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Human Kinetics
CONSENSUS STATEMENT

International Association of Athletics Federations Consensus Statement 2019: Nutrition for Athletics

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The International Association of Athletics Federations recognizes the importance of nutritional practices in optimizing an Athlete's well-being and performance. Although Athletics encompasses a diverse range of track-and-field events with different performance determinants, there are common goals around nutritional support for adaptation to training, optimal performance for key events, and reducing the risk of injury and illness. Periodized guidelines can be provided for the appropriate type, amount, and timing of intake of food and fluids to promote optimal health and performance across different scenarios of training and competition. Some Athletes are at risk of relative energy deficiency in sport arising from a mismatch between energy intake and exercise energy expenditure. Competition nutrition strategies may involve pre-event, within-event, and between-event eating to address requirements for carbohydrate and fluid replacement. Although a "food first" policy should underpin an Athlete's nutrition plan, there may be occasions for the judicious use of medical supplements to address nutrient deficiencies or sports foods that help the athlete to meet nutritional goals when it is impractical to eat food. Evidence-based supplements include caffeine, bicarbonate, beta-alanine, nitrate, and creatine; however, their value is specific to the characteristics of the event. Special considerations are needed for travel, challenging environments (e.g., heat and altitude); special populations (e.g., females, young and masters athletes); and restricted dietary choice (e.g., vegetarian). Ideally, each Athlete should develop a personalized, periodized, and practical nutrition plan via collaboration with their coach and accredited sports nutrition experts, to optimize their performance.

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The sport of athletics (track and field) encompasses a wide range of events involving running, walking, jumping, and throwing, in which success is underpinned by a diversity of physiological, psychological, and biomechanical attributes. Its governing body, the International Association of Athletics Federations (IAAF), recognizes a number of distinct disciplines: sprints, middle/long distance, hurdles, and relays on the track; throws and jumps on the field; the combined events of heptathlon and decathlon; road running; race walks; cross-country; and mountain running and ultrarunning (www.iaaf.org). The term "athlete" can be used as a generic description for any type of sports person, whereas athletics is known as "track and field" in North America: to avoid confusion, this statement will use the terms Athletics and Athletes (with a capital "A") to denote the disciplines within the IAAF umbrella and their participants. Despite the extreme range in the characteristics between and within these disciplines, high-performance Athletes share some common goals: to train as hard as possible with optimal adaptation and recovery, to remain healthy and injury free, to achieve a physique that is suited to their event, and to perform at their best on the day(s) of peak competitions.

The IAAF has long recognized the role of diet and nutrition strategies in helping the athlete to achieve these goals. In 1995, it hosted the first meeting on nutrition for Athletics in Monaco, followed by an update in 2007. Both meetings led to a consensus statement on the importance of nutrition in the preparation for, and performance of, events in the track-and-field program (International Association of Athletics Federations, 2007; Maughan & Horton, 1995). These statements were underpinned by review papers, published in special issues of the *Journal of Sports Science* (13: [Suppl. 1] 1995 and 25: [Suppl. 1] 2007, respectively). Other outputs from these meetings have included booklets for Athletes and coaches, provided at major Athletics' competitions and accessible via the IAAF communications link (Maughan & Burke, 2012).

Knowledge and practice of nutrition evolve over time and must be constantly updated and integrated into the Athlete's preparation. Indeed, in the decade since the last IAAF consensus meeting, a range of new developments in sports nutrition has been recognized globally by expert bodies such as the American College of Sports Medicine, Academy of Nutrition and Dietetics, and Dietitians of Canada (Thomas et al., 2016). In the light of some profound changes, the IAAF has recently commissioned a review of the current status of knowledge, attitudes/cultures, practices, and opportunities for sports nutrition to be specifically applied to events in Athletics. This consensus statement provides a summary of the contemporary principles of sports nutrition, identifying strategies that may be used by competitors in Athletics to enjoy a long, healthy, and successful career in their chosen event. The focus targets high-performance Athletes, while acknowledging the needs of some special elite populations (e.g., adolescents, females, masters) as well as the opportunity for the many nonelite competitors who enjoy Athletics (e.g., recreational marathon runners) to benefit from an appropriate translation of these principles into their own pursuits.

Recognizing the Special Issues of Event Groups in Athletes

For the purposes of this summary, the IAAF disciplines in track and field were divided into five event groups for individual review (sprints, jumps/throws/combined events, middle distance, long distance, and ultradistance/mountain running; Table 1). The considerable heterogeneity of events present within each group is acknowledged; nevertheless, this strategy achieves a pragmatic balance between the need for efficiency and the challenge of addressing unique and specific needs of each event. These reviews were charged with summarizing key nutrition goals and concerns within each event group, discussing novel aspects such as contemporary beliefs and dietary practices, identifying the scenarios in which the rules or conditions of events assist or hinder the optimal intake of nutrients, especially in the competition scenario, and reviewing event-specific research on nutritional issues. The key findings of these reviews are presented in Table 1.

Issues identified in the event group summaries are expanded in this consensus statement below, and the special issue of the *International Journal of Sport Nutrition and Exercise Metabolism*, via the examination of 12 themes that provide a framework of nutrition for Athletics and allow a more global understanding of the recent changes in sports nutrition knowledge and practice. Contemporary sports nutrition should be underpinned by a recognition that Athletes often share common goals (e.g., to meet the energy and specific fuel requirements needed to support training and competition); common challenges (to balance such intake against the desire to manipulate body composition, while remaining free of illness and injury); and common scenarios (e.g., periods of travel away from their home base and its familiar food environment). However, the specific features of each event, including optimal physique, typical training protocols, competition characteristics, and the parameters that limit performance, create differences in nutritional requirements as well as the opportunities to address them. The principles of sports nutrition for each event must be further individualized and periodized for each Athlete, then implemented via translation into practical eating practices and food choices, and, sometimes, the judicious use of special sports products and supplements. Thus, Athletes and coaches are advised to work collaboratively with sports science, medicine and nutrition experts to develop a model that identifies where nutrition can enhance event- and individual-specific performance, to refine this model through experimentation and experience, and to achieve it in real-life practice.

Theme 1. Periodization of Nutrition Strategies in the Yearly Training Plan (Stellingwerff et al., 2019b)

Periodization is a cornerstone concept in training for Athletics whereby the exercise load (mode, frequency, intensity, and duration) is strategically manipulated within a sequence of cycles to gradually achieve the physical, biomechanical, physiological, neuromuscular, and psychological attributes needed for success at chosen competition(s). It is self-evident therefore that the Athlete's dietary intake and nutrition strategies should be continually changing to optimize the adaptive effects from the ever changing training program. Although a repositioning of the Athlete's diet from static and universal, to changing and individualized, was specifically targeted in the 2007 consensus statement, there have been further developments in the principles and practices around periodized nutrition since then. The overarching philosophy of periodized nutrition is that each training session, micro-, meso-, and macro-cycle of training should be analyzed in terms of how it addresses an individual Athlete's gaps to achieving the event specific attributes of success, with nutrient intakes and dietary strategies being arranged around

Table 1 Common Characteristics of Different Event Groups in Athletics

Event group/key events	Special features	Key nutritional challenges	Key nutritional strategies
Sprints (Slater et al., 2019) 100 m, 100/110 m hurdles 200, 400, 400 m hurdles 4 × 100, 4 × 400 relays	• Performance determined primarily by reaction time, acceleration, maximum running velocity, and the ability to sustain this in the presence of increasing fatigue • Large dependence on anaerobic energy generation • Training typically involves brief maximum intensity repetitions of varying length, with either long or short recovery periods, while competition involves single efforts through heats and finals	• Much greater metabolic demands in training (via multiple daily sessions) compared with competition • Power to weight needs to be optimized rather than maximized. Currently, there are insufficient morphological data to provide detailed guidance • When contrasted against other Athletes, relative energy and macronutrient intake is lower than in middle-distance and long-distance Athletes. • Nutrition strategies to amplify training-induced adaptive signals outside of protein metabolism remain to be explored	• Greater focus on training nutrition given the metabolic demands of training far exceed those of competition • Emphasis placed on the strategic timing of nutrient intake before, during, and after exercise to assist in optimizing training capacity, recovery, and body composition • Some evidence to support the use of a small number of supplements (e.g., caffeine and creatine, plus beta-alanine and bicarbonate for longer sprints) to assist in the training and/or competition environment
Jumps/throws/combined events (Sygo et al., 2019) Long, triple, high, pole vault, shot put, hammer, javelin, discus Heptathlon and decathlon	• An emphasis on speed and explosive movements along with technical proficiency to convert forward or rotational movement into the highest jump or longest jump or throw • Wide ranging somatotypes that share the commonality of optimal strength–weight ratios and Type II muscle fiber typing • Competition consists of short repeated explosive bouts but often includes prolonged time in the field of play. • The additional challenge of counterbalancing speed/power with middle-distance aerobic/anaerobic bioenergetics demands for combined event Athletes	• Optimization of athlete body mass, which varies widely by event, with emphasis on optimal power–weight ratio in some events • Recovery from training that may result in substantial muscle damage and neuromuscular fatigue • Energy requirements that can vary considerably between peak training vs. competition phase • "Trade-offs" for combined event Athletes of maintaining a more powerful physique suitable for shorter sprints and throws vs. a lower body mass for jumps and middle-distance events	• Periodization of energy and macronutrient intake to meet training demands across the yearly training plan and competition cycle • Appropriate use of ergogenic aides, such as creatine, beta-alanine, and/or caffeine, depending on event, stage of season, and performance goals • Periodized body composition over the season, reaching peak power–weight ratio for key competitions • Planning of nutrition and hydration strategies to support extended competition days, often occurring in peak sun and/or heat
Middle distance (Stellingwerff et al., 2019a) 800/1,500 m 3,000 m steeplechase, 5,000 m	• Exceptional aerobic and anaerobic bioenergetic development, with emphasis on sprint biomechanical/structure performance components • Large dependence on exogenous and endogenous buffering systems for performance • Large individual and seasonal diversity of training programs, with large volumes during general preparation phase, and sprint-based workouts in the competition phase • 2–3 races in major championships with minimal days for recovery between races	• Huge variability of training throughout the season (large differences in volume and intensity) dictates very different caloric and macronutrient demands • High-metabolic acidosis limits performance • Important of exceptional power to weight ratios for optimal competition performance while staying healthy in a structurally demanding sport (risk of stress fractures) • 2–3 training bouts/day and 2–3 races over several days in major competitions require optimized nutritional recovery	• Periodization of nutrition to meet the demands of training and competition volumes and intensity to dictate caloric and macronutrient requirements • Potential use of exogenous (sodium bicarbonate) and endogenous (beta-alanine leading to carnosine) buffering approaches • Periodized approach to body composition throughout the yearly training plan to optimize power–weight ratio for targeted competition season. • Optimized nutrition and fluid-based recovery routines during intensive training days and competition periods

(continued)

Table 1 *(continued)*

Event group/key events	Special features	Key nutritional challenges	Key nutritional strategies
Distance (Burke et al., 2019) 10,000 m Half marathon/marathon 20/50 km race walks Cross-country	• Race times for elite performers span ~26 min–>4 hr • Elite performers typically peak for two races/year • Key factors for success are high aerobic power, the ability to exercise at a large fraction of this power, and high economy of movement • High-volume training typically maintained	• High training volume requires dietary energy and CHO support, especially for high quality and race practice workouts • High power to weight ratio (i.e., low body mass/fat content) associated with success but poses another risk for low energy availability. • Race success requires high availability of economical CHO fuels • Longer races permit within-event intake of CHO and fluid, but must be balanced against time lost in obtaining/consuming supplies from feed zones and risk of gut upset	• Periodization of energy and CHO intake according to training volume and goals to balance performance and adaptation goals of each session and cycle • Periodization of body composition to balance health and performance • Race nutrition strategies to meet event-specific CHO requirements including appropriate pre-race glycogen storage, within-event CHO intake according to opportunity to achieve muscle and central nervous system benefits • Event-specific hydration plan before and during race to find individual balance between rates of sweat loss and opportunities to drink • Well practiced use of evidence-based performance supplements (e.g., caffeine)
Ultradistance and mountain running (Costa et al., 2019) >Marathon distance: self-sufficient, semisupported, and full support	• Much longer race distances (~50–250 km than other Athletics events; however, conducted at much lower intensities, across varied terrain and surfaces (i.e., desert, mountain, forest, jungle, arctic) • Large dependency of endogenous fat energy substrate but requires a constant supply of exogenous CHO energy substrate for synergistic energy provisions and prevention of metabolic fatigue • May include additional burden of carrying day or self-sufficiency pack	• Establishing the ideal power–weight ratio for specific race characteristics • High training volumes and quality running require sufficient carbohydrates before, during, and posttraining. • High-risk events for promoting fluid overload and exercise-associated hyponatremia • High prevalence of gastrointestinal symptoms, including gradual development of food and fluid intolerance as distance progresses	• Periodization of nutrition to meet specific (i.e., terrain, surface and environmental conditions) training and competition demands • Ad libitum fluid intake for protection against dehydration and overhydration. Assess gastrointestinal tolerance to race food and fluid, and adjust accordingly • Practice race nutrition prior to competition (i.e., train the gut)

Note. CHO = carbohydrate.

each period, from individual session to overall season, to contribute to the changes that will address the Athlete's long-term goals. The diversity and complexity of the needs for success across different Athletic events means that many models of periodized nutrition are possible.

An illustration of periodized nutrition is provided in Figure 1 in relation to four different concepts: carbohydrate (CHO) fuel for support and adaptation of "aerobic" events, protein for adaptation and physique manipulation, special needs around micronutrient support, and understanding the different roles of supplements for training support and performance optimization. The first of these concepts provides an example of an evolving subtheme in nutritional periodization: Nutritional strategies employed to achieve one goal might be contradictory for another. More specifically, although proactive nutrient support directed at the specific factors that limit performance is an important goal for competition and performance-focused training sessions, in some cases, the deliberate or accidental exposure to the absence of nutrient support can accentuate adaptive responses to an exercise stimulus. This is illustrated by robust evidence demonstrating that strategies which provide high CHO availability enhance the performance of sustained exercise conducted at intensities below the so-called anaerobic threshold. Yet, when such exercise is undertaken with low CHO availability (particularly low muscle glycogen stores), there is a further upregulation of the signaling pathways underpinning various adaptive responses. The deliberate integration and sequencing of adaptation-focused and performance-focused nutrition strategies into an Athlete's training program is a highly individualized and specialized task that should involve the input of Athlete, coach, and scientists specializing in nutrition, while featuring continual modifications according to feedback and experience.

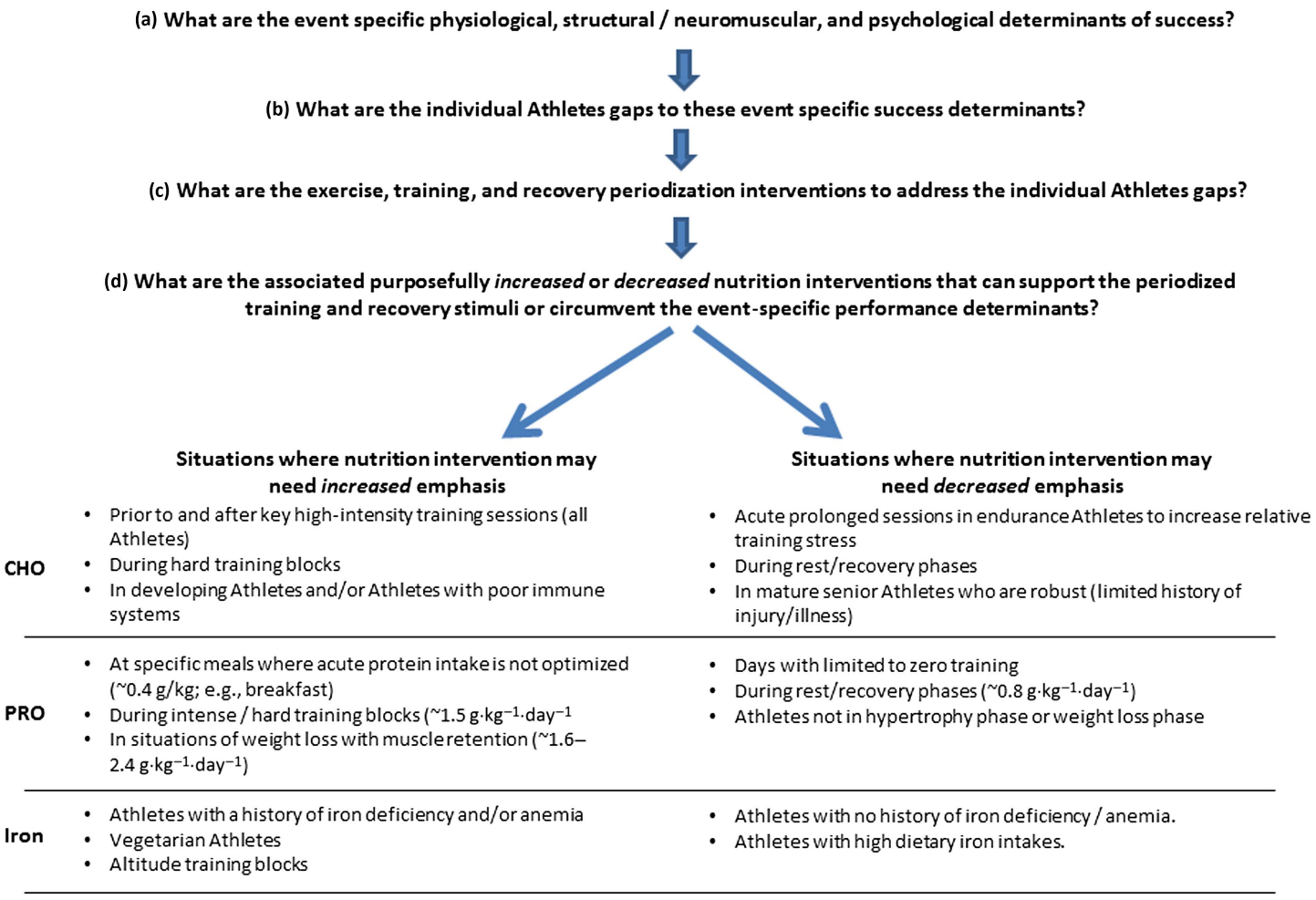

Figure 1 — A theoretical model highlighting periodization considerations for three common nutrition interventions of CHO, PRO, and iron in relation to the Athletics event performance determinants. CHO = carbohydrate; PRO = protein.

Theme 2. Energy Availability in Athletics: Managing Health, Performance, and Physique (Melin et al., 2019)

Dietary energy must meet the energy cost of an Athlete's training load and competition program as well as support the body's nonsport function/activities related to health and well-being. The conventional interest in energy targets the concept of energy balance where differences between dietary energy intake and total daily energy expenditure create opportunities for changes in body composition to store or utilize body fat and protein. This is recognized as an important concept in Athletics since, at different times in their sporting career or each annual training plan, many Athletes deliberately manipulate both sides of the energy balance equation to achieve physique changes that optimize performance in their event (e.g., gain in body mass [BM]/muscle mass, loss of BM/body fat). However, the contemporary concept of energy availability examines energy intake in relation to the energy that is left to address the body's myriad nonexercise needs once the energy expenditure committed to training and competition is removed. Here it should be noted that, as the energy expenditure associated with the Athlete's prescribed training load is already committed, an energy mismatch (i.e., initial energy deficit) leads to an adjustment in expenditure on the nonexercise body functions to conserve energy, with potential impact on health and performance. Low energy availability (LEA) underpins the Female Athlete Triad syndrome, but new insights over the last decade have identified its occurrence in male Athletes and its impact on a range of body systems and performance factors, beyond bone and menstrual health. Thus, the concept of relative energy deficiency in sport was developed to address this expanded range of concerns, together with the sequelae of functional hypothalamic amenorrhea (females), reduced testosterone levels and libido (males), poor bone health, increased risk of illness and injuries, gastrointestinal disturbances, cardiovascular disease, impaired hematological, training capacity and performance. LEA is known to occur in Athletics, and, although the highest prevalence appears to be in the weight-sensitive endurance and jump events, all Athletes may be at risk of its development via disordered eating, misguided weight loss programs, and inadvertent failure to recognize or address increased energy expenditure associated with training/competition. Preventive educational programs and screening to identify Athletes with LEA/relative energy deficiency in sport are important for early intervention to prevent long-term secondary health consequences. Treatment for these Athletes is primarily to increase energy availability and often requires a team approach including a sports physician, sports dietitian, physiologist, and psychologist.

Theme 3. Protein Needs for Adaptation and Physique Manipulation (Witard et al., 2019)

Whether the recommended daily allowances for protein for the general population, set at 0.8–1 g/kg in most countries, are suitable for high-level Athletes has been a point of controversy for many decades. It is only recently that there has been agreement that allowances, which target the absence of protein insufficiency in largely sedentary populations, are not relevant to competitive Athletes who need to optimize the adaptive response to training and to achieve the physique attributes of lean mass to body fat ratio needed for successful performance in their events. There is now clear evidence of the benefits of consuming high-quality proteins (those providing relevant amounts of all essential amino acids) in a well-timed distribution over the 24-hr period following key workouts or events; this promotes the manufacture of new body proteins in response to the specific training stimulus as well as replacing damaged ones. High-quality protein-rich foods (high in leucine), when consumed in amounts equivalent to ~0.3–0.4 g/kg of rapidly digested protein at four to five eating occasions per day, can optimize the training response in Athletes with optimal energy availability. This target probably should be increased to 0.4–0.5 g/kg in the case of mixed meals that slow the protein digestion/absorption kinetics and scenarios of energy deficit/weight loss in which rates of muscle protein synthesis are suppressed. Overall, dietary protein intakes of 1.3–1.7 $g \cdot kg^{-1} \cdot day^{-1}$ represent optimal targets for the physique and adaptation goals of weight-stable Athletes. Meanwhile, Athletes who wish to achieve effective weight loss, which promotes the retention or even an increase in lean mass, are advised to engage in resistance exercise and to consume dietary protein in quantities of 1.6–2.4 g/kg. Protein-rich whole food sources are the preferred source of protein due to cost, safety and nutrient content. However, protein supplements may sometimes provide a valuable option when it is impractical to transport, prepare, or consume food sources of protein (e.g., immediately postexercise). Table 2 summarizes the current recommendations for protein intakes for high-performance Athletes according to their major goals.

Theme 4. Fluid Needs for Training, Competition, and Recovery (Casa et al., 2019)

The past decade has seen controversy over guidelines for fluid intake during sport. The best advice to enable adequate replacement of sweat losses has been debated, as have the benefits/impairment to performance associated with proactive or passive hydration strategies. What is irrefutable is that the fluid needs of most Athletes are determined by their reliance on the evaporation of sweat to dissipate the heat produced during exercise or absorbed from a hot environment. Athletics, probably more than any sport, illustrates the futility of trying to apply a single set of guidelines for behavior regarding fluid and electrolyte replacement around sport. Not only is there great diversity in terms of sweat loss during different Athletic events, but there are also differences in opportunities for fluid intake and the penalty for incurring a fluid mismatch. At one end of the spectrum are events such as jumps in which the risk of becoming dehydrated during an event is low and where there may even be benefits to performance if a mild level of hypohydration on competition day creates an increase in power–weight ratios. Conversely, distance and ultradistance events are associated with large rates and absolute volumes of sweat loss due to sustained high-intensity exercise, prolonged duration, hot/humid weather, or combinations of these three. However, opportunities for fluid intake from aid stations or the Athletes' own supplies range from minimal to excessive in comparison with sweat losses. In the case of high-level competitors, at least, fluid intake during continuous events needs to be balanced against the time lost in drinking and the risk of gut upsets. Fluid losses equivalent to >2–3% BM are typically associated with increases in perceived exertion and reductions in plasma volume, cardiac, and thermoregulatory function and performance in warm–hot conditions. However, the difficulty in drinking during some races means that the winners (i.e., those who are most successful at maintaining an absolute speed despite hypohydration) may incur fluid losses >5% of BM.

Advice for fluid intake for training and events in track and field should encourage Athletes to understand the characteristics of their event in terms of the likelihood of large sweat losses, the opportunities to replace these by drinking during the event, and the

Table 2 Guidelines for Protein Intake for Athletes

Current recommendations based on available evidence	
1	The optimum daily protein intake for weight stable Athletes exceeds the protein RDA (0.8–1.0 g/kg BM/day) set for the general adult population.
2	The optimum daily protein intake for Athletes who have a goal of weight maintenance or weight gain ranges from 1.3 to 1.7 g/kg BM/day.
3	The optimum per meal/serving of protein for Athletes who have a goal of weight maintenance or weight gain ranges from 0.3 to 0.4 g/kg BM/meal.
4	Very high protein intakes of >2.5 g/kg BM/day offer no adaptive advantage.
5	The optimum daily protein intake for Athletes who are undertaking high-quality weight loss exceeds 1.6 g/kg BM/day and may be as high as 2.4 g/kg BM/day.
6	Athletes who consume a high-protein diet (e.g., 2.4 g/kg BM/day) during weight loss are not at increased risk of kidney problems or poor bone health.
Areas for future research	
1	Event-specific protein needs in Athletics related to body composition manipulation.
2	Dose response of muscle protein synthesis to different protein-rich food sources and meals rather than isolated proteins (e.g., whey, soy)
3	Long-term benefits and/or protein needs of Athletes undertaken high-quality weight loss.
4	Individual variability in body composition responses to manipulation of dietary protein during weight loss in Athletes.

Note. RDA = recommended daily allowance; BM = body mass. High-quality weight loss is defined as the loss of fat mass while preserving, or even increasing, lean BM (Witard et al., 2019).

consequences of being hypohydrated. It may be possible and useful to drink to the dictates of thirst when sweat losses are low and the opportunities to drink are plentiful. However, other circumstances require a proactive plan, that is, when performance is affected by hypohydration and the likelihood of large losses is matched with fewer opportunities for hydration. In very hot and/or humid environments, such as may be encountered in high-level competition (e.g., 2019 IAAF World Championships in Doha or 2020 Tokyo Olympic Games), strategies for hyperhydration and precooling prior to events may provide an additional advantage. Table 3 summarizes some of the events in Athletics in which within-race fluid plans may be beneficial. All strategies should be well practiced in training and fine tuned for the specific event. In the case of Athletes who undertake distance and ultradistance events at slower paces with lower sweat rates, specific advice against overconsuming fluids may be necessary to avoid the problems associated with hyponatremia (low blood sodium levels, usually due to excessive fluid intake). In some scenarios where large sweat-associated electrolyte losses occur, replacement of electrolytes, particularly sodium, may be beneficial in within and postexercise plans; this may be achieved via the use of whole foods or sports food/supplement choices.

Theme 5. Competition Fuel Needs for Longer Events (Burke et al., 2019; Costa et al., 2019)

Most of the power used in long and ultradistance events is provided by oxidative fuel-generating pathways. As CHO is a more economical fuel source than fat (i.e., it produces great amounts of adenosine triphosphate for a given amount of oxygen) and can produce adenosine triphosphate via oxygen-independent pathways, it becomes the dominant fuel source at higher intensities.

Table 3 Nutritional Strategies for CHO and Fluid Intake Before and During Distance and Ultrarunning Events in Athletics

Issue and general guidelines	21.1-km half marathon	20-km race walk	42.2-km marathon	50-km race walk	Ultramarathon
Pre-race refueling: • Normalization of glycogen = 7–12 g/kg/day for 24 h • CHO loading = 10–12 g/kg/day for 36–48 h	Glycogen normalization	Accentuated glycogen normalization	CHO loading, especially with low-residue diet	CHO loading, especially with low-residue diet	CHO loading especially with low-residue diet and removal of foods known to cause gut issues
Pre-race meal: • 1–4 g/kg CHO in 1–4 h pre-race • Reduced fat, fiber, and protein according to risk of gut issues	Familiar pre-race meal + CHO after warm-up	Familiar pre-race meal + CHO after warm-up	Familiar pre-race meal + CHO after warm-up	Familiar pre-race meal + CHO after warm-up	Familiar pre-race meal + CHO after warm-up
Opportunities for in-race nutrition: (availability of drink stations)	Typically every 5 km in elite races Frequency differs in large city races	Every lap of 2 km loop course (sometimes course = 1 km loop)	Typically every 5 km in elite races. Frequency differs in large city marathons: may be every 1–2 miles	Every lap of 2 km loop course	Ranges from fully or semisupported to requiring runner to carry own supplies
In-race fueling goals: • 45–75 min: mouth rinse/small CHO amount • 1–2.5 h: 30–60 g/h • >2.5 h: up to 90 g/h	Trial CHO mouth rinse up to intake of 30–60 g from CHO drinks or gels/confectionery	Trial CHO mouth rinse up to intake of 30–60 g from CHO drinks or gels/confectionery	30–60 g/hr CHO; Consider trialing intakes up to 90 g/hr from mix of CHO drinks and more concentrated gels/confectionery	Target 60–90 g/hr from mix of CHO drinks or concentrated gels/confectionery	Target 30–90 g/hr according to needs (rate of CHO use decreases with slower pace of longer races) and what is tolerated/practical
In-race hydration goals: • Aim to keep net fluid deficit <2–3% BM, especially in hot weather	Cost–benefit analysis may show that time cost of drinking may negate benefits in elite runners	Drink stations allow plentiful opportunities for frequent small intakes of CHO containing fluid toward a race plan	Fast runners will find it difficult to drink large volumes	Drink stations allow plentiful opportunities for frequent small intakes of CHO containing fluids within the race plan	BM changes less likely to reflect true fluid deficit. Lower sweat rates with slower pace in longer races might mean drinking to thirst may underpin race plan
Special issues for hot weather events	Consider pre-cooling with ice slurry in addition to external cooling strategies if significant thermal challenge is anticipated Consider pre-race hyperhydration if large fluid deficit is anticipated Adjust fluid intake during event where possible in view of increased sweat losses. Be aware of sweat rates for an array of environmental conditions so that rehydration plans can be individualized and rehearsed prior to the event				
Special comments for nonelite or slower competitors	Do not overdrink by consuming fluid in excess of sweat losses. A good tip is to avoid drinking beyond thirst cessation if not aware of individual fluid needs				

Note. BM = body mass; CHO = carbohydrate (Burke et al., 2019; Casa et al., 2019; Costa et al., 2019).
All strategies should involve a personalized and well-practiced plan that is suited to the specific needs of the events. General guidelines can be found in more detail in the guidelines by Thomas et al. (2016).

The depletion of the body's finite CHO stores can be a limiting factor in the performance of distance and ultradistance events, and strategies that increase CHO availability to meet their fuel demands are associated with performance enhancement. Such strategies including CHO intake during the days prior to the event to normalize or supercompensate muscle glycogen stores, CHO intake in the pre-race meal to restore liver glycogen after overnight fasting, and the intake of CHO during the event. Table 3 summarizes guidelines for strategies that are commensurate with the demands of different events on the Athletics program, as well as the opportunities to achieve feeding during a race. Contemporary evidence regarding events of over 90 min in duration indicates that within-race CHO becomes more important in supplying substrate to the muscle and brain as endogenous supplies dwindle; indeed, with races of >2 hr, higher CHO intakes (e.g., up to 90 g/hr from mixed CHO sources) are often associated with larger performance benefits. However, with the longest ultraendurance events, realistic/optimal rates of intake may start to scale down due to reduced fuel needs at lower exercise intensities, the logistics of gaining access to such supplies, and the increasing importance of managing gastrointestinal comfort and function during the race.

Although the role of within-race CHO intake as additional substrate for the muscle and brain has been understood for nearly a century, there is now evidence that CHO consumed during exercise can provide an additional performance benefit via central (brain/nervous system) effects. More specifically, CHO intake can stimulate areas of the brain that control pacing and reward systems via communication with receptors in the mouth and gut. This "mouth sensing" of CHO provides another reason for frequent intake of CHO during longer events (Table 3) as well as some of the shorter events in which it may not be necessary to provide muscle fuel (e.g., half marathon, 20-km race walk). All strategies used during races should be personalized to the event and the individual: they should be well practiced and able to be achieved within the event logistics which include considerations of supply, consumption while running/walking, and gut comfort.

Meanwhile, there is interest in nutritional strategies including chronic or periodized exposure to high-fat, low-CHO diets that may allow Athletes in ultraendurance (>4 hr) events to increase their ability to oxidize fat as a muscle fuel in view of its relatively unlimited pool size and capacity to support exercise at intensities up to ~75–80% VO_2peak. However, it should also be noted that most ultramarathon runners already have a high capacity for fat oxidation, regardless of dietary background. Furthermore, although targeted adaptation to a high-fat diet with CHO restriction is associated with very high rates of fat utilization across a range of exercise intensities, this comes at a cost of a greater oxygen demand during exercise (lower speed for a given oxygen supply or greater oxygen requirement for the same speed) as well as a downregulation of the capacity of CHO oxidation pathways. Such adaptations have been shown to impair performance of races, or selected segments within a longer race conducted at higher exercise intensities (>80–85% VO_2peak), probably limiting the utility of high-fat, low-CHO diets to selected individuals, events, or scenarios.

Theme 6. Staying Healthy (Castell et al., 2019)

The physiological, metabolic, and psychological stresses involved in training and competition may be linked to immune dysfunction, inflammation, oxidative stress, and muscle damage. Physically demanding bouts of exercise reduce the metabolic capacity of immune cells, with this transient immunodepression lowering the resistance to pathogens and increasing the risk of subclinical and clinical infection and illness. Indeed, early studies reported a high incidence of postexercise upper respiratory tract illness among marathon and ultramarathon runners, especially among the faster runners and those with greatest training volumes. Illness surveys conducted at major competitions have reported high levels of upper respiratory tract illness among Athletes within mixed sport events (e.g., the London Olympic Games), while among Athletics groups at IAAF World Championships females and endurance Athletes reported the highest incidence of illness.

Optimizing training load management (e.g., excessively large training volumes and/or sudden changes in training) plays a major role in reducing the incidence of illness. Illness interferes with training consistency and can directly affect performance for several days if it occurs during competition. Athletes who start an endurance event with systemic acute illness symptoms are two to three times less likely to finish the race. Other factors to be considered include high levels of depression/anxiety, long-haul flights, winter competitions, lack of sleep, and LEA.

Immunonutrition may help to combat exercise-induced immunodepression, with important considerations including energy availability and adequate intakes of protein, CHO, fatty acids, and micronutrients (iron, zinc, magnesium, and Vitamins A and D).

Traveler's diarrhea is a frequently reported illness among Athletes who travel across multiple time zones and continents to train or compete in remote countries. Pathogens vary from country to country but contamination of food and water by *Escherichia coli* is a frequent cause, while Norovirus and Rotavirus are the most frequently reported, and highly contagious, viruses. Although recovery may occur within a couple of days, an infectious episode may seriously impair the Athletes' ability to train or compete. The effectiveness of precautions around food and water management in high-risk areas is unclear; nevertheless, it makes sense to avoid unsafe drinking supplies or foods (see Table 4). An illness prevention program should be implemented, requiring coordinated involvement of medical staff, coaches, and Athletes, focusing on preventative precautions for high-risk individuals, with isolation and appropriate treatment of team members who are ill.

Athletes may experience various gastrointestinal problems during exercise, with the main complaint being diarrhea known as "runner's diarrhea." During running or racewalking, reduced splanchnic blood flow is sometimes associated with reperfusion, creating intestinal barrier function loss, increased permeability and bacterial translocation. Aggravating factors include a hot environment, consumption of nonsteroidal anti-inflammatory medicines, long duration or high-intensity exercise and, potentially, the jarring action of running. Nutritional factors include high dietary intakes of fiber, intakes of fructose, and other fermentable CHO sources (known as FODMAPS [fermentable oligosaccharides, disaccharides, monosaccharides, and polyols]) in susceptible individuals, the use of bicarbonate or caffeine as performance supplements, and within race intake of drinks of high CHO content and osmolality. The stomach and gut can possibly be trained to improve tolerance, gastric emptying, and absorption during exercise. Other strategies to reduce gut problems include the removal of problem foods in susceptible people.

Iron status is an important factor in health and performance, but compromised iron status is a common occurrence among endurance Athletes, particularly females. This occurs due to factors from both exercise (e.g., hemolysis and alterations to the iron regulatory hormone hepcidin) and nonexercise origin (e.g.,

Table 4 Strategies to Promote Athlete Health

Training and competition load management
- Develop detailed and personalized training and competition plans, which promote adequate recovery using sleep, nutrition, hydration, and psychological strategies
- Use small increments when changing training loads (typically <10% weekly)
- Develop competition calendar based on the Athletes' health
- Monitor for early signs and symptoms of overreaching, overtraining, and illness
- Avoid intensive training when experiencing illness or early signs and symptoms

Psychological load management
- Follow stress management techniques to reduce the extraneous load of life hassles and stresses
- Develop coping strategies to minimize internalized impact of negative life events and emotions
- Periodically monitor psychological stresses using available instruments

Hygienic, lifestyle, and behavioral strategies
- Maintain appropriate vaccination schedule for home (e.g., annual flu vaccine) and travel (recommended protocols for foreign countries)
- Minimize general exposure to pathogens by avoiding close contact with infected individuals in crowded spaces and avoiding the sharing of drinking/eating implements and personal items
- Establish good hygiene practices that limit hand to face contact, including regular and effective hand washing and capturing sneeze/cough expectorant in the crook of the elbow
- In group situations (e.g., travel, communal living) encourage Athletes/entourage to report illness symptoms at an early stage to allow expedited isolation of persons with potentially infectious illnesses
- Implement practices that limit all infection types including safe sex/condom use, insect repellant and skin coverage strategies, and protection against skin infections in public places
- Facilitate regular, high quality sleep
- Avoid excessive alcohol intake

Nutritional strategies

To promote general immune health:
- consume well-chosen diet with adequate energy availability and nutrient provision

To minimize traveler's diarrhea:
- drink only safe fluids: hot drinks made from boiled water, cold drinks from sealed bottles
- avoid high-risk foods, for example, unpeeled fresh fruit and vegetables, buffet meals that have been standing without precise temperature and hygiene control, undercooked meat, street vendors' foods

To minimize runner's diarrhea in susceptible individuals:
- avoid poorly tolerated nutrients/ingredients in pre-exercise meals; these may include fiber, fat, protein, fructose, and caffeine or bicarbonate supplementation
- experiment with the type and amount of drinks/sports foods/foods consumed during longer sessions or races to develop a protocol that can be tolerated with practice
- with Irritable Bowel Syndrome, trial the avoidance of fermentable oligosaccharide, disaccharide, monosaccharide, polyol carbohydrates in some foods

To maintain adequate iron status:
- include iron-rich foods in the diet (e.g., red meats, nuts, seeds and fortified cereals, leafy green vegetables, legumes, etc) and use strategies to enhance bioavailability (mixing plant iron sources with Vitamin C or animal iron sources)
- check iron status regularly if in high-risk group for suboptimal iron status (females, endurance Athletes, and vegetarians)
- To treat deficiency or suboptimal status, use intravenous or intramuscular iron supplements but only under medical supervision

Note. Adapted from Castell et al. (2019).

inadequate iron intake, heavy menstrual blood losses). Routine screening of iron status according to standardized protocols and treatment of suboptimal iron stores is recommended. Options include dietary counseling to improve iron intake, oral iron supplements and, in the case where the athlete is unresponsive or where faster approaches are needed, an intramuscular or intravenous supplement. These latter options must only be undertaken in a medical setting under the supervision of a physician. Strategies to address issues of illness in athletes are summarized in Table 4.

Theme 7. Preventing and Treating Injuries (Close et al., 2019)

Injuries are an inevitable consequence of participation in high-level Athletics with most competitors sustaining one or more during their athletic careers. This can directly affect performance if it occurs during a major competition, as well as have indirect effects on performance due to interrupted training. Injuries to skeletal muscle account for over 40% of all injuries with the lower leg being the predominant injury site. Other common injuries include fractures, especially stress fractures in Athletes with LEA, and injuries to tendons and ligaments, especially those involved in high-impact sports such as jumping. Given the high prevalence of injury in Athletes, it is not surprising that there has been a great deal of interest in factors that may reduce the injury risk or that decrease the recovery time should an injury occur.

Low energy availability is known to be a major risk factor in the development of bone stress fractures and should be corrected in both the prevention and treatment of such problems. Attention to Vitamin D status and intake of protein and calcium may also be of value. Nutrition goals during the rehabilitation of muscular injuries include adjustment to new energy requirements and distribution of daily

protein intake to minimize loss of lean mass and increase muscle repair. The prevention and treatment of injuries to tendons and ligaments are an area of recent active research with initial data on the role of nutritional support from collagenous proteins and micronutrients (e.g., Vitamin C, copper) showing potential benefits.

Theme 8. Supplements and Sports Foods (Peeling et al., 2019)

Athletes represent an enthusiastic audience for the numerous supplements and sports foods that are marketed with often questionable claims of optimizing health, function, and performance. Although a "food first" philosophy is promoted in relation to nutritional needs, medical supplements may be used under supervision to treat or prevent nutrient deficiencies (e.g., iron deficiency, see Theme 6), while sports foods may assist the Athlete to meet their nutritional goals or nutrient targets in scenarios where it is impractical to eat whole foods. The majority of performance products lack evidence to support their efficacy. However, five evidence-based performance supplements (caffeine, creatine, nitrate/beetroot juice, beta-alanine, and bicarbonate) may contribute to performance gains, according to the event, the specific scenario of use and the individual Athlete's goals and responsiveness (Table 5). Specific challenges include developing protocols to manage repeated use of performance supplements in multi-event or heat final competitions or the interaction between several products that are used concurrently. Potential disadvantages of supplement use include expense, false expectancy, and the risk of ingesting substances banned under the World Anti-Doping Agency's List, which are sometimes present as contaminants or undeclared ingredients. However, major organizations and expert bodies now recognize that a pragmatic approach to supplements and sports foods is needed in the face of the evidence that some products (previously mentioned) can usefully contribute to a sports nutrition plan and/or directly enhance performance. We conclude that it is pertinent for sports foods and nutritional supplements to be considered only where a strong evidence base supports their use as safe, legal, and effective, and, moreover, that such supplements are trialed thoroughly by the individual before committing to using them in a competition setting. Table 5 provides a summary of performance supplements that might be of value in different events in Athletics, as well as evidence-based uses of medical supplements and sports foods.

Theme 9: Special Environments: Altitude and Heat (Saunders et al., 2019)

High-level Athletes are often required to compete in environments (e.g., hot weather, altitude) that reduce performance. Furthermore, in the continual search for ways to optimize competition performance in normal conditions, it has become popular to train in such challenging/altered environments to increase the adaptive stress. Indeed, this may be further potentiated by associated nutrition and hydration interventions. Although altitude training was first used to prepare for competition in a similar environment (e.g., 1968 Mexico City Olympic Games), it is now more routine for elite Athletes to undertake a series of altitude training camps to improve their sea-level performance. Similarly, the use of heat acclimation/acclimatization to optimize performance in hot/humid environmental conditions (e.g., 2019 IAAF Doha World Championships) is a common and well-supported practice. However, the use of heat training to improve exercise capacity in temperate environments is a more recent theme that may produce positive outcomes. When Athletes expose themselves to blocks of training with either or both environmental challenges, it is important to provide ample dietary support to optimize training quality and the resultant adaptive responses. For example, LEA, poor iron status, and illness are known to attenuate the response to altitude training and should be addressed prior to the training block. In addition, the special or additional nutrition needs of the training block (e.g., increased energy and CHO utilization or fluid losses) due to the environment or changed training load should be recognized and addressed.

Table 5 Performance Supplements and Sports Foods That May Achieve a Marginal Performance Gain in Athletics Events as Part of a Customized and Periodized Training and Nutrition Plan

Event	Caffeine	Creatine	Nitrate	Beta-alanine	Bicarbonate	Sports foods
100/200 m + 100/110 m hurdles, 4 × 100 m relay	✓	✓				Sports drinks • Can be used to achieve hydration and fuel strategies around longer/high-quality training sessions and longer races Electrolyte supplements • Can be used to achieve (re)hydration goals by replacing electrolytes lost in sweat Sports gels/confectionery • Can be used to achieve fueling strategies during longer training sessions/races Protein supplements • Can provide a convenient source of quickly digested, high-quality protein when it is impractical to eat food Liquid meals • Can provide a convenient source of carbohydrate, protein, and nutrients when it is impractical to eat food
400 m + 400 m hurdles 4 × 400 m relay	✓	✓		✓	✓	
800 m	✓	✓	✓	✓	✓	
1,500 m + 3,000 m steeplechase	✓		✓	✓	✓	
3,000 m steeplechase	✓		✓	✓	✓	
5,000/10,000 m, cross-country	✓		✓			
20/50 km race walk Half marathon/marathon	✓		✓			
Mountain/ultrarunning	✓		✓			
Jumps (long, high, triple, and pole vault)	✓	✓				
Throws (discus, hammer, javelin, and shot put)	✓	✓				
Heptathlon and decathlon	✓	✓	✓	✓	✓	

Note. Readers are referred to Burke et al. (2019), Costa et al. (2019), Slater et al. (2019), Stellingwerff et al. (2019a), Sygo et al. (2019).

Theme 10. Special Populations: Young, Female and Masters Athletes (Desbrow et al., 2019)

Adolescent, female, and masters Athletes have unique nutritional requirements as a consequence of undertaking daily training and competition in addition to the specific demands of age and sex-related physiological characteristics. Dietary education and recommendations for these special populations require a focus on eating for long-term health, with particular consideration given to "at risk" dietary patterns and nutrients (e.g., sustained periods of restricted eating, low calcium, Vitamin D and/or iron intakes relative to increased requirements). Recent research highlighting strategies to address age-related changes in protein metabolism and the development of tools to assist in the management of relative energy deficiency in sport are of particular relevance to Athletes in these special populations. Whenever possible, young Athletes should be encouraged to meet their nutrient needs by the consumption of whole foods rather than supplements, as the recommendation of dietary supplements to this population overemphasizes their ability to manipulate performance in comparison with other training/dietary strategies.

Theme 11. Special Needs for Travel (Halson et al., 2019)

Domestic and international travel represents a regular challenge to high-performance Athletes, particularly when associated with the pressure of competition or the need to support specialized training (e.g., altitude or heat adaptation). Jetlag is a challenge for transmeridian travelers while fatigue and alterations to gastrointestinal comfort are associated with many types of long haul travel. Planning food and fluid intake that are appropriate to the travel itinerary may help to reduce problems. Resynchronization of the body clock is achieved principally through manipulation of zeitgebers such as light exposure and the typical timing of meals. More investigation of the effects of melatonin, caffeine, and the timing/composition of meals will allow clearer guidelines for their contribution to be prepared. At the destination, the Athlete, the team management, and catering providers each play a role in achieving eating practices that support optimal performance and success in achieving the goals of the trip. Best practice includes pretrip consideration of risks around the quality, quantity, availability, and hygiene standards of the local food supply and the organization of strategies to deal with general travel nutrition challenges as well as issues that are specific to the area or the special needs of the group. Management of buffet style eating, destination-appropriate protocols around food/water and personal hygiene, and arrangement of special food needs including access to appropriate nutritional support between the traditional "3 meals a day" catering schedule should be part of the checklist.

Theme 12. Special Diets: Vegetarians, Food Intolerances, and Fasting (Lis et al., 2019)

Some Athletes implement special diets in accordance with their culture or beliefs or with a specific aim to improve health and/or performance. Four diets of contemporary interest are: vegetarianism; diets with low fermentable oligosaccharides, disaccharides, monosaccharides, and polyols; gluten-free eating; and fasting. An evidence-based approach to any diet is recommended to minimize the risks associated with unnecessary dietary restriction, which may potentially do more harm than good. Gluten-free diets and low fermentable oligosaccharides, disaccharides, monosaccharides, and polyols diets have emerged as novel regimens thought to improve gastrointestinal health and reduce the risk of exercise-associated gastrointestinal symptoms. No direct benefits have been associated with the avoidance of gluten by clinically healthy athletes. However, a gluten-free diet is associated with other dietary changes, particularly a reduction in fermentable oligosaccharides, disaccharides, monosaccharides, and polyols, for which emerging evidence suggests a potential improvement in adverse gastrointestinal symptoms. Vegetarian diets can theoretically support athletic demands, but special attention and good planning are required to ensure adequate intake of energy and specific nutrients that are less abundant or less well absorbed from plant sources (e.g., iron). Finally, intermittent fasting is a long-standing concept, undertaken on an obligatory basis (e.g., Ramadan fasting), or a voluntary pattern (e.g., time-restricted feeding, intermittent energy-restricted days) in search of putative health or body composition benefits. Strict obligatory fasting is likely to require the implementation of tailored nutrition strategies to help Athletes cope with their sports-related demands. Overall, a multitude of factors influence adherence to special diets. Even when adherence to a special diet is a necessity, education and advice from an accredited dietitian/nutritionist are recommended to allow the Athlete to integrate nutrition strategies for optimal health and performance.

Conclusions

The IAAF recognizes that the Athlete's well-being, performance, and recovery from sporting activities are enhanced by well-chosen nutrition strategies. Although Athletics encompasses a diverse range of events with different requirements for success, there are common goals around nutritional support for adaptation to training, optimal training performance, and remaining at low risk of injury and illness. This includes guidelines for the appropriate type; amount; and timing of intake of food, fluids, and occasionally, some supplements and sports foods, to promote optimal health and performance across different scenarios of training and competition. Ideally, Athletes should develop a personalized, periodized, and practical nutrition plan via collaboration with their coach and sports science/medicine team, including accredited sports nutrition experts.

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