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Nutrition for throwers, jumpers, and combined events athletes

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Abstract

Throwers, jumpers, and combined events athletes require speed, strength, power, and a wide variety of technical skills to be successful in their events. Only a handful of studies have assessed the nutritional needs of such athletes. Because of this, recommendations for nutritional requirements to support and enhance training and competition performances for these athletes are made using research findings from sports and exercise protocols similar to their training and competitive events. The goals of the preparation cycle of nutrition periodization for these athletes include attaining desirable body weight, a high ratio of lean body mass to body height, and improving muscular power. Nutritional recommendations for training and competition periods include: (1) meeting energy needs; (2) timing consumption of adequate fluid and electrolyte intakes before, during, and after exercise to promote adequate hydration; (3) timing consumption of carbohydrate intake to provide adequate fuel for energy demands and to spare protein for muscle repair, growth, and maintenance; (4) timing consumption of adequate protein intake to meet protein synthesis and turnover needs; and (5) consuming effective nutritional and dietary supplements. Translating these nutrient and dietary recommendations into guidelines these athletes can apply during training and competition is important for enhancing performance.

Keywords: *Nutrition, diet, jumpers, throwers, combined event athletes, hydration, supplements, fluid, carbohydrate, protein, energy, body composition*

Introduction

Few studies have assessed the nutritional needs, dietary intake, and body composition of elite athletes in throwing, jumping, and combined events (Faber, Spinnler-Benade, & Daubitzer 1990; Houtkooper, Mullins, Going, Brown, & Lohman 2001; Malina, 1992; Mullins, Houtkooper, Howell, Going, & Brown, 2001). Because of this, recommendations for nutritional needs for training and competition are made using research findings from athletes that have exercise training and competition schedules similar to these athletes.

Combined events athletes participate in the men's decathlon (heptathlon in indoor competition) and women's heptathlon (pentathlon in indoor competition); these competitions consist primarily of events requiring speed, endurance, strength, power, and a wide variety of technical skills. The decathlon includes ten events that take place over two consecutive days: 100 m, long jump, shot put, high jump, 400 m, 110-m hurdles, discus, pole vault, javelin, and 1500 m. The heptathlon includes seven events over two days: 100-m hurdles, shot put, high jump, 200 m, long jump, javelin, and 800 m (International Association of Athletics Federations, 2007).

Throwing events include the shot put, discus, javelin, and hammer, which require strength, power, speed, and technical skills. Successful shot putters have a large body mass, and strong arms and legs. They must produce the dynamic power needed to propel a heavy, metal ball as far as possible. The discus thrower must add a wide reach, speed on the turn, and a sense of rhythm to the shot-putter's skills. The javelin weighs less than the other throwing implements and requires a fast run-up, smooth acceleration, and power for a fast throw. Hammer throwers require both a relatively large body mass and throwing technique that includes strength, speed, and relaxation (International Association of Athletics Federations, 2007).

Jumps include high jump, long jump, triple jump, and pole vault. The high jump requires strength, power, speed, coordination, and relaxation. A long jumper transforms running movement into flight by using powerful legs and an elastic take-off. The triple jumper requires a precise approach, producing kinetic energy from an almost maximum approach

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speed. The pole vault requires strong arms and shoulders, a high jumper's skills of relaxation and coordination, a sprinter's speed, and a gymnast's control (International Association of Athletics Federations, 2007).

Nutrition for training periodization

The principles related to training periodization, separating training into different cycles by varying specificity, intensity, and volume, can be applied to nutrient and dietary intake (Seebohar, 2004; Stellingwerff, Boit, & Res, 2007). Nutritional needs vary with the periods of training: preparation, competition, off-season, and the transitions between these periods.

Several nutritional factors are required for these athletes to achieve their training and performance goals, including: (1) meeting energy needs; (2) timing consumption of adequate fluid and electrolyte intakes before, during, and after exercise to promote adequate hydration (Coyle, 2004; Ganio, Casa, Armstrong, & Maresh, 2007; Sawka *et al.*, 2007); (3) timing consumption of carbohydrate intake to provide adequate fuel for energy demands and to spare protein for muscle repair, growth, and maintenance (Burke, Kiens, & Ivy, 2004; Tipton & Witard, 2007); (4) timing consumption of adequate protein intake to meet protein synthesis and turnover needs (Miller, Tipton, Chinkes, Wolf, & Wolfe, 2003; Rasmussen, Tipton, Miller, Wolf, & Wolfe, 2000; Tipton & Witard, 2007; Tipton & Wolfe, 2004); and (5) choosing effective nutritional and dietary supplements (Maughan, Depiesse, & Geyer, 2007; Maughan, King, & Lea, 2004; Volpe 2007).

Energy

In the preparation cycle of the training period, athletes should strive to attain their competitive body weight and composition (e.g. gain muscle mass and/or lose body fat) and to improve or maintain muscular strength and power. Table I summarizes body composition profiles for throwers, jumpers, and combined events athletes. The relationships among body weight, body composition, power-to-mass ratio, and performance in different athletic events, and strategies used to reduce weight and body fat, have been addressed by O'Connor and Colleagues (O'Connor, Olds, & Maughan, 2007) and Tipton and co-workers (2007b). Issues related to low energy availability and body composition are addressed by Manore and colleagues (Manore, Kam, & Loucks, 2007).

Energy needs vary with the training, competition, and transition periods. Carbohydrate is the major energy source. Protein provides energy but it should be consumed in an amount that meets amino acids needs for formation and turnover of body protein, leaving fat to provide the remainder of energy needs. Alcohol provides energy but it is not an essential nutrient. Table II summarizes reported average daily macronutrient intakes of throwers, jumpers, and combined events athletes.

Fluid

Euhydration wards off fatigue and heat-related illnesses associated with dehydration (Coyle, 2004; Ganio *et al.*, 2007; Gonzalez-Alonso, Mora-Rodriguez, Below, & Coyle, 1997; Shirreffs, Armstrong, & Cheuvront, 2004). Body weight changes and urine colour can be used to assess hydration status. To replace a body fluid loss of 1 kg will require about 1.5 litres of fluid. Generally, when an athlete is euhydrated urine colour will be pale yellow and when dehydrated will be darker (Casa *et al.*, 2000). Excessive intakes of some vitamin supplements can also give urine a dark colour.

Table I. Age, height, weight, and body composition of elite female and male throwers, jumpers, and combined events athletes.

Sport	*n*	Age (years)	Height (m)	Weight (kg)	%Fat	FFM (kg)	FFBMI	Reference
Female discus throwers	11	21.1	1.681	70.8	24.9	53.2	19	Malina *et al.* (1971)
Female heptathletes	19	25.5	1.750	67.3	15.0	57.2	19	Houtkooper *et al.* (2001)
Female jumpers/hurdlers	11	20.3	1.659	59.4	20.8	47.0	17	Malina *et al.* (1971)
Female pentathletes	9	21.5	1.754	65.4	11.0	58.2	19	Krahenbuhl *et al.* (1979)
Female shot putters	9	21.5	1.676	78.0	28.0	56.2	20	Malina *et al.* (1971)
Female throwers	5	16–23	1.754	78.6	23.9	58.9	19	Brown and Wilmore (1974)
Female throwers	15	22.0	1.773	87.6	29.2	62.0	20	Faber *et al.* (1990)
Male throwers	22	22.1	1.878	99.0	16.7	82.5	23	Faber *et al.* (1990)
Male decathletes	3	22.5	1.863	84.1	8.4	77.0	22	Withers *et al.* (1987)
Male discus throwers	7	28.3	1.861	104.7	16.4	87.5	25	Fahey *et al.* (1975)
Male shot putters	5	27.0	1.882	112.5	16.5	93.9	27	Fahey *et al.* (1975)
Male jumpers	16	17.6	1.817	69.2	8.5	63.3	19	Thorland *et al.* (1981)

Note: Fat-free body mass index (FFBMI) = fat-free mass (FFM) (kg)/height (m) squared. Adapted from Houtkooper *et al.* (2001).

Table II. Mean daily macronutrient intakes of throwers, jumpers, and combined events athletes.

Sport	*n*	Age (years)	Energy (kJ)	CHO (%kJ)	CHO (g)	PRO (%kJ)	PRO (g)	Fat (%kJ)	Fat (g)	Method of assessment	Calibre of athletes	Reference
Female heptathletes	19	21–29	9 866	58	339	16	95	27	71	4-day record	Elite	Mullins *et al.* (2001)
Female jumpers	4	21	8 297	51	244	16	82	33	72	3-day record	National rank	Sugiura and Kobayashi (1998)
Female throwers	10	22	9 285	46	255	17	94	38	94	7-day record	National rank	Faber *et al.* (1990)
Female throwers	8	25	10 955	54	336	14	93	32	94	3-day record	National rank	Sugiura and Kobayashi (1998)
Male throwers	20	22	14 612	41	357	19	166	40	155	7-day record	National rank	Faber *et al.* (1990)

Adapted from Mullins *et al.* (2001).

Drinking adequate amounts of fluids before, during, and after exercise is essential for promoting recovery and preparing for the next training session. Current guidelines indicate that about 4 h before exercise athletes should drink about 5–7 millilitres per kilogram of body weight ($ml \cdot kg\ BW^{-1}$). If the athlete does not produce urine or the urine is dark coloured or highly concentrated, then about 3–5 $ml \cdot kg\ BW^{-1}$ should also be consumed about 2 h before exercise (Sawka *et al.*, 2007).

The current guidelines and strategies for fluid intake and replacement are based on the goal of matching intake with loss. Achieving euhydration can be difficult and the goal of limiting fluid loss to $<2\%$ body weight reduction is more feasible, with research indicating that it does not adversely affect exercise performance (Casa *et al.*, 2000; Coyle, 2004; Shirreffs, Casa, & Carter, 2007). Specific guidelines for fluid intake before, during, and after training are discussed by Shirreffs *et al.* (2007) and have been reviewed previously (Coyle, 2004; Ganio *et al.*, 2007; Sawka *et al.*, 2007; Shirreffs *et al.*, 2004).

Moderate (300–400 $mg \cdot day^{-1}$) acute and long-term caffeine intake does not appear to have a negative effect on hydration status during exercise (Armstrong *et al.*, 2005; Fiala, Casa, & Roti, 2004; Roti *et al.*, 2006). Caution should be practised regarding caffeine intake, since some athletes find the stimulant effect of caffeine causes gastrointestinal discomfort, over-stimulation of the nervous system or sleep disturbances.

Carbohydrate

Depletion of carbohydrate (CHO) stores is an underlying factor leading to fatigue and decreased performance (Maughan & Burke, 2002; Hargreaves, Hawley, & Jeukendrup, 2004). Daily exercise training recovery fuel needs during very light training with low-intensity exercise or skill-based exercise can be met with 3–5 $g\ CHO \cdot kg\ BW^{-1} \cdot day^{-1}$ (Burke, 2007). Consuming 5–7 $g\ CHO \cdot kg\ BW^{-1} \cdot day^{-1}$ will support recovery fuel needs for athletes with moderate training programmes lasting less than $1\ h \cdot day^{-1}$ (Balsom, Gaitanos, Soderlund, & Ekblom, 1999; Burke, 2007; Burke *et al.*, 2004). Intakes of 7–12 $g\ CHO \cdot kg\ BW^{-1} \cdot day^{-1}$ will meet daily recovery fuel needs for moderate- to high-intensity exercise training lasting 1–3 $h \cdot day^{-1}$ (Burke *et al.*, 2004).

The timing of carbohydrate intake in relation to exercise training is important. Pre-exercise training meals should generally be consumed 1–4 h before starting exercise and contain around 1–4 $g\ CHO \cdot kg\ BW^{-1} \cdot day^{-1}$ (Hargreaves *et al.*, 2004). Training sessions for jumpers, throwers, and combined events athletes often last 1.5 to >3 h (continuous or accumulated) and draw significantly upon the athlete's glycogen stores. If these stores are not replaced during or after exercise, performance in subsequent training sessions can be hindered leading to a reduction in overall performance. Strength training to increase muscle mass and the power-to-mass ratio also requires adequate carbohydrate intake to provide energy to fuel training and help ensure total energy needs are met while sparing protein for muscle growth and turnover (Tipton & Wolfe, 2004).

Athletes need to plan ahead to have carbohydrate readily available during training sessions of moderate intensity or intermittent exercise that lasts longer than an hour. In general, it is recommended for these types of sessions that athletes consume 0.5–1.0 $g\ CHO \cdot kg\ BW^{-1} \cdot h^{-1}$, or about 30–60 $g \cdot h^{-1}$ throughout each hour of actual exercise training period, by eating/drinking every 10–30 min (Burke, 2007; Coyle, 2004).

The highest rates of glycogen replacement occur within the first hour after exercise (Burke *et al.*, 2004) and thus athletes can take advantage of this opportunity by planning recovery meals and snacks that contain adequate carbohydrate. Following exercise, consuming 1.0 – 1.2 g CHO · kg BW^{-1} immediately after and then again 2 h after exercise (Burke *et al.*, 2004) will help replenish glycogen stores. This enhanced period of glycogen storage is related to exercise-induced glycogen depletion activating glycogen synthase (Wojtaszewski, Nielsen, Kiens, & Richter, 2001), exercise-induced increases in insulin sensitivity (Richter, Mikines, Galbo, & Kiens, 1989), and exercise sensitization of muscle cell membranes to glucose delivery (Burke *et al.*, 2004).

Carbohydrate may not be the only macronutrient important for glycogen replenishment. Some research suggests that the addition of protein enhances glycogen storage (Ivy *et al.*, 2002), but this is not supported by all (Carrithers *et al.*, 2000; Jentjens, van Loon, Mann, Wagenmakers, & Jeukendrup, 2001; Tarnopolsky *et al.*, 1997; van Loon, Saris, Kruijshoop, & Wagenmakers, 2000). Evaluation of study designs between the conflicting groups shows that the timing interval of nutrient consumption and total amount of carbohydrate consumed may explain the discrepancy. Studies that provided exercisers with either a carbohydrate-only or carbohydrate + protein beverage at frequent intervals (i.e. every 15 – 30 min) after exercise found no difference in glycogen storage (Carrithers *et al.*, 2000; Jentjens *et al.*, 2001; Tarnopolsky *et al.*, 1997; van Loon *et al.*, 2000), whereas studies using feeding intervals of 2 h did so (Ivy *et al.*, 2002; Zawadzki, Yaspelkis, & Ivy, 1992). These results suggest that the more frequent consumption of carbohydrate may offset any benefit that additional protein can have on enhancing glycogen resynthesis. When consumption of carbohydrate is high (~1.0 g CHO · kg BW^{-1}), additional protein does not appear to provide any further benefit for glycogen resynthesis (Jentjens *et al.*, 2001).

When recovery time is short between exercise sessions, the consumption of a carbohydrate + protein beverage or snack relatively soon after exercise has been shown to improve glycogen recovery over that of a beverage or snack containing only carbohydrate when consumed at the same instant in time (Ivy *et al.*, 2002). Currently, it is unclear whether the consumption of protein with carbohydrate after exercise improves glycogen resynthesis, especially in sports with limited recovery times, but it is unlikely that the addition of protein to a post-training snack will decrease glycogen resynthesis.

Protein

Protein (PRO) provides amino acids, which play key roles in the formation and turnover of protein in the body and also provides energy. Male power athletes undertaking heavy resistance exercise can meet their protein needs in the early phase of training by consuming 1.5 – 1.7 g PRO · kg BW^{-1} · day^{-1}, and in an established training programme by consuming 1.0 – 1.2 g PRO · kg BW^{-1} · day^{-1} (Burke, 2007; Lemon, 2000; Tarnopolsky, 2006). Highly trained athletes undertaking periods of large and intense training loads who consume a maximum of 1.7 g PRO · kg BW^{-1} · day^{-1} will adequately meet their protein needs (Tarnopolsky, 2004). These protein guidelines should also meet the needs of the female athlete.

Most power athletes have high intakes of protein (Tarnopolsky, 2006). Estimates of protein intake for male and females throwers are 1.65 and 1.14 g PRO · kg BW^{-1} · day^{-1} respectively (Faber *et al.*, 1990). Dietary estimates of protein intake by female combined events athletes are around 1.4 g PRO · kg BW^{-1} · day^{-1} (Mullins *et al.*, 2001). In the off-season and transition periods of training when exercise loads and duration are small, protein needs are lower and similar to the needs of recreational exercisers (0.8 – 1.0 g PRO · kg BW^{-1} · day^{-1}; American College of Sports Medicine, 2000; Burke, 2007).

Recommending exact amounts of protein to individual athletes is controversial. A recent review on the controversy indicates that determining a research-based consensus for the protein needs of athletes is unrealistic because many factors influence these needs (Tipton & Witard, 2007). Two factors are important for making individualized recommendations for protein intake. First, overall energy needs must be met to allow ingested protein to be available for muscle repair, maintenance, and growth (Tipton & Witard, 2007; Tipton & Wolfe, 2004). Second, timing of protein intake is important for influencing the anabolic response of muscle in relation to exercise.

The timing of protein ingestion is particularly important for jumpers, throwers, and combined events athletes during the period of training when they are trying to build strength and power. When muscle hypertrophy and improving the power-to-mass ratio are the athlete's goals, the focus should be on consuming enough energy, while consuming protein close to the start and/or end of exercise, and maintaining adequate protein and energy intakes during rest days (Tipton & Wolfe, 2004). The high protein intakes, common in these athletes, are unlikely to cause harm to their health; however, emphasis should be placed on ensuring that protein consumption does not compromise the consumption of other nutrients, especially carbohydrate, which are also essential for athletic success (Tipton & Witard, 2007; Tipton & Wolfe, 2004).

Protein from food sources readily provides all of the amino acids needed to meet protein requirements (Elliott, Cree, Sanford, Wolfe, & Tipton, 2006). Protein supplements may be convenient sources of protein and amino acids; however, they do not provide protein that is superior to protein in food. Additional details regarding protein requirements for increasing size, strength, and the power-to-body mass ratio are addressed by Tipton *et al.* (2007b).

Other nutrient and dietary considerations

Vitamins and minerals

Research on vitamin and mineral intakes of athletes has been limited in the main to female populations and to a few types of sports (Volpe, 2007). A recent review on the topic indicates that dietary calcium is often low in male athletes, while dietary calcium *and* iron intakes are low in female athletes (Volpe, 2007). The only study to evaluate the diet of combined events athletes reported that female heptathletes did not consume adequate vitamin E (Mullins *et al.*, 2001). Without adequate research-based information on the vitamin and mineral intakes of jumpers, throwers, and combined events athletes, definitive conclusions about their ability to meet their needs for these nutrients from dietary sources cannot be made.

In general, the Dietary Reference Intakes (DRI) for micronutrients should be met for athletes, as long as the athletes are meeting their energy needs from a variety of recommended foods groups (Volpe, 2007). When athletes' diets are restrictive in total energy, limited in food variety, or severely restrict or eliminate specific food groups (i.e. meat or dairy), low-dose vitamin and mineral supplementation may be warranted to help these athletes meet their needs for these nutrients (Maughan *et al.*, 2007). For these athletes, consuming a vitamin and mineral supplement that does not exceed the DRIs for these nutrients may be appropriate.

The roles some vitamins and minerals play as antioxidants (e.g. vitamin C, vitamin E, beta-carotene, selenium) has received attention because of the high levels of oxidative stress that exercise can induce (Atalay, Lappalainen, & Sen, 2006; Clarkson & Thompson, 2000; Powers, DeRuisseau, Quindry, & Hamilton, 2004; Sen, 1995, 2001). There are limited data indicating that athletes need additional antioxidants in their diet or that dietary antioxidant supplementation improves performance (Powers *et al.*, 2004). A recent review of dietary antioxidants for athletes made the following recommendations: (1) antioxidant needs vary with individuals and thus each athlete's needs should be assessed before supplementation recommendations can be made; and (2) athletes should be cautious when considering antioxidant supplementation but, if deemed necessary, choose multi-nutrient preparations over mega-doses of individual nutrients (Atalay *et al.*, 2006). A nutrient-dense diet that includes whole grains, fruits, vegetables, nuts, and seeds can help provide dietary sources of antioxidants.

Jumpers, throwers, and combined events athletes put tremendous stress on their joints. Nutrition can play an important role in supporting joint health. Key nutrients important for healthy joints include: protein, calcium, phosphorus, zinc, vitamin C, vitamin D, and vitamin E (Clark, 2007). Including more omega-3 fatty acids and collagenous materials (i.e. meat) in the diet can also promote joint health (Clark, 2007). Several joint health supplements are available and can be appealing to athletes who suffer from joint pains. Currently, the most popular supplements are glucosamine sulphate and chondroitin sulphate. A meta-analysis of placebo-controlled trials in osteoarthritic populations, not specifically athletes, using these two supplements concluded that while joint pain symptoms may have been reduced following supplementation, the effects were likely exaggerated (McAlindon, LaValley, Gulin, & Felson, 2000). A recent review of joint health supplements and herbs used in other populations (Clark, 2007) concluded that more research is needed before optimal joint health supplement recommendations can be made. For the athletes today, what this means is focusing first on eating foods that provide nutrients needed for healthy joints.

Other supplements and ergogenic aids that effectively improve speed, strength, and power can potentially benefit jumpers, throwers, and combined events athletes. These supplements include creatine, sodium bicarbonate, and caffeine. Sodium bicarbonate does not appear to provide benefits for jumpers or throwers, but may improve performance in events from 400 m to 5000 m, and thus may benefit combined events athletes (Maughan *et al.*, 2007). Athletes need to be aware of the potential for contamination of vitamin, mineral, and other dietary supplements with banned substances, which can lead to inadvertent doping. Issues regarding the principles and general evidence for effectiveness of specific supplements (including creatine, bicarbonate, and caffeine) are summarized by Maughan *et al.* (2007). Additional nutritional strategies to promote recovery and adaptation from training are discussed in the articles by Hawley and colleagues (Hawley, Gibala, & Bermon, 2007) and Burke and co-workers (Burke, Millet, & Tarnopolsky, 2007) in this issue.

Nutrition for competition periods

Planning nutrition support during competition periods is an important part of preparation for all of these athletes and especially for the combined events athletes because they spend two full days competing without much down-time.

Timing of fluid intake

Fluid intake should start long before the first event and be individualized. Fluids should be consumed about 4 h and 2 h before warm-ups and events (Sawka *et al.*, 2007; Shirreffs *et al.*, 2004). It is also important to allow time to use the restroom before competition, since most events do not allow for bathroom breaks. Jumpers, throwers, and combined events athletes all participate in events that consist of bouts of short-duration exercise ($<6-8$ min) spread out over longer periods. This schedule allows the athlete ample opportunity to hydrate before and after events to minimize dehydration. When this down-time occurs outdoors in hot environmental conditions, it can lead to dehydration unless adequate amounts of fluids and sodium are consumed. Over-consumption of fluids during down-time can also lead to hyperhydration, which can have negative impacts on performance (Shirreffs *et al.*, 2007). Athletes should be careful not to drink excessive amounts of fluid that result in hyperhydration and weight gain on competition days. Athletes need to plan for fluid access at competitions and follow an individualized drinking schedule for fluid intake throughout their competition schedules to prevent dehydration and hyperhydration.

When exercise is strenuous, performed in extremely high temperatures or humidity, and/or lasts longer than 60 – 90 min (accumulated time competing), a fluid with carbohydrate and electrolytes, like that found in sports beverages, should be consumed. The electrolytes (mainly sodium and potassium) in a typical carbohydrate – electrolyte sports beverage aid in the absorption of fluid, while carbohydrates supply additional energy (Shirreffs *et al.*, 2004). Overall, for most athletes a cool temperature and appealing flavour help enhance fluid consumption.

Fluid and electrolyte intake during competition days, as well as training sessions, can help reduce the risk for heat cramps. Heat cramps are most prevalent in active muscle like the thigh and calf (Ganio *et al.*, 2007), and thus athletes using these muscle groups can be at increased risk for heat cramps when hydration strategies are not appropriate. The origination of heat cramps is not clear, although large fluid and sodium losses have been implicated (Ganio *et al.*, 2007). Athletes, therefore, need to focus not only on replacing fluid losses during exercise, but also sodium lost through sweating. Simple strategies of packing sodium-containing fluids and/or snacks (e.g. crackers, pretzels, sports drinks) and consuming these during competition can help prevent heat cramps.

Recovery after competition includes not only rest but rehydration and refuelling. This is particularly important for combined events athletes, because they compete in five to ten events spread over 2 days. These multiple events put the athlete at increased risk for dehydration and decreased performance on the days of competition and particularly at the end of the day in hot environmental conditions. Therefore, combined events athletes need to rehydrate between events (Ganio *et al.*, 2007). Generally, these athletes need to consume about 1.5 litres of fluid for each kilogram of body weight lost over the day of competition with the goal of returning to pre-competition weight (Sawka *et al.*, 2007; Shirreffs *et al.*, 2004). In addition to volume, these athletes also need to focus on electrolyte replacement, mainly sodium. Some research suggests that rehydration may be enhanced by consuming beverages after exercise that contain higher sodium concentrations than those found in sports drinks formulated for consumption during exercise (Shirreffs *et al.*, 2004). In-depth information on this topic is summarized by Shirreffs *et al.* (2007) and in an American College of Sport Medicine Position Paper (Sawka *et al.*, 2007).

Timing of food intake

It is generally recommended that the pre-exercise meal be consumed 1 – 4 before exercise and be high in carbohydrate, containing around $1-4$ g CHO $\cdot$ kg BW^{-1} (Burke, 2007; Hargreaves *et al.*, 2004). With early morning start times for some competitions, not every athlete will wake 3 – 4 h before competition. In these circumstances, athletes should delay the consumption of a pre-competition meal to within the hour before starting competitions (Hargreaves *et al.*, 2004; Jeukendrup, 2004). When this is the case, the pre-competition meals should be mainly carbohydrate, familiar foods, and well tolerated so as not to cause gastrointestinal distress.

When time spent competing exceeds 1 h, carbohydrate should be consumed to replenish glycogen stores and keep energy levels high (Jeukendrup, 2004; Maughan & Burke, 2002). This carbohydrate can be consumed in solid form, if available, or as part of a sports drink. For some athletes, foods with a lower glycaemic index may be better tolerated.

Post-competition meals are important for fluid and carbohydrate fuel replacement needed for recovery from competitions. To maximize performance, athletes need to make arrangements to have suitable beverages and foods available before and after events and after the day of competition.

Translation of nutritional recommendations into practice

Planning and practice are key elements to using nutrition guidelines effectively to help optimize individual nutrition plans for jumpers, throwers, and combined events athletes. Applied sports nutrition manuals and books provide practical sports nutrition information for coaches and athletes (Burke, 2007; Houtkooper, Maurer Abbot, & Mullins, 2007; Maurer 2004). It is important to maintain flexibility when planning fluid and food intake during competitions and make adjustments in response to changes in environmental conditions.

Conclusions

Combined events athletes, throwers, and jumpers require speed, strength, power, and a wide variety of technical skills to be successful in their events. Few studies have assessed the nutritional needs of these athletes. Because of this, recommendations for nutritional requirements to support and enhance training and competition performances for these athletes need to be individualized using research findings from sports and exercise protocols that are similar to their training and competition events. It is also important to recognize the individual variability in responses among these athletes when applying these guidelines during training, competition, and transition periods under varied environmental and psychological conditions.

Summary of nutritional guidelines for combined events athletes

Consesnsus for:

- Food and fluid intakes need to be individualized because nutrient needs vary with body weight, periods of training preparation, competition schedules, transitions, and the off-season.
- Changes in body weight and composition should be attempted before or after the competition season.
- Fluid losses should be limited to $<2\%$ reduction of euhydrated body weight by consuming appropriate amounts of fluid before, during, and after exercise.
- The athlete should rehydrate after exercise training and at the end of competition days by consuming enough fluid and sodium to replace body fluid and sodium losses and to have urine that is a pale yellow colour.
- Protein and carbohydrate needs vary with individual body weight and with the intensity and duration of training periods.
- Protein and carbohydrate needs, even for high-intensity and long-duration strength training exercise loads, can be met by food sources.
- Protein supplements provide convenient sources of protein but the protein is not superior to that found naturally in foods.
- During training sessions of moderate-intensity or intermittent exercise that lasts longer than an hour, consuming carbohydrate will help replace glycogen stores.
- After exercise, consuming adequate amounts of carbohydrate will speed up the rate of replacement of glycogen stores.
- Dietary Reference Intakes for vitamins and mineral should be attained.
- Dietary supplements that have demonstrated efficacy can improve speed, strength, and power and thus potentially improve performance.
- Translating research-based recommendations for nutrient intakes into practical plans that athletes actively apply during training, competition, transition, and off-season periods can help to enhance performance.

Consensus against:

- Indiscriminate use of nutrient supplements and ergogenic aids.
- Excessive fluid intake that leads to hyperhydration and weight gain during a competition day.

Issues that are equivocal:

- Protein aids glycogen resynthesis when intervals between events are short.
- That dietary antioxidant supplementation or other nutrient supplements will improve performance unless there is a deficiency of the nutrient.

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