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Human Kinetics
SCHOLARLY REVIEW

Fueling for the Field: Nutrition for Jumps, Throws, and Combined Events

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Athletes participating in the athletics (track and field) events of jumps, throws, and combined events (CEs; seven-event heptathlon and 10-event decathlon) engage in training and competition that emphasize speed and explosive movements, requiring optimal power–weight ratios. While these athletes represent a wide range of somatotypes, they share an emphasis on Type IIa and IIx muscle fiber typing. In general, athletes competing in jumps tend to have a lower body mass and may benefit from a higher protein (1.5–1.8 g PRO·kg^{-1}·day^{-1}) and lower carbohydrate (3–6 g CHO·kg^{-1}·day^{-1}) diet. Throwers tend to have a higher body mass, but with considerable differences between events. Their intense, whole-body training program suggests higher PRO requirements (1.5–2.2 g PRO·kg^{-1}·day^{-1}), while CHO needs (per kg) are similar to jumpers. The CE athletes must strike a balance between strength and muscle mass for throws and sprints, while maintaining a low enough body mass to maximize performance in jumps and middle-distance events. CE athletes may benefit from a higher PRO (1.5–2 g PRO·kg^{-1}·day^{-1}) and moderate CHO (5–8 g CHO·kg^{-1}·day^{-1}) diet with good energy availability to support multiple daily training sessions. Since they compete over 2 days, well-rehearsed competition-day fueling and recovery strategies are imperative for CE athletes. Depending on their events' bioenergetic demands, athletes in throws, jumps, and CE may benefit from the periodized use of ergogenic aids, including creatine, caffeine, and/or beta-alanine. The diverse training demands, physiques, and competitive environments of jumpers, throwers, and CE athletes necessitate nutrition interventions that are periodized throughout the season and tailored to the individual needs of the athlete.

Keywords: ergogenic aids, performance, power, strength

Within the sport of athletics (track and field), field events (jumps and throws) differ substantially from track events, both in training demands and in competition format. Combined events (CEs; the seven-event heptathlon and 10-event decathlon) encompass these demands, as well as those from multiple track events, including sprints, hurdles, and middle-distance events. Unlike track events, which rely on a single timed race to determine outcomes, field event athletes must translate speed (forward or rotational) and power into the farthest or highest jump or throw, with the best outcome over multiple (typically at least three, but up to six) attempts. Jumping events, which include the long jump, high jump, triple jump, and pole vault demand extreme technical proficiency, while placing significant asymmetrical neuromuscular (NM) loads on the athlete due to the single-limb dominant nature of these events. The need to jump as high or as far as possible also demands that athletes maintain an optimal body mass (BM) and body composition that maximize their power–weight (power-to-weight) ratio. Throwing events, which include shot put (SP), discus throw, javelin throw (JT), and hammer throw (HT), demand exceptional strength and speed to generate velocity to maximize the throwing distance, and they are typically performed by athletes with a higher relative BM, although this varies by event. Athletes in CE compete over 2 days in multiple events that utilize a range of energy systems, requiring divergent phenotypic adaptations and disparate training modalities.

This review is intended to update the last International Association of Athletics Federations (IAAF) nutrition consensus review (Houtkooper et al., 2007). Given the wide range of the energy and nutrient requirements, somatotypes, and training and competition demands of jumpers, throwers, and CE athletes (hereafter, referred to collectively as field event athletes), other reviews in this IAAF nutrition consensus series will be referenced, and this review will focus on novel nutrition and ergogenic supplement interventions and strategies to support performance relevant to field events.

Performance Determinants of Success in Jumps, Throws, and CEs

There has been a significant morphological divergence among successful field event athletes (e.g., the morphology of current elite shot putters is very different than it was 50 years ago, but also very different from that of high jumpers; O'Connor et al., 2007). Despite this morphological specialization, all of these event groups

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require superlative speed and explosive strength and power, and are highly influenced by structural and mechanical factors, such as absolute peak force, rate of force development, BM, and height (Weyand & Davis, 2005; Weyand et al., 2010). Underpinning these structural and mechanical determinants of performance is a predominance of fast-twitch Type II muscle fibers (Type IIa and IIx; Billeter et al., 2003; Costill et al., 1976; Trappe et al., 2015). Human peak muscle strength and power, of particular relevance to the throwing events, are thought to be primarily determined by the fiber typing of the protagonist muscles, the magnitude of the muscle mass to apply force and velocity, and the NM activation required to complete a specific skill (Moritani, 2005).

The biological limit to running speed appears to be limited by the minimum time needed (ground contact time or time under tension) to apply large forces, which is related to fast-twitch fiber typing (Weyand et al., 2000, 2010). There are also strong correlations between maximum running speed and various vertical and horizontal jump heights (Loturco et al., 2015). Given that training has a limited impact on fiber typing, the most effective training strategies for jumping and throwing events will probably involve high-speed limb extensor force production in the primary limb (i.e., take-off leg in jumpers or throwing arm in throwers). Notably, the biomechanical and structural factors are very similar for sprinters and jumpers, given the similar speed and explosive factors linked to performance (Loturco et al., 2015). By extension, performance for sprinters, and presumably jumpers, can additionally be influenced by increased force while decreasing ground contact time. This can be achieved through increased tendon stiffness, ideally without excessively increasing the BM, unless the athlete is force limited by skeletal mass function (Weyand et al., 2010). In this regard, nutrition can play a role, as emerging data suggest that there may be nutritional interventions that can influence tendon stiffness (Close et al., 2018), along with the direct influence nutrition has on an athlete's BM.

Although competition performance in field events is significantly influenced by structural and myocellular factors, the training regimes of field event athletes can place a significant, and perhaps surprising, demand on bioenergetic substrate availability. For example, *vastus lateralis* glycogen content decreased by 23%, 40%, and 44% in Type I, IIa, and IIx muscle fibers, respectively, after a 45-min weight room session (Koopman et al., 2006). Furthermore, the significant utilization of glycogen (Figure 1, Panel b) and aerobic oxidation of pyruvate (oxidative phosphorylation; Figure 1, Panel a) has been observed during repeat sprints (three sets of 30″ cycling sprints with 4′ rests; Parolin et al., 1999). The primary substrate for adenosine triphosphate production within the first ~5–6 s of maximal sprint efforts is phosphocreatine. However, beyond 6 s, and over repeated sprints, the majority of adenosine triphosphate is produced from glycolysis and pyruvate-derived oxidative phosphorylation from muscle glycogen breakdown (Figure 1), with both muscle phosphocreatine and glycogen concentrations having potent nutritional influences. These bioenergetic constraints have relevance for speed/power athletes who may engage in multiple bursts of activity during training and/or competition.

Success in CE demands that athletes consider each of these performance determinants, while balancing "trade-offs" between antagonistic pairs of ecologically and genetically relevant traits (e.g., the choice between speed vs. endurance development). In an analysis of 600 world-class decathletes (>8,000 points in the decathlon), conflicting or synergistic morphological (BM, height, or limb proportions) and fiber-type requirements dictated correlations in relative performance between events; for example, 1,500-m performance was negatively correlated with SP and 100-m performance (Van Damme et al., 2002). Consequently, given that nearly all the specific events in the heptathlon and decathlon require maximum speed and explosive strength, much of the emphasis to optimize performance should focus here.

Altogether, there are substantially different technical skill requirements between the various field events, with the major performance determinant being either structural (fiber typing) and/or mechanical (technical proficiency) in nature. Accordingly, nutrition interventions that target optimal event-specific body composition are of primary importance. Second, elite field event athletes engage in six to 12 training sessions per week, many with high phosphocreatine and glycogen and NM dependence; thus, optimizing the availability of appropriate substrates and recovery via nutrition is critical.

General Nutrition Strategies to Support Training Adaptations

An appreciation of the NM demands of field event athletes can be useful for estimating the potential energetic costs of their event. Table 1 demonstrates that field event athletes spend a small amount

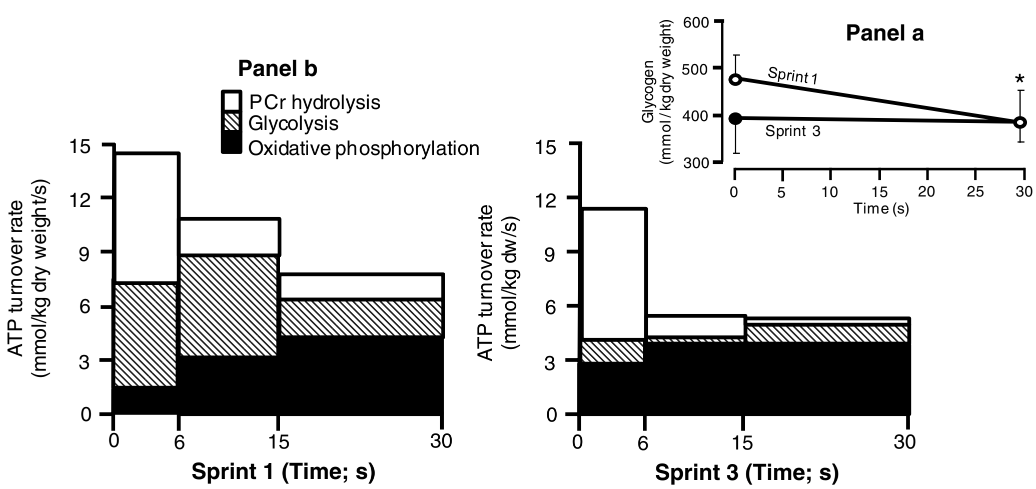

Figure 1 — Glycogen utilization (Panel a) and ATP turnover rate (Panel b) from PCr hydrolysis, glycolysis and oxidative phosphorylation throughout a first 30" and third 30" cycling sprint (on 4' rests). Data adapted from Parolin et al., (1999). ATP = adenosine triphosphate; PCr = phosphocreatine. *Significantly different from rest within same trial.

of time competing, or accumulating time under tension. Indeed, most field events accumulate only 1–5% of the estimated ~700 s time under tension for a typical 5,000-m race (Table 1). However, these athletes also spend a lot of time in the field of play between attempts. The specifics of training across these event groups is too varied to present here, but an individual approach to analyzing training demands, as outlined in Table 1, might be considered and should also include weight-room activities, as well as an appreciation of nonactivity thermogenesis (e.g., daily step counts). For example, technical high jump workouts tend to be very short, with long rest periods between jumps, and thus, not energetically costly. Conversely, heavily muscled shot putters may have periods of the season where the total training demands are very high and incredibly energetically expensive.

Nutrition Strategies to Support Training Adaptations for Jumpers

Olympic-level jumpers typically train 2–4 hr/day, 5–6 days/week at varying intensities that include event-specific training along with separate plyometric and strength training sessions (Schiffer, 2011, 2012). Training and weight room sessions can be back-to-back on the same day or separated by a few hours for recovery. The volumes of aerobic and anaerobic training will fluctuate throughout the season, but technique and explosive speed development is a persistent focus (Schiffer, 2011, 2012). The lower NM and energetic demands of the anaerobic-dominant training regimen suggest that athletes may be best served by a low–moderate-carbohydrate (CHO) diet to support high-intensity, low-volume training energy and recovery demands, along with a moderately high-protein (PRO) intake to support muscle protein synthesis (MPS; Table 2; Slater & Phillips, 2011).

Early season training blocks focus on higher volumes paired with technical and strength training. These training sessions include repeated high intensity and volume efforts, with increased reliance on CHO-derived glycolytic adenosine triphosphate production. The training volume typically decreases as the season progresses, with an increased focus on jump technique and increasing speed and power in the weight room (Schiffer, 2011). Thus, daily CHO requirements may be lower during the precompetition phase compared with the general preparation phase, and they may remain lower as a competition approaches (i.e., 3–5 g CHO·kg^{-1}·day^{-1} vs. 5–7 g CHO·kg^{-1}·day^{-1}, respectively; Table 2; Thomas et al., 2016). The PRO requirements in the general preparation phase may also be elevated due to the increased muscle repair associated with bounding and landing (Hector & Phillips, 2018).

Table 1 Estimated Event Times and Structural Demands Across Several of the Jumps, Throws, and the Decathlon During Competition

	Competition				
	Single-trial execution time (s)	Single-trial time under tension (ms)[a]	Total estimated time in the field of play (stadium, hr)	Total accumulated event time (s)[b]	Total accumulated event time under tension (ms)
High jump	2.5–4.5	1,250–1,750	2–4	35–63	17,500–24,500
Triple jump	6.0–7.5	1,500–2,750	2–4	54.0–67.5	13,500–24,750
Shot put	0.8–1.5	800–1,500	2–4	7.2–13.5	7,200–13,500
Decathlon	N/A—10 events	N/A—10 events	6–10	480–550	230,000–260,000

Note. Data estimated from video measurements and feature typical ranges across male and female athletes. All estimates within do not include time for warm-up or reactivation between attempts, but could potentially add 25–50% (individual variability) to the total estimated time in the field of play. N/A = not applicable.
[a]For simplicity, all events featuring running a standard ground contact time of 125 ms and 200 steps per minute were implemented to calculate time under tension. [b]Total time spent physically competing, assuming a maximum number of potential attempts and competition rounds. For the jumps, a standard number of 14 jumps was implemented (total number of average qualifier and final jumps).

Table 2 Predicted Nutrient Requirements for Jumps, Throws, and CE by Discipline

Event	Energy (kcal/day)	Protein (g·kg^{-1}·day^{-1})	Carbohydrates (g·kg^{-1}·day^{-1})	Fat (g·kg^{-1}·day^{-1})
Jumps	2,500–3,200 (F) 3,000–3,600 (M)	1.5–1.8 (higher end of range during periods of intentional energy restriction)	3.0–6.0 (HJ typically lower than TJ, LJ, and PV)	1.0–1.2, or as needed to meet energy requirements
Throws	3,200–4,400 (F) 3,600–5,400 (M)	1.5–2.2 (higher due to whole-body exercise)	3.0–6.0 (JT typically higher than SP, DT, and HT due to energy demands training for run-up)	0.8–1.5, or as needed to meet energy requirements
Decathlon	3,500–4,200 (M)	1.5–2.0 (higher due to whole-body exercise)	5.0–8.0	1.0–1.5, or as needed to meet energy requirements
Heptathlon	3,100–3,800 (F)	1.5–2.0 (higher due to whole-body exercise)	5.0–8.0	1.0–1.5, or as needed to meet energy requirements

Note. Energy requirements reflect energy balance and may be adjusted during periods of intentional changes in body mass or composition. Nutrient requirements are assumed to be similar between genders unless otherwise noted (Bell et al., 2015; Burke et al., 2011; Coelho Rabello Lima et al., 2015; Faber et al., 1990; Moore et al., 2009, 2012; Samia & Youssef, 2013; Slater & Phillips, 2011; Thomas et al., 2016). CE = combined event; LJ = long jump; HJ = high jump; TJ = triple jump; PV = pole vault; SP = shot put; HT = hammer throw; DT = discus throw; JT = javelin throw; M = male; F = female.

Conversely, small, frequent doses of high-quality PRO (~0.25–0.3 g PRO·kg^{-1}·dose^{-1}; Table 2) can reduce muscle damage during longer or back-to-back training sessions (~90–120 min) and preserve muscle mass leading into the competition phase (Phillips & Van Loon, 2011; Thomas et al., 2016).

While the nutrition plan for jumpers should address the training-specific requirements of developing speed and power, while also supporting good energy availability to fuel training and prevent injury and illness, occasionally, brief periods of modest energy deficit may be required to help jumpers to attain peak power-to-weight ratio for competition. This periodized approach to fueling can optimize quickness and support maximum power generation with a lower BM; however, athletes should be advised that long-term focus on achievement or maintenance of low BM can result in low-energy availability (LEA), leading to compromised health and an increased risk of injury, including relative energy deficiency in sport (Melin et al., 2018; Mountjoy et al., 2018). When possible, athletes should address BM and composition changes months in advance of competition, with the support of professional counseling. Education should focus on careful timing of nutrient and energy intake (EI) to decrease metabolic stress associated with inadequate fueling associated with the increased risk of adverse performance (Mountjoy et al., 2018).

Competition season varies for each athlete and often includes heavy international travel. The training volume will drop considerably, due in part to long travel days and reduced time spent on strength training. With these changes in training demands, PRO intake should be prioritized and adequate to preserve lean mass (LM) and strength (Hector & Phillips, 2018). CHO needs may decrease during this phase (i.e., 3–5 g CHO·kg^{-1}·day^{-1}), but still need to be strategically implemented around training and competition to support performance.

Nutrition Strategies to Support Training Adaptations for Throwers

Olympic throwers typically train 2–4 h/day, 5–6 days/week. Their workouts tend to include both a throwing session and a weight room session that may include Olympic lifts, plyometrics, and other training strategies that emphasize power from the legs, torso, and arms necessary to maximize the velocity of the throw. As with all athletes, energy demands can vary throughout the training cycle, with increased demands during heavy lifting phases, but also during periods when many throws are completed during training, as the process of retrieval of the throwing implement can potentially add thousands of extra steps per day. The energy requirements of throwers can vary by event; for example, JT may expend additional energy from speed training as part of their run-up/approach, while the hammer throw and JT may have higher energy demands due to repeated implement retrieval in the field.

Despite being one of the earliest contested Olympic events, there is a paucity of data characterizing diet and body composition, or the relationship between these parameters and performance success in throwers. Using food journals from 37 national age-level throwers, Faber et al. (1990) estimated that male throwers consume an average of 3,485 kcal/day, along with 3.5 g CHO·kg^{-1}·day^{-1}, 1.6 g fat·kg^{-1}·day^{-1}, and 1.7 g PRO·kg^{-1}·day^{-1}. This is less than the estimated energy requirement of 4,328 kcal/day for athletes of the same dimensions training 2 h/day (Cunningham, 1980). Female throwers in the same study reported consuming 2,215 kcal/day, suggesting significant underreporting, as even a moderately active female of similar dimensions would have a predicted energy requirement of 2,956 kcal/day (Cunningham, 1980).

Based on the current state of knowledge in PRO metabolism to optimize MPS, a diet high in PRO appears to be appropriate for both male and female throwers (Table 2), including ~0.3–0.4 g PRO·kg^{-1}·dose^{-1}, a threshold that has been associated with maximal MPS (Moore et al., 2009, 2012; Stokes et al., 2018). Throwers seeking gains in muscle mass may also benefit from a prebed bolus of 40 g or more (~0.3 g/kg) to support MPS and recovery overnight (Res et al., 2012; Snijders et al., 2015).

Since intense resistance training places significant demands on muscle glycogen stores (Koopman et al., 2006), throwers tend to have increased CHO needs during heavy lifting phases versus the competition phase. In general, however, throwers' CHO needs by BM may be low–moderate (Table 2), yet relatively high in absolute terms compared with jumpers or CE athletes, due to their higher BM. Future research should endeavor to characterize the energy demands of training, as well as the dietary habits of throwers.

While sweat rate and fluid balance studies on throwers are lacking, their larger body surface area and higher subcutaneous body fat compared with other athletes can impair heat exchange, serving as a barrier to heat loss (O'Connor et al., 2007). This, combined with prolonged training or competition, often conducted in heat and direct sunlight, suggests that throwers could be prone to dehydration. Care should be taken to ensure adequate hydration for throwers, especially during competition, when athletes may have limited to no shade for extended periods of time.

Nutrition Strategies to Support Training Adaptations for CE Athletes

The CE athletes typically engage in 3–6 h of training, covering three to five events per day, 5–6 days per week. Fueling for and recovering from each of these numerous daily training sessions becomes a challenge for these athletes due to the limited facilities to keep and prepare food, limitations on time to consume and digest food before the next session, tolerance for food in the gut during training sessions, and a strain on logistical planning to consume enough calories, especially when training extends into typical meal times (personal observations of elite CE athletes).

Preseason training for CE athletes focuses on both higher volume aerobic and anaerobic sessions (Schiffer, 2011, 2012). These sessions are best completed with adequate CHO and energy availability (e.g., by consuming 1–2 g CHO/kg BM in the hours prior to longer training sessions) to support optimal training adaptations, while realizing limitations of gut tolerance prior to training with high intakes of CHO (Thomas et al., 2016). Compared with the off season, PRO needs are increased (1.5–2 g PRO·kg^{-1}·day^{-1}; Table 2), with intakes split into smaller meals and snacks, positioned around the training sessions (Areta et al., 2013; Phillips & Van Loon, 2011). Athletes may benefit from an emphasis on consuming sufficient energy earlier in the day to fuel morning training and recover for afternoon sessions, with reduced EI in the evening, if necessary, to offset earlier increased EI (Hector & Phillips, 2018).

Preparation phases of training introduce more event-specific technical work, with increased strength and conditioning volume (Schiffer, 2011, 2012). When the training load is at its highest, CE athletes can be at risk of energy imbalances, injuries, overtraining, and other LEA symptoms, similar to those previously reported in sprinters (Sygo et al., 2018). Thus, quickly absorbed and easily digested CHO and PRO snacks are needed for these training days, and can include both commercially made products and whole foods, such as sport drinks, PRO shakes, sport bars, gels, pureed fruit pouches, trail mixes, peanut butter sandwiches, fruit and yogurt smoothies, and meat and cheese sandwiches.

The precompetition and competition phases sharpen discipline-specific skills, while building strength, power, and speed into each event. Athletes will often only compete in two to four full CE competitions per season, as these competition days are mentally and physically draining. This switch from training to competition necessitates a focus on nutrient-dense foods to encourage recovery and support immune function, while maintaining a favorable body composition.

Periodized Body Composition for Jumpers, Throwers, and CE Athletes

Jumping events require maximum speed paired with explosive power to launch an athlete's body weight horizontally or vertically. Therefore, jumpers must focus on power-to-weight ratio, particularly in the competitive phase, to optimize speed and ease of flight. From the beginning of the season, strength gains and the training load may increase LM, but strategic caloric manipulation that prioritizes lower energy density, higher nutrient food choices, and timing of the ingestion of CHO and PRO, along with event-specific strength work, can help athletes to control BM gains that may decrease power-to-weight ratio. Ideally, any changes in BM that do occur should be gradual, since sudden changes in BM may affect the maximal approach speed and jumping technique. Equally important is an avoidance of excessive and lengthy dietary restrictions leading to LEA and associated negative health and performance outcomes (Melin et al., 2018; Mountjoy et al., 2018).

Throwing success is largely determined by the ability of the athlete to generate the largest amount of force from their legs, trunk, shoulders, and throwing arm in the shortest amount of time. Since force development is affected by both mass and velocity, the throwers' training plan should be designed to support the highest BM possible that does not compromise velocity. A third variable affecting throwing performance are technical components optimizing the moment of force, including precise body positioning and center of gravity (Liset, 2006). Accordingly, athletes at a lower BM might still be able to succeed if they have more technical skill. This is especially true in throwing events that rely more heavily on body position and technique, such as the rotational SP versus the traditional glide position. In fact, a recent study on male SP reported that, despite no change in BM or LM over a 12-week training block, the mean rotational throwing distance increased by ~1 m, suggesting that improvements to technique and velocity may be more important to performance than strictly adding LM (Kyriazis et al., 2010).

Nutrition interventions to manage body composition for throwers should emphasize meeting energy requirements and appropriately individualized body and LM for each event. For example, JT athletes must consider the benefits of greater force production associated with a higher LM versus lower LM that can support increased speed for the approach run-up and, potentially, a decreased injury risk due to lower forces required to "block" at the end of the throw. The demands of some throwing events may require athletes, especially at the developmental level, to gain significant amounts of weight, with an emphasis on muscle mass. To maximize LM gains and to allow athletes to adapt to changing BM, alterations should occur gradually, with reasonable within- and between-season targets. During periods of intentional mass gain, athletes should increase energy by approximately 500 kcal/day above the predicted energy requirements, emphasizing a high-PRO intake (2.0 $g\cdot kg^{-1}\cdot day^{-1}$ or more; Garthe et al., 2011). In gaining mass, shot putters may demonstrate unfavorable lipid profiles (Faber et al., 1990). Therefore, athletes may benefit from periodic blood lipid profiling, along with a high-quality diet that balances the need to consume energy-dense foods to support training demands.

Attaining an optimal body composition can be more challenging for CE athletes than for athletes in other events, and it is often personal to each athlete, depending on individual event strengths and weaknesses. Athletes may benefit from a slightly higher fat mass and LM in the early part of the season to support recovery and to limit indicators of LEA that may emerge over the season (Sygo et al., 2018). Muscle mass may increase during phases where strength is the focus, but decrease in phases where running and jumping are prioritized, due to a higher energy expenditure in running workouts and reduced resistance training load (O'Connor et al., 2007).

The training demands and associated anthropometric changes that occur in the field events can eventually lead each athlete to an individualized and periodized peak body composition for performance. The same LEA risks and potential for illness and injury exist in the CE populations as with jumps athletes (Mountjoy et al., 2018). Accordingly, athletes and support team staff would benefit from frequent and transparent communication with coaches to understand how training will change between the training cycles of a season. Athletes may also benefit from tracking body composition to monitor training responses and assess the need to manipulate energy and nutrient intake to beneficially alter body composition (Meyer et al., 2013). Athletes' proactive accountability for shifts in body composition throughout their season and careers can be a key to performance and success.

Nutrition Strategies for Competition

Microperiodization of Body Composition for Competition

With optimal power-to-weight ratio a critical performance determinant in field events, mild precompetition acute weight loss (AWL) strategies have the potential to enhance performance, especially in the jumping events (Markstrom & Olsson, 2013). We are unaware of any data regarding AWL strategies in athletics, but the interested reader is directed to a recent review of rapid weight loss techniques for Olympic combat sports (Reale et al., 2018). Instead, this section will focus on strategies that might have an application within jumps and be of interest for future research.

Hypohydration. Acute hypohydration can impact muscle strength, power, and endurance to varying degrees, as well as vertical jump ability (Savoie et al., 2015). According to a recent meta-analysis, while hypohydration of 2.9% ± 1.0% (ranging from 1% to 5%) resulted in significant reductions in muscle endurance, muscle strength, and anaerobic power, neither anaerobic capacity nor vertical jump height were negatively impacted (Savoie et al., 2015). Furthermore, inferential-based statistical analysis suggested a practically meaningful (1.4% ± 0.7%) increase in jump height with a hypohydration of 2.7% ± 1.1% BM. Previous research demonstrated that NM patterns of the knee, along with knee flexion and extension torque, remained stable during 40 min of treadmill running combined with heat stress (Ftaiti et al., 2001). More recently, Hayes et al. (2010) reported no impact of exercise-induced hypohydration on vertical jump height, despite significant reductions in BM from dehydration (2.0% ± 0.5%), and a mean core temperature of 40.0 ± 0.2 °C.

The impact of hypohydration on the speed of force development and in athletics-specific field conditions requires further investigation. Furthermore, the implementation of nonexercise hypohydration protocols (fluid restriction and/or acute sauna sweating) that may influence fatigue for explosive vertical jump performance has yet to be studied. Since some athletes instinctively report to competition with mild dehydration, an intervention such as this may not always be necessary, and should be considered on an individual basis, with the safety of the athlete at the forefront. Careful consideration around the environmental conditions and duration of the event must also be made before implementation of any such strategy.

Short-term low-fiber diets. The nearly complete removal of dietary fiber is a technique originating from medical sciences as part of bowel surgery preparation to cleanse the intestines of fecal matter (Vanhauwaert et al., 2015). Strategies to decrease BM that involve food restriction resulting in excessive glycogen depletion are not appropriate due to the repeated explosive activities required for training and competition. Conversely, given that glycogen storage also results in whole-body/muscle water storage and weight gain (Burke et al., 2011; Kreitzman et al., 1992), super-compensated muscle glycogen, beyond normal/moderate levels, may actually be ergolytic in jumpers. Nevertheless, very low-fiber diets do not limit total EI, and therefore, offer a viable strategy that could be appropriate to consider in athletics. Anecdotally, practitioners report typical weight losses of 0.5–1.5 kg (−1–3% BM in a 50 kg athlete) in elite athletes after following very low-fiber diets over 48 h. Although the concept of manipulating the dietary CHO or fiber to influence power-to-weight ratio and subsequent jump performance in elite athletes requires further investigation, it remains an area of potential interest for athletes seeking AWL.

CHO Mouth Rinsing

An additional, and potentially alternative intervention to AWL that could be implemented by field event athletes in competition is CHO mouth rinsing, which has been shown to have a nearly instantaneous impact on NM performance outcomes (Gant et al., 2010; Jensen et al., 2015). This intervention avoids body weight gain from drinking fluids, does not cause adverse gastrointestinal effects (e.g., "sloshy gut"), and is very easy to implement throughout competition. The interested reader is directed to reviews on the topic (Jeukendrup et al., 2010; Stellingwerff & Cox, 2014).

Competition Day Nutrition

Field event athletes can keep a small bag with them throughout competitions, which provides a unique opportunity for in-competition fueling, hydration, and cooling strategies. Field-event athletes may spend 2–4 h in the field of competition, sometimes without any shade, necessitating well-rehearsed nutrition and hydration strategies. High-energy snacks and sources of caffeine are popular choices.

In general, the precompetition meal for jumpers and throwers should be designed to support satiety, minimize gastrointestinal distress, and provide stable blood glucose throughout the competition. Conversely, the nature of CE competitions means very crowded competition schedules over two consecutive days, and thus, the impact of nutrition and hydration can be far more significant relative to a single speed–power event. Major championship schedules for CEs typically include one to three events in both morning and evening sessions, allowing for a reasonable break during the middle of the day for refueling and rehydrating. The CE athletes also have a separate recovery room that typically features catering at major competitions (Figure 2; London 2017 IAAF World Championships CE menu). Outside of major championships, there may be no food provision, so CE athletes must preplan and bring their own food supplies. The schedule and timing of events (and associated breaks) must be understood in order to determine food timing and volumes, while taking steps to maximize gastrointestinal comfort and ensure sustained energy levels and recovery between events. High-energy easily digestible snacks (cereal bars, bananas, sports drinks, and energy gels) may be appropriate throughout competition, with the midday break providing an opportunity for a more substantial meal. Including both sweet and savory options throughout the day can limit flavor fatigue. A review of the CE 2015 IAAF World Athletics Championships, including 12 CE athletes, reported that planned fluid intakes on competition day were greater than 2 L from water or CHO-electrolyte beverages to support performance in the heat and humidity (Periard et al., 2017). Furthermore, 40% of the CE athletes intended to use ice slurries during competition.

Overnight recovery after Day 1 for CE athletes presents another opportunity to maximize the ability to perform on Day 2. A recovery meal providing PRO and CHO shortly after the final event on Day 1 is a vital first step for recovery; however, PRO and CHO containing sports drinks may be the first available option before the athletes return to their accommodations (Table 2 for daily macronutrient targets). A recent study on heptathletes demonstrated high levels of oxidative stress across the 2 days, and particularly on the second day of competition (Samia & Youssef, 2013). Recent research suggests that polyphenol-rich beverages such as tart cherry juice can reduce acute muscle damage and inflammatory markers in competition following intense training sessions prior to competition (Bell et al., 2015; Coelho Rabello Lima et al., 2015). This suggests that foods rich in antioxidants, such as polyphenol-rich foods, could help support recovery between competition days, and immediately after the completion of the competition.

Ergogenic Supplements for Training or Competition

The consideration for use of an ergogenic supplement for training or competition should be taken with an appreciation of the event-specific performance determinates in relation to the individual athlete's requirements (Burke et al., 2018). Therefore, given the diversity in training and bioenergetics across the 25 different events that comprise the field events, a multitude of ergogenic aids might be considered. An in-depth discussion is beyond the scope of this study, so the interested reader is referred to recent reviews (Maughan et al., 2018; Peeling et al., 2018). Instead, we have highlighted the key supplements that have a theoretical evidence base for performance across each event grouping (Table 3). Athletes and coaches should always seek professional advice on supplements. This includes an analysis and discussion of the risks to health and/or potential adverse analytic findings according to the World Anti-Doping Association list, as well as potential rewards, prior to the implementation of any ergogenic aid intervention (Maughan et al., 2018).

Delaware North

Combined events athletes menu

	Menu 1 Saturday, August 5 Friday, August 11	Menu 2 Sunday, August 6 Saturday, August 12
Clean protien	Roasted chicken breast 170–198 g skin on	Baked salmon 140–160 g skin on
Carbohydrate 120 g cooked 90 g raw	Penne	Long macaroni
	Fusilli (GF)	Penne (GF)
	Braised rice	Steamed rice
Pasta sauce 150 g cooked	Roasted vegetable sauce	Tomato and basil
	Corizo and olive	Turkey bolognaise
Side veg 80 g portion	Sliced carrots	Green beans
	Brocoli	Steamed swede
	Cauliflower	Braised red cabbage
Jackets—each	Oven baked jacket potato	Oven baked jacket potato
Beans—80 g	Baked beans	Baked beans
Protein side—150 g	Tuna mayonnaise, cottage cheese, and grated mature cheddar	Tuna mayonnaise, cottage cheese, and grated mature cheddar
Bread rolls—each	Bread basket selection	Bread basket selection
	Gluten-free roll selection	Gluten-free roll selection
Whole fruit—each	Apple—green and red	Apple—green and red
	Easy peeler	Easy peeler
	Banana	Banana
	Pears	Pears
Dessert—each	Strawberry tart	Berry tart
	Flapjack	Flapjack

Figure 2 — Combined events menu.

Table 3 Ergogenic Aid and Sport Food Considerations in Relation to the Jumps, Throws, and CE

		Performance efficacy per event group			
Ergogenic aid	**Rationale**	**Vertical jumps**	**Horizontal jumps**	**Throws**	**Multievents**
Beta-alanine	Beta-alanine is an amino acid precursor of muscle carnosine, an intramuscular buffer with largest performance effects in very high-intensity events from ~2 to 10 min in duration. Potential performance benefits for heptathlon 800 m and decathlon 1,500-m events. No evidence of benefit for jumpers or throwers.	N/A	N/A	N/A	In 800- and 1,500-m events[a]
Caffeine	Caffeine is a natural central nervous system stimulant that supports increased focus and vigilance, and may reduce perceived exertion and perception of pain. Some evidence that use of caffeine can support acute increases in strength and power that may be of benefit in training for throwers, and possibly jumpers, or CE. In competition, strongest evidence for benefit is via improved endurance in 800 and 1,500 m. Possible benefit for throwers and jumpers seeking alertness, especially for early morning preliminary rounds, or later evening finals, though consideration should be given to dosing and timing. Large doses (>9 mg/kg BM) do not appear to increase performance and result in increased side effects (nausea, overstimulation, and anxiety). Given the stimulatory effect (sleeplessness) and caffeine half-life (~5–6 h), the timing of caffeine throughout the rounds of competition requires much planning and practice.	[b]	[b]	[b]	In middle-distance events[a,b]

(continued)

Table 3 (continued)

Ergogenic aid	Rationale	Performance efficacy per event group: Vertical jumps	Horizontal jumps	Throws	Multievents
Creatine	Supplementation leads to a ~20% increase in muscle creatine stores, augmenting the rate of PCr resynthesis. This can lead to increased repeated high-intensity sprints or enhance the chronic outcomes of training programs featuring near repetition max resistance training. Creatine can support increases in strength and LM gains that could be of particular benefit to throwers. May be useful for training phases emphasizing strength gains for jumpers and CE athletes. In competition, there is potential benefit from increased BM for SP and HT. May be ergolytic in competition for jumps and CEs due to excess weight from water retention.	During specific training blocks[b]	During specific training blocks[b]	[a]	[a]
Nitrates (beetroot)	Increased NO availability has been shown to improve muscle function and lower O_2 demand at submaximal exercise, and emerging data suggest enhanced function of Type II (fast twitch) muscle fibers, which are abundant in these event group athletes.	[c]	[c]	[c]	[b]
Sodium bicarbonate	Sodium bicarbonate supplementation can further augment the extracellular (blood) buffering capacity. Most performance effects seen with intense repeated efforts of 30–60″ up until ~10 min. In competition, strongest evidence for benefit is via improved endurance in 800 and 1,500 m in CE athletes. High potential for gastrointestinal side effects and potential for acute BM gain due to water retention, and thus, weight-dependent sports not as effective. Therefore, individualization required.	N/A	N/A	N/A	In 400-, 800-, and 1,500-m events[c]
		Sports foods			
CHO food, or drinks/gels	Easily digestible and portable energy source, providing substrate for high-intensity efforts, as well as posttraining and competition recovery (glycogen synthesis), especially after hard training bouts. The portability of commercial products is ideal for multiround competition settings.	[a]	[a]	[a]	[a]
CHO mouth rinsing	CHO mouth washing (without swallow) can stimulate the pleasure and reward centers of the brain, and emerging evidence suggests this effect might be nearly instantaneous for peak force/torque production. Intervention appears more effective in situations of fatigue and could be especially ergogenic in the jumps, as there is no increase in BW due to fluid intake. Does not appear to have any negative side effects. Protocol: Wash mouth out with CHO sports drinks for 5–10 s every 10 min of event or training.	[c]	[c]	[c]	[c]
Electrolyte replacement supplements	Used in situations of heat stress and/or when rapid rehydration is necessary, featuring primarily sodium and potassium and typical low-CHO contents. More evidence required in speed–power events beyond the use of water, but acutely does not appear to be any negative side effects.	[c]	[c]	[c]	[b]

Note. For standard supplement protocols (e.g., acute timing, dosage, uptake and washout rates), please refer to the review by Peeling et al. (2018). This table highlights the key supplements that have a significant theoretical evidence base across each event group, while also giving event-specific rationale and context. Potential performance efficacy is based on global assessment on the strength of the ergogenic aid literature in combination with the performance determinates of the event group. The CEs are the heptathlon and decathlon. N/A = supplement not applicable to this event group; BM = body mass; CE = combined event (heptathlon and decathlon); CHO = carbohydrate; HT = hammer throw; LM = lean mass; PCr = phosphocreatine; SP = shot put.

[a]Hypothetical, but more research needed or evidence is weak for performance, adaptation, and/or recovery enhancement. [b]Potential, some to moderate performance, adaptation, and/or recovery evidence, but highly variable. [c]Strong performance, adaptation, and/or recovery evidence in relation to event group.

Conclusions

Athletes in the field events are disparate in many ways, but they share commonalities in their need to optimize power-to-weight ratio, an emphasis in Type II fiber typing, and participation in events that are largely short burst and use relatively little energy for a single competitive bout. As such, a diet that is high in PRO and moderate in CHO, with an emphasis on nutrient-dense foods, may be appropriate at various points throughout the training cycle, although dietary needs vary by event and should be periodized across the season. While periodic alterations to EI may be required to maximize BM and body composition for performance, care should be taken to prevent undesirable health consequences, such as dyslipidemia or LEA. Athletes in certain event groups may benefit from tailored nutrition interventions, such as strategic precompetition strategies or the use of ergogenic aids, although these interventions should be undertaken under expert guidance and with consideration to the athlete's performance goals. In conclusion, carefully planned and rehearsed nutrition interventions can play an integral role in supporting training adaptations and competition day performance for field athletes. When possible, athletes and coaches would benefit from engaging with trained nutrition professionals who can provide nutrition programming, monitoring, and feedback to support both health and performance over time.

Novelty and Practical Application Statement

Athletes in field events can benefit from customized nutrition interventions to support health and performance. Nutrition interventions should be periodized over the training cycle, should favor high-quality nutrient-dense foods, and be undertaken with expert guidance when possible.

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