrate in the form of sports drinks, energy drinks or sports gels following their warm-up, immediately prior to the event to add to their pre-race carbohydrate intake.

Studies have shown that the intake of a substantial amount of carbohydrate (~100-300 g) 2-4 h before exercise can improve endurance exercise capacity (Schabort, Bosch, Weltan, & Noakes, 1999; Wright, Sherman, & Dernbach, 1991) and enhance performance of an exercise task undertaken at the end of a standardised endurance protocol (Neufer et al., 1987; Sherman et al., 1989) compared with an overnight fast. These observed benefits are believed to result from an increase in muscle glycogen and/or increase in liver glycogen concentrations (Casey et al., 2000). Given liver glycogen is substantially reduced after an overnight fast, the consumption of a carbohydrate-rich meal may increase these reserves and contribute to maintenance of blood glucose levels throughout exercise (Hargreaves, Hawley, & Jeukendrup, 2004). This is of practical significance to elite triathletes as the introduction of the draft-legal cycling format into elite ODT has resulted in highly variable workloads during the cycling stages compared with non-drafting events (Bentley, Cox, Green, & Laursen, 2008). Variable intensity cycling has been shown to elevate carbohydrate oxidation during the early stages of exercise and increase total plasma glucose oxidation during a prolonged endurance cycling protocol (Palmer, Borghouts, Noakes, & Hawley, 1999; Palmer, Noakes, & Hawley, 1997).

A unique feature of elite ODT racing is that race start times typically commence around mid-day. In our study, race start times varied from 11.00am to 1.30pm, which contrasts with start times of age-group and long course triathlon events which are typically 6.00-7.00am. Lindeman (1990) reported that 40% of participants contesting a short-course triathlon (1.3km swim, 40km cycle and 10km run) which started at 7.30 am, omitted breakfast on the morning of the event. By contrast, triathletes in our study consumed significantly greater intakes of energy and carbohydrate before races scheduled after mid-day (Table 2). As might be expected, a later race start provided athletes with more time and opportunities to eat; it was typical for athletes in our study to schedule two meals or substantial snacks prior to afternoon race starts. The observed difference in pre-race nutrient intakes between our study and that of Lindeman (1990), provides direct support that race start time can influence pre-race nutrition habits of athletes contesting endurance competition. Therefore, sports nutrition professionals should consider race start time when interpreting current pre-race nutrition guidelines for carbohydrate intake.

Carbohydrate ingestion during endurance exercise (>90 min duration) has been consistently shown to improve exercise capacity and performance in single modality exercise tasks (Angus, Hargreaves, Dancey, & Febbraio, 2000; Coggan & Coyle, 1987, 1988; Coyle, Coggan, Hemmert, & Ivy, 1986; Coyle et al., 1983; Langenfeld, Seifert, Rudge, & Bucher, 1994; McConell, Kloot, & Hargreaves, 1996; Mitchell et al., 1989; Tsintzas, Liu, Williams, Campbell, & Gaitanos, 1993; Wilber & Moffatt, 1992; Wright et al., 1991). The observed benefits of carbohydrate ingestion during prolonged exercise are most likely due to the maintenance of blood glucose concentrations and carbohydrate oxidation in the latter stages of exercise (Coggan & Coyle, 1987, 1988; Coyle & Montain, 1992; Mitchell et al., 1989).

Triathletes who participated in this study typically failed to meet the current guidelines for carbohydrate intake during endurance exercise. The American College of Sports Medicine suggests that athletes consume 30-60 $g.h^{-1}$ of carbohydrate in events greater than 90 min duration (Sawka et al., 2007). Sixty-six percent of observations, triathletes consumed less than 60 g of carbohydrate during the race, with an average total race intake of 48 ± 25 g carbohydrate and 49 ± 25 g carbohydrate for males and females, respectively. Given average race times of 1:57:07 h and 2:08:12 h, hourly carbohydrate intakes were ~25 g and ~23 g for males and females, respectively. Despite failing to meet suggested carbohydrate intake guidelines during exercise, athletes in this study typically consumed carbohydrate-containing drinks and sports gels during the event. The more carbohydrate carried during the race, the more athletes consumed. This finding is in contrast to earlier studies which reported that athletes typically consume water only during short (i.e. ODT events) duration triathlon events (Burke & Read, 1987; Lindeman, 1990). Likely explanations for higher during-race carbohydrate intakes amongst athletes in the current study include: a greater awareness of the benefits of consuming carbohydrate during exercise; increased access to sports drinks and sports foods at races; increased popularity of sports gels as an alternate source of carbohydrate to sports drinks; sponsorship arrangements; and, promotion of sports drinks and sports foods through various media avenues (i.e. triathlon magazines, internet, and television commercials).

Triathletes contesting long course triathlon events consume higher rates of carbohydrate than that observed in our study. Kimber et al (2002) reported carbohydrate intakes of 81.8±14.9 $g.h^{-1}$ and 62.3±18.7 $g.h^{-1}$ for male and female Ironman competitors, respectively. Lower rates of carbohydrate ingestion in our study, likely reflect the limited time available for ingestion of carbohydrate (Jeukendrup et al., 2005), reduced gastrointestinal tolerance at higher intensities of exercise (Bentley et al., 2008) and race nutrition strategies adopted by individual athletes. Whether it would be beneficial to consume higher carbohydrate intakes during an ODT event than we observed among our subjects cannot be addressed by the design of our study. However, it has previously been shown that carbohydrate intakes below the recommended range can enhance endurance exercise performance (Maughan et al., 1996). Furthermore, in non-endurance activities lasting ~ 60 mins where muscle fuel stores are not limiting, there is evidence that the consumption of very small amounts of carbohydrate – even the use of a carbohydrate mouth wash- can provide benefits to the central nervous system to reduce the perception of effort and enhance pacing (Carter, Jeukendrup, & Jones, 2004; Chambers, Bridge, & Jones, 2009). This may have some relevance to a triathlon where different activities and muscle groups (e.g. swimming, cycling and running) contribute to the total exercise time and may not be individually limited by fuel availability. In other words, although the ODT fulfils the general criteria of an endurance sport, we are presently uncertain whether it truly fits all the expected nutritional characteristics.

The cycle leg of an ODT event presents most opportunity for carbohydrate intake and better tolerance for fluid and food (i.e. sports gel) intake compared to the swim and run. In our study, despite failing to meet hourly carbohydrate intake recommendations during exercise, all triathletes consumed some carbohydrate during the cycle leg. Athletes used carbohydrate-containing drinks (namely sports drink) and sports gels routinely during the cycle. In contrast, carbohydrate was consumed during the run in only 20% of observations, in the form of a carbohydrate-containing sports gel. Sports gels were used in 85% of during-race observations by athletes in this study. Athletes relied on them as the only source of carbohydrate in 32% of during-race observations; or in combination with sports drinks in 53% of observations. Sports gels provide a compact, reliable carbohydrate alternative to carbohydrate-containing drinks, particularly for athletes who dislike consuming sweet fluids while racing.

In our study, observed carbohydrate intakes from triathletes contesting ODT events held in warm environmental conditions (Mooloolaba and Perth races) were 23% greater than those observed in races contested in mild conditions (Devonport race). This difference was due to greater amounts of carbohydrate-containing drinks being consumed when racing in warm weather conditions. This finding suggests that athletes consume more carbohydrate by virtue of increasing their fluid intake, with no specific intent to increase carbohydrate intake. This is of practical significance to sports nutrition professionals as different strategies need to be implemented, and sources of carbohydrate (drinks versus gels) prioritised when counselling athletes contesting ODT events in varying environmental conditions. Failure to account for environmental conditions when advising athletes with regards to race nutrition strategies will result in markedly different during-race carbohydrate intakes.

A primary finding from the current study was the large variation in the observed pre-race and during-race carbohydrate intakes of participating athletes (see Figures 1 and 2). There are several factors that are likely to influence an athletes' race-day carbohydrate intake such as their routine nutrition practices in training, relative experience of the athlete at racing ODT events, tolerance of food and fluids on race-day, organisation and assess to suitable options, the dynamics of the race and subsequent opportunities for intake, previous experience of gastrointestinal upset while racing, previous nutrition education and their personal perceptions regarding the importance of carbohydrate before and during competition.

Current sports nutrition guidelines encourage endurance athletes to exercise under conditions of high carbohydrate availability by incorporating adequate carbohydrate before and during exercise in daily training and competition (Rodriguez et al., 2009). The findings of this study suggest that ODT athletes typically meet current sports nutrition guidelines for pre-exercise carbohydrate, however fail to meet suggested carbohydrate intake guidelines during actual competition for endurance activity. In order to determine the significance of these findings on metabolism and performance for endurance trained athletes, it is important to consider the interaction that exists between pre-exercise carbohydrate feeding and during exercise carbohydrate ingestion (Hawley & Burke, 1997). It is possible that consuming carbohydrate during exercise, overrides the likely benefits associated with consuming a pre-exercise carbohydrate meal (Febbraio, Chiu, Angus, Arkinstall, & Hawley, 2000). However, the reverse could also be true; the benefits of a pre-exercise carbohydrate-containing meal may override the likely benefits associated with consuming carbohydrate during exercise (Beelen, Berghuis, Ballak, Jeukendrup, & van Loon, 2009; Desbrow, Anderson, Barrett, Rao, & Hargreaves, 2004). Findings from this study, provide no evidence that athletes adjust their during-race carbohydrate intakes in response to pre-race intake of carbohydrate.

In conclusion, athletes in the current study consumed adequate carbohydrate in their pre-exercise meal to meet current sports nutrition guidelines, with the later timing of the race start appearing to support this practice. However, the findings of this study demonstrate the difficulty faced by athletes in meeting current guidelines for carbohydrate intake during exercise in high intensity endurance competition where opportunities for intake and tolerance of ingesting carbohydrate-containing drinks and sports gels are reduced. Further research is warranted to investigate the possible benefits on performance of consuming higher rates of carbohydrate than observed in this study. Given the challenges a triathlete may face in meeting suggested competition nutrition guidelines, athletes are best advised to seek the assistance of a sports nutrition expert in order to devise a pre-race and race nutrition strategy to optimise their competition performance.

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Table 1: Race day, pre-race nutrient intake analysis for elite male and female triathletes contesting Olympic distance triathlon events.

	Energy (kJ/kg BM)	CHO (g)	CHO/BM (g/kg BM)	Fat/BM (g/kg BM)	Protein/BM (g/kg BM)	Fibre/BM (g/kg BM)
Males (n=44)						
Mean ± SD	71 ± 27	198 ± 81	2.9 ± 1.2	0.3 ± 0.2	0.5 ± 0.3	0.2 ± 0.1
Range	18-128	60-370	0.9-5.3	0.0-0.9	0.1-1.2	0.1-0.4
Females (n=18)						
Mean ± SD	75 ± 16	195 ± 52	3.3 ± 0.8*	0.2 ± 0.2	0.5 ± 0.2	0.2 ± 0.1
Range	40-104	102-321	1.9-4.9	0.0-0.8	0.2-1.0	0.1-0.4
Combined (n=62)						
Mean ± SD	72 ± 24	197 ± 73	3.0 ± 1.1	0.3 ± 0.2	0.5 ± 0.2	0.2 ± 0.1
Range	18-128	60-370	0.9-5.3	0.0-0.9	0.1-1.2	0.1-0.4

CHO = carbohydrate; BM = body mass; * $p < 0.05$.

Table 2: Race day, pre-race nutrient intake analysis for elite triathletes, contesting Olympic distance triathlon events starting early (11.00-11.15am) and late (1.00-1.30pm).

	Energy (kJ/kg BM)	CHO (g)	CHO/BM (g/kg BM)	Fat/BM (g/kg BM)	Protein/BM (g/kg BM)	Fibre/BM (g/kg BM)
Early (n=30)						
Mean ± SD	64 ± 21	170 ± 63	2.7 ± 1.0	0.3 ± 0.2	0.4 ± 0.2	0.2 ± 0.1
Range	18-103	60-328	0.9-4.6	0.0-0.8	0.1-1.0	0.1-0.4
Late (n=32)						
Mean ± SD	80 ± 24**	222 ± 75**	3.3 ± 1.1**	0.4 ± 0.2	0.6 ± 0.3*	0.2 ± 0.1
Range	28-128	89-370	1.4-5.3	0.0-0.9	0.1-1.2	0.1-0.4

CHO = carbohydrate; BM = body mass; * $p < 0.05$; ** $p < 0.01$.

Table 3: During-race carbohydrate intake for elite male and female triathletes contesting Olympic distance triathlon events.

	Total CHO consumed (g)	Total CHO carried (g)	Available CHO consumed (%)	CHO consumed from Drink (g)	Available Drink CHO consumed (%)	CHO consumed from Gel (g)	Available Gel CHO consumed (%)
Males (n=45)							
Mean ± SD	48 ± 25	60 ± 29	80 ± 23	21 ±2 2	72 ± 26	26 ± 18	82 ± 33
Range	5-108	12-131	23-100	0-108	14-100	0-64	0-100
Females (n=22)							
Mean ± SD	49 ± 25	64 ± 33	81 ± 20	19±19	77 ± 16	30 ± 16	83 ± 26
Range	18-118	18-142	31-100	0-64	44-91	0-64	23-100
Combined (n=67)							
Mean ± SD	48± 25	62 ± 30	80 ± 22	21 ± 21	73 ± 23	27 ± 17	82 ± 30
Range	5-118	12-142	23-100	0-108	14-100	0-64	0-100

CHO = carbohydrate.

Figure Legends

Figure 1. Race day, pre-race carbohydrate intakes ($g.kg^{-1}$) for elite male and female triathletes contesting Olympic distance triathlon events.

Figure 2. During-race carbohydrate intakes (g) for elite male and female triathletes contesting Olympic distance triathlon events.