Nutrition Considerations for Open-Water Swimming

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Open-water swimming (OWS) is a rapidly developing discipline. Events of 5–25 km are featured at FINA World Championships, and the international circuit includes races of 5–88 km. The Olympic OWS event, introduced in 2008, is contested over 10 km. Differing venues present changing environmental conditions, including water and ambient temperatures, humidity, solar radiation, and unpredictable tides. Furthermore, the duration of most OWS events (1–6 hr) creates unique physiological challenges to thermoregulation, hydration status, and muscle fuel stores. Current nutrition recommendations for open-water training and competition are either an extension of recommendations from pool swimming or are extrapolated from other athletic populations with similar physiological requirements. Competition nutrition should focus on optimizing prerace hydration and glycogen stores. Although swimmers should rely on self-supplied fuel and fluid sources for shorter events, for races of 10 km or greater, fluid and fuel replacement can occur from feeding pontoons when tactically appropriate. Over the longer races, feeding pontoons should be used to achieve desirable targets of up to 90 g/hr of carbohydrates from multitransportable sources. Exposure to variable water and ambient temperatures will play a significant role in determining race nutrition strategies. For example, in extreme environments, thermoregulation may be assisted by manipulating the temperature of the ingested fluids. Swimmers are encouraged to work with nutrition experts to develop effective and efficient strategies that enhance performance through appropriate in-competition nutrition.

Keywords: carbohydrate intake, race practices, hydration, open-water swimming

Interest in OWS has increased since the introduction of the first events to the 1991 FINA World Aquatic Championships program in Perth, Australia (25-km marathon), and the 2008 Beijing Olympic Games (10 km). The most recent 2013 FINA World Aquatic Championships in Barcelona featured a multi-event schedule (5, 10, and 25 km), including a mixed 5-km team race. Additional opportunities for international competition include the FINA 10-km World cup series and Grand Prix circuit (seven races of 15–88 km), each offering an annual program with prize money available (US $2,500–$3,100 for first place in FINA events). Therefore, OWS has evolved from a fringe discipline to a sport with considerable international recognition and potential financial rewards. There is now an established subset of “specialist” open-water swimmers, although some overlap occurs between those who may also compete in the 800-m/1500-m pool events.

Because OWS venues include lakes, rivers, inland waterways and the open sea, with standard events ranging from 5 to 25 km, OWS represents the most diverse and physiologically challenging of all FINA disciplines.

Changing environmental factors, including variable water and ambient temperatures, humidity, solar radiation, and unpredictable tidal influences, are unique to OWS. Furthermore, the duration of some events involves physiological issues not typically seen in other events within aquatic sports: thermoregulatory challenges, significant fluid losses, and muscle fuel depletion during a single competition. Emerging scientific evidence around these challenges informs the FINA rules for athlete safety but has also led to the introduction of feeding pontoons, now integral to the layout of all standard open-water courses, that facilitate fluid and carbohydrate intake during the race. The aim of this review is to describe the nutritional demands of OWS, with specific focus on the competition requirements unique to this aquatic discipline.

Training Requirements

Open-water swimmers complete the majority of their training in a controlled pool environment supplemented with the occasional open-water session. Training volumes are consistently at the higher end of the range typically completed by pool swimmers and is combined with camps that focus on training in an open-water environment to acclimatize swimmers to race conditions. Elite open-water swimmers have been reported to complete weekly training distances of ~6 km (VanHeest et al., 2004), compared with the average distances of 40–70 km per week undertaken by pool swimmers. Although
this volume of training represents a considerable energy and fuel cost, it is interesting to note that “distance” swimmers in pool events (e.g., 1500 m) may exceed 70 km per week (or 45 times the length of their race), whereas open-water swimmers, particularly swimmers who specialize in races longer than 25 km, clearly train at a much lower volume in proportion to the demands of their event. Training for open-water swimmers focuses on high-intensity, aerobic-dependent speeds; indeed, at one training camp undertaken by elite competitors, more than 85% of training was undertaken at these intensities, with less than 2% devoted to anaerobic training or training at speeds “near max” (VanHeest et al., 2004). This distribution of work suggests that the nutrition requirements for training of open-water swimmers are consistent with the recommendations for distance swimmers in pool events during their highest volume training. Further discussion on elements of training nutrition is provided in a separate review by the current authors (Shaw et al., 2014).

**Body Composition and Physiological Characteristics**

Anthropometric data collected on open-water swimmers have shown them to be shorter and lighter, with a lower percentage of lean muscle mass than pool swimmers (Carter & Ackland, 1994; VanHeest et al., 2004; Zamparo et al., 2005). This may be because less absolute power is required to successfully complete open-water events compared with sprint events (50 and 100 m) or, traditionally, less competent swimmers have competed in such events. However with the increased participation of longer-distance pool swimmers in open-water events, given enhanced competition, commercial opportunity, and the possibility of Olympic success, a morphological optimization has been observed with the body shape and physique of these two groups appearing to be similar. These observations are purely anecdotal, however, and closer scientific scrutiny is warranted. Maximal oxygen uptake of open-water swimmers (80 and 66 ml/min/kg for male and female swimmers, respectively) have been reported to be higher (VanHeest et al., 2004) than those seen in swimmers of shorter distances (Capelli et al., 1998) but similar to other land-based endurance athletes.

**Energy and Nutrient Recommendations for Training**

Because the training undertaken by open-water swimmers entails consistently large volumes of work completed mostly at high aerobic intensities (<75% of training; VanHeest et al., 2004), the energy demands of training are substantial. High energy requirements (23 MJ/day) have been demonstrated in female swimmers undertaking large training volumes (17.5 km/day; Trappe et al., 1997). Extrapolating energy expenditure data to male swimmers undertaking similar training would suggest similar energy requirements (~4–29 MJ/day; Costill et al., 1988a).

Similar training volumes are also likely to consistently challenge muscle glycogen stores, highlighting the need for nutrition strategies focused on glycogen replacement for prolonged or higher-intensity sessions, particularly during high-volume phases. The failure to sufficiently replenish glycogen stores between training sessions may impair the open-water swimmer’s ability to complete the high intensities and volumes of training required for sustained success (see review by Shaw et al., 2014). Open-water swimmers are therefore encouraged to aim for carbohydrate intakes at the higher end of sports nutrition guidelines (~6–10 g/kg body mass, or BM, per day), especially during heavy training weeks, and use specific strategies for glycogen replacement between key training sessions as described in the review by Burke et al. (2014).

Carbohydrate intake during a workout can contribute to total daily carbohydrate needs, provide additional fuel to support performance in a particular session (see Shaw et al., 2014), and allow practice of the feeding tactics that will be used in races. Special mention should also be made of supporting immune function in swimmers who are undertaking large training volumes. Immune system responses are impaired when exposed to the stress hormone environment associated with high intensity/high volume training, particularly when sessions are completed with low carbohydrate availability (Pyne et al., 2014). To reduce the risk of illness, open-water swimmers are encouraged to enhance carbohydrate availability by starting training sessions with adequate glycogen stores and consuming carbohydrate-containing food or fluid during high intensity training to attenuate the impairments in immune function seen after high intensity training. Training with low carbohydrate availability may be undertaken but should be by design rather than by accident and should follow a careful consideration of a cost-benefit analysis and appropriate periodization (Mujika et al., 2014).

Because of the extended nature of OWS, prolonged workouts are often undertaken in hot conditions where hydration requirements need to be considered. The thermoregulatory impact of swimming in varying water temperatures is discussed elsewhere (Stellingwerff et al., 2014). Although reported values for non–urine-related water loss during swimming and daily water turnover in swimmers are not as high as for terrestrial activities, losses of ~0.5 L/hr can be expected (Cox et al., 2002a; Leiper et al., 2004; Lemon et al., 1989). These losses increase with training intensity and water temperature (Cade et al., 1991, 2002a). Therefore, open-water swimmers should consider proactive fluid replacement during prolonged sessions. It is more difficult to undertake field assessments of sweat rates/losses on the basis of body mass changes in aquatic athletes, as is commonly done during land-based sports (Cox et al., 2002a). Indeed, errors in fluid balance calculations occur because of the failure to account for water swallowed from the pool, water collected in clothes and swimsuits, and urine losses. Nevertheless, swimmers are encouraged to hydrate...
appropriately, minimizing significant losses and avoiding overdrinking during sweat-incurring workouts, especially when this provides an opportunity to practice race-day tactics. Fluids may also contain a source of carbohydrate toward fueling goals. Swimmers may also need to track daily hydration status to adjust fluid intake between sessions. Strategies for rehydration after exercise are discussed in more detail by Burke et al. (2014).

**Competition Nutrition**

During the competition phase, nutrition needs for open-water swimmers deviate significantly from those of pool swimmers. The specific considerations for each event will be determined by race duration, environmental conditions, and the opportunity to consume nutrients during the race. A well-planned and well-practiced nutrition strategy of intake before, during, and after open-water events will ensure that open-water swimmers can perform optimally and compete in events across a multiday program such as the World Championships. Table 1 summarizes key considerations for the main types of races.

**Prerace Nutrition**

Open-water events longer than 5 km may be considered glycogen depleting. Costill and colleagues (1988b) reported that as little as 5,500 m of high-intensity swimming significantly depletes muscle glycogen of type I and II muscle fibers (Costill et al., 1988b), which functionally reduces distance per stroke (Costill et al., 1988a) and therefore stroke efficiency. Because stroke efficiency is a key determinant of energy expenditure in OWS (Zamparo et al., 2005), the protection of endogenous carbohydrate stores is important to performance. The combination of high rates of carbohydrate use and limited opportunities to consume exogenous carbohydrate sources throughout shorter races (5–10 km) means that swimmers are encouraged to optimize muscle glycogen stores before the commencement of competition.

**Carbohydrate loading** refers to the strategy of manipulating carbohydrate intake and exercise taper to produce a supercompensation of muscle glycogen stores, thereby enhancing endurance capacity and performance of events longer than 90 min (Hawley et al., 1997). Traditional carbohydrate loading regimens involve lengthy (7 days) preparations, combining a phase of carbohydrate depletion before high-carbohydrate refueling (Ahlborg et al., 1967). More contemporary research suggests carbohydrate intakes of 10–12 g/kg BM/day for the 36–48 hr before exercise combined with normal training is sufficient to achieve a supercompensation in muscle glycogen stores (Bussau et al., 2002). Female swimmers are encouraged to increase their energy intake in conjunction with carbohydrate intakes to ensure that suitable “loading” occurs (Tarnopolsky et al., 2001). Such strategies help to offset fatigue through the maintenance of a high average pace, particularly in the closing stages of endurance events longer than 2 hr (Hawley et al., 1997). As the duration of an event increases (25 km and greater), the benefits of carbohydrate loading may be less evident, or at least need to be extended with a supply of exogenous carbohydrate sources during the race.

The prerace meal offers a final opportunity for swimmers to start the event with optimal carbohydrate availability. General recommendations for a prerace meal involve the consumption of well-tolerated foods providing a carbohydrate target of 1–4 g/kg BM 1–4 hr before race start (Burke et al., 2011) and sufficient fluid to ensure that euhydration is achieved. Because of the early start time (before noon) of the majority of open-water events, the prerace meal is most likely to be in breakfast form. Because the race location may be distant from competition accommodation and require travel, the last opportunity for a formal meal may be up to 4 hr before race time. In such scenarios, the swimmer should continue to consume carbohydrate-containing fluids or foods (whole foods or formulated sport foods) as snack options until race marshalling begins.

**Precooling With Cold Beverages and Ice Slurries**

Swimmers competing in hot environmental conditions (water temperatures >30 °C) may benefit from strategies that can support thermoregulation throughout the race (Ross et al., 2013). One intervention that has been suggested to support thermal stress has been the ingestion of cold beverages (<4 °C) and/or ice slurries before exercise. The ingestion of substantial volumes (6.5–7.5 g/kg BM) of ice slurries in the 30 min before exercise has been shown to improve endurance capacity and performance during terrestrial exercise (Ihsan et al., 2010; Siegel et al., 2010, 2011; Burdon et al., 2013). An investigation undertaken in a group of elite open-water swimmers demonstrated that ingestion of cold water significantly reduced core temperature and thermal sensation, particularly during an evening training session, in a warm pool (29 °C; Hue et al., 2013). The physiological mechanisms of such strategies are explained elsewhere (Stellingwerff et al., 2014). Such strategies may be considered for open-water events in which water temperatures are expected to exceed 30 °C and last longer than 2 hr. However, more scientific evidence is needed in aquatic environments, and swimmers are encouraged to test the use of any cold and/or ice beverage intervention before using them in a race situation.

**Energy Provision During Racing**

**Carbohydrate for Open-Water Performance**

Analysis of the performance progression of the 10-km marathon swim event over the past 4 years has identified that swimmers reach speeds of up to 1.75 m/s or close to
Table 1  Nutrition Focus for Open-Water Swimming Events

<table>
<thead>
<tr>
<th>Event</th>
<th>Duration</th>
<th>Physiological Challenges</th>
<th>Nutritional Focus</th>
<th>Feeding Strategy</th>
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<tbody>
<tr>
<td>5 km</td>
<td>~0 min–1 hr</td>
<td>Thermoregulation</td>
<td>Optimal glycogen storage</td>
<td>Minimal</td>
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<td></td>
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<td></td>
<td>Optimize hydration status prerace in hot conditions</td>
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<td>Precooling strategies with hot conditions</td>
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<td>Caffeine</td>
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<td>Supplementation to enhance buffering capacity</td>
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<tr>
<td>5 km teams</td>
<td>~0 min–1 hr</td>
<td>Thermoregulation</td>
<td>Optimal glycogen storage</td>
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<td>Optimize hydration status prerace in hot conditions</td>
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<td>Caffeine</td>
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<td>Supplementation to enhance buffering capacity</td>
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<tr>
<td>10 km</td>
<td>~1 hr 40 min –2 hr 10 min</td>
<td>Thermoregulation</td>
<td>Optimal glycogen storage</td>
<td>Pontoon and on body</td>
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<td></td>
<td></td>
<td>Glycogen depletion</td>
<td>Optimize hydration status prerace in hot conditions; precooling strategies with hot conditions</td>
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<td>Feed opportunities</td>
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<td>Maximize carbohydrate oxidation rates</td>
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<td>Caffeine</td>
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<td>Supplementation to enhance buffering capacity</td>
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<tr>
<td>25 km</td>
<td>~4–5 hr</td>
<td>Thermoregulation</td>
<td>Optimal glycogen storage</td>
<td>Pontoon mainly</td>
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<td></td>
<td></td>
<td>Glycogen depletion</td>
<td>Optimize hydration status prerace in hot conditions; precooling strategies with hot conditions</td>
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<td>Warm food and fluids may be beneficial for cold conditions</td>
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<td>Sodium considerations for hot environments</td>
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<tr>
<td>&gt; 25 km</td>
<td>&gt; 5 hr</td>
<td>Thermoregulation</td>
<td>Optimal glycogen storage</td>
<td>Pontoon, support boats</td>
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<td>Glycogen depletion</td>
<td>Optimize hydration status prerace in hot conditions; precooling strategies with hot conditions</td>
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<td>Maximize carbohydrate oxidation rates</td>
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<td>Warm food and fluids may be beneficial for cold conditions</td>
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<td>Moderate food and fluid composition for GI comfort</td>
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<td>Sodium considerations for hot environments</td>
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<tr>
<td>Multiple events in single meet</td>
<td>1–3 days</td>
<td>Glycogen replacement</td>
<td>Aggressive nutrition recovery between races</td>
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<td>High carbohydrate intake (8–10 g/kg BM/day)</td>
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<td>Moderate protein intake</td>
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<td>Rehydration with fluid and sodium containing meals</td>
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Note. GI = gastrointestinal. BM = body mass.
their maximal efforts after long periods of submaximal work (Vogt et al., 2013). Training strategies that adapt the muscle to maximize the contribution of fat to energy production during such swimming are encouraged (see Mujika et al., 2014). Nevertheless, in longer races, muscle carbohydrate stores may become limiting, and an exogenous supply of this fuel source is needed to sustain swimming speed. Carbohydrate consumed before and during may support muscle fuel needs for longer races; in addition, it may enhance performance via its effect on brain function even in events that are not glycogen depleting.

**Carbohydrate For Events Lasting Less Than 1 hr**

Races lasting less than 1 hr may still benefit from carbohydrate ingestion during competition, even when glycogen levels are optimized before race start. Events of this duration are not limited by the depletion of muscle glycogen, and there may be little muscle oxidation of carbohydrate consumed during such a race (McConnell et al., 2000). Nevertheless, there is consistent evidence that the performance of sustained high-intensity exercise of 45–75 min is enhanced when carbohydrates are ingested during exercise of this nature, with the benefits isolated to situations in which it is consumed orally at frequent intervals and absent when it is delivered by intravenous means (Carter et al., 2004a, 2004b). Several studies that have used a protocol of rinsing the mouth with a carbohydrate solution have demonstrated that the performance benefit is achieved via the frequent exposure of the oral cavity to small amounts of carbohydrate (Jeukendrup & Chambers, 2010). The suggested mechanism for this phenomena is the presence of carbohydrate-sensing receptors in the mouth that provide positive feedback to the reward centers of the brain (Chambers et al., 2009). It should be noted, however, that the studies that show this effect have all involved terrestrial exercise, and evidence is lacking in aquatic sports, particularly in real-life performance settings.

**Carbohydrate Intake for Glycogen-Depleting Events**

Muscle glycogen stores are influenced by gender, training status, and dietary intake and typically become depleted during sporting events of lasting longer than 90 min (Hawley et al., 1997). This outcome could be expected to occur during races of 10 km or longer, challenging a swimmer’s ability to maintain high swimming velocities. Additional carbohydrate sources should be supplied via the ingestion of carbohydrate-rich foods and fluids during the race as is commonly practiced in many land-based endurance sports (Burke et al., 2011). Jentjens and colleagues (2004) demonstrated that the intestinal absorption of glucose via the SGLT1 transporters is limited. However, combining glucose with carbohydrates that are absorbed through different gastrointestinal transporters (e.g., fructose transported via GLUT5) can increase the rate of exogenous carbohydrate available to working muscle for oxidation and enhancing endurance performance (Currell & Jeukendrup, 2008). This has led to the introduction of specialized sports foods containing “multitransportable carbohydrates” to the market. Swimmers looking to use such products should be aware that fructose and similar sugars are known to cause significant gastrointestinal (GI) discomfort in certain individuals (Gibson & Shepherd, 2010). Swimmers should also be aware that increasing the carbohydrate composition of their training diet (both overall and within training) may increase their ability to optimally absorb and oxidize these additional carbohydrate sources (Cox et al., 2010). Therefore, swimmers are encouraged to practice consuming carbohydrates at high rates (up to 90 g/hr) in training before competition to minimize GI discomfort.

**Practicality of Feeding During Open-Water Races**

Currently, both shorter (5-km, 10-km) and longer (25-km) open-water events at the World Championships are completed on a loop course. Floating or stationary feeding stations are situated at regular intervals on the course; for example, during FINA Open-Water Swimming Grand Prix events, stations are placed at least every 2.5 km along the course (FINA Open-Water Grand Prix Rule 4.5). Accredited handlers are positioned at these stations passing food and fluids to swimmers on long poles with a cup or delivery vessel attached to one end. Unlike events such as the marathon and an Olympic distance triathlon, where feeding can occur while athletes maintain a relatively normal velocity, open-water swimmers must stop or substantially reduce velocity to feed or drink. On entering the feed area, swimmers use one of two techniques to consume their foods or drinks: They either come to a complete stop, find their handler, and feed, or they maintain a constant speed while rolling onto their backs, feeding, then rolling back over and continuing to swim. These techniques are time consuming and could potentially affect swimming rhythm, particularly in shorter duration races. Feeding strategies that require minimal interruption to swimming speed may provide a tactical advantage to swimmers especially when the feed zones are positioned at significant distances off the race line. As race durations increase (>2 hr), swimmers and coaches are encouraged to use feeding pontoons frequently to meet high carbohydrate and fluid demands.

**Event-Specific Strategies**

**5 km and 5 km Teams**

Because of the duration and nature of 5-km individual and team races, the requirement for nutrition support during racing is minimal. Although feeding opportunities in the majority of OWS races governed by FINA
are ample (~every 1.25 km), swimmers may not benefit from using these stations in races such as the individual and team 5-km event for a variety of reasons. First, the positioning of the pontoons requires swimmers to deviate from the line of least distance between buoys, adding unnecessary time and effort to complete the race. Second, well-practiced open-water swimmers regularly use tactics such as drafting (i.e., streamlining behind another competitor) to reduce the energy cost of swimming (Chatard & Wilson, 2003), hence sparing valuable glycogen and reducing the need for endogenous sources. Indeed, swimming between 0 and 50 cm behind the feet of a fellow competitor can reduce the oxygen cost of swimming by approximately 12% (Chatard & Wilson, 2003). Third it is unlikely that the consumption of exogenous nutrients, despite their perceived central benefits via mouth sensing, would offset the time penalties and other disadvantages of pontoon feeding (Colombani et al., 2013). Although the intake of carbohydrates for central benefit may be achieved through the use of sports gels, the time taken to consume the gel would offset the benefits of feeding in races of such durations. Therefore, swimmers competing in these events are encouraged to focus on prerace nutrition strategies to optimize carbohydrate availability and hydration status using feed stations and on body nutrition support only when tactically advantageous.

10 km

Swimmers competing in 10-km races should optimize prerace glycogen and hydration status. Because the duration and intensity of a 10-km open-water event corresponds with the theoretical limits of glycogen storage, swimmers are encouraged to identify opportunities throughout a race where nutrient ingestion is possible. Feeding pontoons are available at regular opportunities throughout the race, as for the 5-km event. In recent years, however, we have observed that swimmers have tended to rely less on the feeding pontoons for nutritional support, carrying their own gels and small flasks tucked into their swimsuits. This arrangement allows the swimmer to feed at opportunities that are tactically advantageous, while maximizing their opportunities to use the energy-saving advantages of drafting behind the feet of another competitor. General guidelines for endurance exercise of 2-hr duration suggest carbohydrate intakes of 30–60 g/hr (Burke et al., 2011). However, the unique environmental and physiological influences of OWS events may require high exogenous oxidation rates to optimize performance. It has been suggested that arm muscle, compared with leg muscle, has lower glycogen stores but uses carbohydrate at a higher rate (Ahlborg & Jensen-Urstad, 1991; Tremblay et al., 2009). This assertion may explain the significant glycogen depletion seen in the deltoid muscle of swimmers completing relatively short distances (5.5 km; Costill et al., 1988b). High utilization rates of exogenous carbohydrate sources by the leg can be achieved by consuming 60–90 g/hr of carbohydrates from sources using different intestinal transporters (e.g., combinations of glucose and fructose); such tactics have been shown to improve ultraendurance exercise protocols (for review, see Jeukendrup, 2011). It is generally recommended that feeding commence early in the race to allow high targets for carbohydrate intake to be met, as well as to take advantage of the central nervous system benefits of oral carbohydrate sensing (Jeukendrup, 2011). However, more research is required to identify optimal amounts and patterns of intake of carbohydrate for OWS protocols. Until such time, swimmers should experiment to determine whether higher rates of carbohydrate intake from multitransportable carbohydrate are possible and beneficial.

High rates of fluid loss have been reported (1.2–1.6 L/hr) in high intensity swimming (Cade et al., 1991). Macaluso and colleagues (2011) reported increasing levels of hypohydration and core temperature when swimmers completed a 5-km time trial in three different water temperatures (23, 27, and 28 °C). Although moderate levels (2%) of dehydration were reported when swimmers completed the time trial in 32 °C water, rises in core temperature were mild (36.9 ± 0.4 to 38.0 ± 0.4 °C; Macaluso et al., 2011). Similar levels of weight loss have been seen in swimmers completing 2 hr of flume swimming at similar water temperatures (personal observations, David Gerrard, Otago University). As greater levels of dehydration would be expected in 10-km events, swimmers may benefit from starting a race with an optimized hydration status. Recent studies have shown that prerace intake of a sodium-containing beverage (10 ml/kg BM, or ~64 mmol/L Na+) can reduce thermal strain and enhance endurance capacity in terrestrial exercise activities (Sims et al., 2007a, 2007b). Swimmers may find advantages in combining the use of sodium and cold beverages to optimize prerace hydration status and enable a reduction in core temperature before competition.

25 km and Longer Events

Pre-race interventions used to enhance performance in shorter duration events may continue to be advantageous in preparation for longer duration events. The duration of the 25-km event is 5 hr or more, so swimmers are encouraged to increase their reliance on central feeding zones and pontoons to access nutritional support. Carbohydrate intakes should be targeted to ~90 g/hr from multiple transportable carbohydrate sources (Jeukendrup, 2011), and with the greater likelihood of extreme temperature variations in these events (16–31 °C), swimmers may benefit from matching beverage temperatures to specific environmental conditions. Cold beverages (4 °C) may enhance endurance exercise performance by reducing thermal strain (Ross et al., 2013). Conversely, warm beverages or food sources, such as warmed sports drinks or soup, are used by open-water swimmers in cold-water events, but there is currently no research suggesting that these practices can attenuate core temperature reductions seen in these events. In these events, just as in other ultraendurance events, there have been observations of...
fluid mismatches in which greatly exceeds sweat rates. Indeed, 17% of competitors (8% of men and 36% of women) competing in a 26.4-km marathon swim in Lake Zurich were reported to have exercise-associated hyponatremia (Wagner et al., 2012). Appropriate hydration plans in hot environmental conditions may require attention to drink sufficient fluid; however, in cooler environmental conditions, swimmers may need to find more concentrated sources of carbohydrate (e.g., gels and confectionery items) so that fuel-intake targets can be met without overhydration. Such race plans need to be well practiced in training but include sufficient flexibility so that they can be adapted to unexpected conditions on race day.

Ergogenic Aids

Ergogenic aids that may enhance swimming performance have been reviewed elsewhere by Derave and Tipton (2014). Of specific interest to open-water swimmers are products that can enhance central drive and help buffer acidic environments; this is especially important in the last few kilometers of any championship race. Current tactics in the completion of 5- and 10-km races involve an incremental increase in speed throughout the event, such that the final kilometers are completed at near maximal intensities. Caffeine has been shown to be beneficial to swimmers competing in longer duration pool events (i.e., 1,500 m; MacIntosh & Wright, 1995) with moderate doses (~mg/kg) able to improve performance in other sporting events lasting longer than 90 min (Cox et al., 2002b). Caffeine supplementation protocols include intakes of up to 3 mg/kg in the hour before short open-water events or smaller doses consumed in conjunction with carbohydrate throughout longer duration races. Supplementation with b-alanine, the rate-limiting component in the formation of the muscle dipeptide carnosine, has been shown to enhance peak power and mean power during the final sprint in a simulated cycling road race (Van Thienen et al., 2009), a protocol similar to sustained near-maximal efforts seen at the end of open-water races. Specific studies should investigate whether enhanced intracellular buffering capacity results in enhanced open-water race performance; currently there is a distinct lack of such research in the literature.

Multiple-Event Programs

Swimmers competing in multiple events at a FINA World Championship have considerable nutritional challenges. Short turnaround (1–2 days) between glycogen-depleting events can place significant strain on swimmers aiming to start each race with optimal fuel stores. Outstanding swimmers may compete in 5-km (individual and team), 10-km, and potentially 25-km events, all within the space of 5 days. Aggressive attention to the amount (>10 g/kg BM) and timing (starting soon after each race) of carbohydrate intakes between races is required to ensure that adequate glycogen replacement is achieved between races (for review of refueling strategies, see Burke et al., 2014). Carbohydrate sources should focus on low-fiber, high-glycemic-index foods and fluids to minimize GI discomfort and enable the large amounts of carbohydrates required for glycogen replacement. Swimmers may benefit from consuming small (~20 g) well-planned (3–4 per day) servings of high biological value protein sources with carbohydrate to optimize muscle tissue recovery (Areta et al., 2013) but also support glycogen replacement (Betts & Williams, 2010).

Conclusion

Because of the emerging nature of OWS, very little research is available to inform nutrition practices. Current nutrition recommendations for open-water training and competition are either an extension of pool recommendations or are extrapolated from other athletic populations with similar physiological requirements. Competition nutrition should focus on optimizing prerace hydration and glycogen stores. Throughout the race, swimmers should rely on self-supplied fuel and fluid sources, using feeding zones only when tactically appropriate for races of 10 km or less. As race durations extend toward and beyond 5 hr, feeding zones become more significant to reduce stresses associated with prolonged environmental exposure. These strategies therefore assume a more significant role in race nutrition. The manipulation of the temperature of ingested fluids may assist with thermoregulation during long events in extreme environments. Swimmers are encouraged to work with trained professionals to develop effective and efficient race nutrition strategies that enhance competition performance.

References


