# Current Trends in Ultramarathon Running

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**Abstract**

Exercise is universally recognized for its health benefits and distance running has long been a popular form of exercise and sport. Ultramarathons, defined as races longer than a marathon, have become increasingly popular in recent years. The diverse ultramarathon distances and courses provide additional challenges in race performance and medical coverage for these events. As the sport grows in popularity, more literature has become available regarding ultramarathon-specific illnesses and injuries, nutrition guidelines, psychology, physiologic changes, and equipment. This review focuses on recent findings and trends in ultramarathon running.

## Introduction

Exercise is universally recognized for its health benefits, and distance running has long been a popular form of exercise and sport (1). Ultramarathons, defined as races longer than a marathon, have become increasingly popular in recent years, and the average age of an ultraendurance athlete is 45 years (2). The diverse ultramarathon distances and courses provide additional challenges (3). As the sport grows in popularity, more literature has become available regarding ultramarathon-specific illnesses and injuries, nutrition guidelines, psychology, physiologic changes, training methods, and equipment. There also are certain factors that may contribute to improved ultramarathon performance and ability to finish, although evidence is limited (Table). This review focuses on many of these recent findings and trends in ultramarathon running.

## Anthropometrics and Physiology

Given the extended periods of exercise, often in extreme conditions (temperature, altitude, etc.), the anthropometrics, baseline physiology, and physiologic changes of ultramarathoners has long been of interest. In general, age 35 to 50 years, low body mass index (BMI), and low body fat are consistent predictors of better ultramarathon performance across many studies (4–6). Most of these data are based solely on male ultramarathoners, however, as initially almost all participants in ultramarathon events were male. More recent data specifically regarding females show that they are overall significantly smaller, lighter, and have lower BMI compared with their male counterparts. There may be less impact of these anthropometric factors on race performance (6).

The acute physiologic changes in ultramarathoners have been studied across many different body systems. Changes in metabolic biomarkers and hormone levels during an ultramarathon include: elevated skeletal muscle, cardiac muscle, and liver enzymes; elevated creatinine and variable fluctuations in electrolyte levels; elevated leukocytes, iron, and ferritin; decreased erythrocytes; elevated inflammatory markers (C-reactive protein, erythrocyte sedimentation rate, interleukins); decreased testosterone and increases in other hormones (cortisol, ACTH, adrenaline, growth hormone) (4,7–9). Recent evidence also shows a correlation between high-energy consumption and bone damage with a decrease in osteocalcin (10). This could lead to a decrease in bone density and eventually osteopenia or osteoporosis after prolonged exposure (4). More research is needed to investigate bone health in ultramarathoners, especially in postmenopausal females. In addition, ultramarathon finishers seem to have a hypovolemic physiologic response during competition with lower diastolic blood pressure and lower oxygen saturation (11). The clinical significance of these changes is unknown.

While many of these studies show short-term fluctuations in biomarkers, hormone levels, and vital signs, it is unclear if these changes are adaptive or pathologic and the longer-term effects of these alterations are not well established. One reason that longitudinal data are likely scant is due to the recent surge in mass participation in the sport, meaning that there are relatively few "veteran" ultramarathoners. A recent small study did investigate longer-term cardiac function in this group of athletes. They found that veteran ultramarathoners older than 35 years with 18 ± 12 years of training and competition showed structural remodeling of the right ventricle inflow and outflow tracts in the presence of normal/enhanced global systolic and diastolic function (12). Hopefully, as ultramarathons continue to grow in popularity, so will longitudinal data regarding both positive and negative physiologic and health effects.

## Injuries/Illnesses

Ultramarathoners are prone to numerous illnesses and injuries, which range from minor skin breakdown to sudden

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**Table.**
**Factors that may be associated with better ultramarathon performance and ability to finish.**

| | |
|---|---|
| Anthropometrics | Low BMI |
| | Low body weight |
| | Age 35–50 yr |
| Training | Higher training volume |
| | Increased training intensity |
| | Prior ultramarathon completion |
| Medications/supplements/ nutrition | Caffeine use |
| | Low-FODMAP diet |
| | Antiemetics (*i.e.*, ondansetron) for nausea |
| | Drinking fluids to thirst |
| | 30 g–90 g carbohydrate intake per hour |
| | "Gut training" for caloric intake while running |

death. These injuries can occur during training or during competition. In the Ultrarunners Longitudinal TRAcking (ULTRA) study of 1212 athletes, almost 65% reported an injury over the last year that resulted in time-loss during training (13). The rate of injury during competition varies based on the length and difficulty of the event, as well as experience level of the competitors, but rates of injury have been reported as high as 56% to 85% in multiday races (14,15). The physical demands of an ultramarathon make these athletes particularly susceptible to musculoskeletal injuries, most commonly affecting the lower extremities (3). The knee is the most commonly injured joint in ultramarathoners, most often affecting the patellofemoral region due to increased compartment stress during running (2–4). Likewise, the ankle is frequently affected; peritendinitis of the extensor tendons of the anterior ankle (anterior tibialis, extensor hallicus longus, extensor digitorum longus), aptly named "ultramarathoner's ankle," is unique to ultramarathon running. Ultramarathoner's ankle is hypothesized to be secondary to repetitive use, external tension from running shoes or equipment, increased foot pronation, and long strides. Athletes will often present with pain and swelling of the anterior ankle with a modified, shorter gait (3). The Achilles region is another area affected by endurance running (2–4). Rest, ice, compression, and elevation therapy and activity modification may be utilized for any of these injuries and physical therapy can be considered. There is some limited evidence regarding other noninvasive modalities, such as extracorporeal shock wave therapy for treating tendinopathies (especially Achilles tendinopathy and plantar fasciitis), but this has not been studied specifically in ultramarathoners (16). It is general consensus that corticosteroids should be avoided in the Achilles tendon. For tendinopathy in the Achilles or about the knee, platelet-rich plasma (PRP) injections may be considered, but strong evidence does not back this recommendation. Treatment of chondral damage in the knee also may include intra-articular injections; however, similar to PRP, there is no strong evidence of the effectiveness of corticosteroid or hyaluronic acid injections in ultramarathoners. Lower-extremity injuries can take weeks-to-months to fully recover (3). Chronically increased compartment pressure predisposes athletes to exercise-induced compartment syndrome, which presents as lower leg pain worsening with exertion. It is diagnosed by testing the compartment pressure immediately after exertion, and definitive management includes a fasciotomy (3). Gait analysis with physical therapy aimed at gait retraining can be considered prior to surgery if abnormalities are detected (17). True gait retraining may be difficult in ultramarathoners, as they often alter their gait pattern in a fatigue dose-dependent manner during a race (18). They tend to develop fatigue of ankle plantar flexion which results in a flatter foot landing and decreased ankle range of motion (18).

Besides the musculoskeletal system, ultramarathon running affects other body systems. Gastrointestinal (GI) symptoms are the most cited complaints during ultramarathons (19). The most common GI complaints are flatulence, belching, and nausea but also may include vomiting, stomach/intestinal cramps, diarrhea, urge to defecate, and hematochezia/melena (20). These symptoms commonly affect race performance and are often cited as a reason for dropping out of a race (20). This impact from GI symptoms is not only due to the physical discomfort they cause but also interference with the ability to adequately take in proper fluids and nutrition. GI symptoms are more prevalent in women, races of longer duration, hotter temperatures, and runners with a history of GI symptoms during exercise. Exercise-induced GI syndrome (EIGS) is a spectrum of GI damage caused by normal effects of exercise at elevated intensity or duration (1,21). With exercise lasting more than 2 h at 60% to 70% $\dot{V}O_{2max}$, decreased splanchnic blood flow causes injury to the cells of the stomach, leading to an inflammatory response. Coupled with activation of the sympathetic nervous system causing slowed gut motility, damage causes increased gut permeability, malabsorption, and systemic inflammation to produce upper and lower GI symptoms (1,21). Probiotics have not been proven to prevent GI symptoms, and athletes should avoid nonsteroidal anti-inflammatory drugs (NSAIDs) as they can potentially exacerbate GI symptoms (especially upper GI). Short-term side effects characteristically resolve with rest, but there is not enough evidence to determine long-term outcomes of chronic EIGS (1).

Sodium imbalances may be seen in ultraendurance athletes. Exercise-associated hyponatremia (EAH) is a common condition linked to ultraendurance events; however, a recent prospective cohort study found that the incidence of hypernatremia may actually be greater (22). The rates of EAH in the literature range widely between 4% and 51% in ultramarathons (2,22,23). Presentation varies from asymptomatic hyponatremia resolving without intervention to altered mental status, seizure, or death (22,23). Symptoms may present with hypohydration or euhydration, but the athletes most at risk for symptomatic EAH are the overhydrated (24,25). Sodium derangement is complicated as symptoms of lightheadedness, oliguria, altered mentation, and syncope can be attributed to both hyperhydration and dehydration and do not always necessitate intravenous (IV) rehydration (26,27). Dehydration is rarely severe and is less likely the cause of muscle cramping or severe acute kidney injury (AKI) (26,27). Although dehydration poses more problems such as rhabdomyolysis and kidney injury, these issues are not typically clinically significant with small rates of kidney failure if athletes lose <8% of their body weight over 30 h (23). In fact, one small study by Wolyniec et al. (28) showed that creatinine clearance is not affected by long-distance running. IV rehydration, especially with isotonic or hypotonic fluids, may worsen EAH, making hypertonic saline generally preferred in these athletes. IV fluids should be used very cautiously if serum sodium levels or hydration status are not known (22,23). In the hospital critical care setting, inferior vena cava collapsibility measured by point-of-care ultrasound (POCUS) has been used to predict volume status. A higher IVC collapsibility index (CI) indicates lower central venous pressure (CVP) and hypovolemia (29). Perhaps this could be studied in ultramarathoners to see if this is also an appropriate surrogate for volume status, especially in situations where laboratory tests are not readily available. Appropriate hydration aimed at preventing EAH is key and discussed further below.

Recent case studies have evaluated the risks associated with athletes with type 1 diabetes competing in ultramarathon races. Due to inconsistent glycemic intake and difficult-to-predict energy expenditure, athletes with type I diabetes are at an increased probability of hypoglycemia or hyperglycemia during an ultraendurance event. With the assistance of insulin pumps as well as intermediate and short acting insulin pens, many athletes with type 1 diabetes have now successfully completed an ultramarathon. The athletes that have been studied and completed races thus far did not have any episodes of significant hyper- or hypoglycemia during the races (30,31), and kidney function was not significantly affected by the stress of an ultramarathon (30). These successful runners decreased their normal basal dose by 50% to 85% and the bolus doses by 50% to 100% (30,31). Another study found that continuous glucose monitoring may significantly improve ultramarathon safety in type I diabetic patients (31). Overall, with proper preparation, athletes with type I diabetes can safely participate in ultramarathons.

Corneal edema, a rare occurrence, has recently been reported and studied in ultramarathon runners. One review suggests elevated environmental factors (UV light, wind, and temperature) likely play a role (32). Increased serum lactate also creates a decreased gradient between the aqueous humor and surrounding cells, which in turn leads to lactate build-up (32). Hoeg et al. (33) evaluated the effect of endurance exercise on eye physiology in a small study. Without any visual symptoms, ultramarathons do not appear to affect eye physiology. Any changes are likely a transient process (32,33) and can be prevented with appropriate eye protection (32).

Medications commonly utilized during ultramarathon training and competitions primarily provide symptom control but are sometimes used to prevent symptoms. NSAIDs are one of the most commonly used medications, and up to half of runners will use an NSAID during or surrounding a race (34). An observational study found that the majority of athletes cite pain control or prevention as indications for using NSAIDs (34). A randomized control trial found that NSAIDs increase the risk of AKI, based on standard diagnostic of increased serum creatinine level, with a number needed to harm of 5.5 (35), but many athletes take these medications without a prescription or adequate knowledge of possible harms (34). It should be noted that traditional definitions for AKI may not apply to ultramarathoners as changes in creatinine level may be due to normal physiologic adaptions, since incidence of mild AKI has been reported in up to 80% of participants (36). Ondansetron also is a commonly used medication during ultramarathons and may reduce nausea and vomiting symptoms (37). Few other medications have recently been studied regarding ultraendurance events.

There is scant literature regarding ultramarathons and marijuana or cannabidiol (CBD) use. Evidence in other athletes has revealed no proven enhancing properties for athletics (38–40). The authors practice in Colorado, where marijuana use is legalized for both recreational and medical use. Anecdotally, the authors have found that ultraendurance athletes utilize marijuana or CBD, usually in oral (oil-based), edible, or topical forms. It is unclear the exact motivations for marijuana use, but we suspect it may be due to the anti-emetic and anti-anxiety properties; this holds especially true as GI disturbances, as outlined above, account for many of the medical concerns cited by ultramarathon runners. CBD oil (both oral and topical) has been linked to pain relief and anti-inflammatory effects and therefore may be used to treat or prevent musculoskeletal ailments that are common in ultramarathoners. The motivations and effects of marijuana and CBD use in ultramarathoners would be an interesting area of further study.

## Nutrition

For successful completion of an ultramarathon, significant caloric and nutrient intake is often required to balance large energy expenditure during these prolonged periods of exercise. Experts have established calorie and macronutrient recommendations (19,41,42). With such high energy demands required during ultraendurance sports, it is common to experience a net-negative energy consumption (42). Lacking sufficient caloric intake can lead to adverse health impacts including female athlete triad or Relative Energy Deficiency in Sport, anemia, increased GI symptoms, and musculoskeletal injuries (21,37,42,43). A closer match between energy expenditure and intake is associated with better performance (44,45). Exertional GI side effects can impede athletes reaching nutrition and calorie goals (2,19). Tolerance may be attained through training (19,21,37,46) and can improve ultramarathon success. Elite athletes overall exhibit fewer GI symptoms than recreational runners, and this is thought to be due to increased "gut training" during exercise training. Athletes should try different types of foods to individualize their own race diet (21). Gluten-free diets are increasingly popular among athletes (up to 41% without celiac disease in one survey study) (47). Athletes often cite self-diagnosis of gluten-related conditions or perceived better health (*e.g.*, less GI symptoms, better body composition) for motivations behind following these diets (47). As such, it is likely that many ultraendurance athletes follow a gluten-free diet. Currently there is no evidence that a gluten-free diet is beneficial for athletes without a diagnosis of Celiac disease (48). Other recent evidence has suggested that perhaps gluten itself does not exacerbate GI symptoms, but rather that fermentable oligosaccharide, disaccharide, monosaccharides, and polyols (FODMAP), which exist in many of the same foods, may be to blame (49). In a small, short-term study, the low-FODMAP diet significantly decreased GI symptoms in runners who suffered from GI symptoms with exercise

(50). Lis et al. (49) recommends avoiding restricting food groups as much as practical to maintain a well-balanced diet while reducing trigger foods 1 to 3 d prior to an endurance event.

Various recommendations for macronutrient intake surrounding an ultramarathon exist, but all strategies stress the importance of developing individualized nutrition plans (46,51,52). Historically, carbohydrates have consistently enhanced ultraendurance performance. Casazza et al. (51) recommends higher fat and lower carbohydrate diets during endurance training but transitioning to increased carbohydrates when approaching competition. The 2019 consensus statement from the International Association of Athletics Federations recommends accelerated carbohydrate intake for the 36 to 48 h prior to the race (10 to 12 $g \cdot kg^{-1} \cdot d^{-1}$) and eating a prerace meal that has been tolerated well in the past (46). Experts recommend approximately 30 to 90 $g \cdot h^{-1}$ during the race, while individualizing to running pace, GI tolerance, and energy expenditure (46,51). For those who experience GI side effects during a race, studies have shown that cooler beverages may decrease symptoms and rinsing the mouth with a carbohydrate-rich drink may have a similar effect to consuming carbohydrates (37). Costa et al. (21) recommends 1 to 1.2 $g \cdot kg^{-1}$ of carbohydrates postexercise with 0.3 to 0.4 $g \cdot kg^{-1}$ of protein for enhanced muscle recovery.

Many endurance athletes have begun following a ketogenic diet in an attempt to utilize fat as a longer-acting energy source. The performance value of diets based on increased fat intake is highly debated. Thus far, there is little evidence suggesting that ketogenic diets are beneficial during ultramarathons (21,37,51,53), and some studies have found detrimental effects on speed. Conversely, one study in a review shows that a prerace high-fat diet may improve ultraendurance performance (42). Casazza et al. (51) recommends a lower percentage of fat compared with carbohydrates while keeping fat intake at 20% or more of caloric intake.

Several reviews have evaluated the effect of hydration status on ultramarathon running. Increased oral intake of water can cause GI upset (27), and faster runners overall have increased body mass loss (54). As noted above, overhydration can be far more dangerous than underhydration or euhydration as it can lead to symptomatic exercise-induced hyponatremia (19,26,27,42,46). It is generally recommended to drink to thirst to avoid hypohydration rather than drinking to replace all losses or timed water drinking (19,21,26,27,42), especially as moderate-intensity exercise does not usually lead to heat exhaustion (27). Other studies, however, recommend consumption of electrolytes through planned fluid consumption (51). Often, body weight loss exceeds 2% during a race and is usually less worrisome than weight gain, which can indicate overhydration (26,27). Not much is known about the preferred method for hydration (carriage systems vs drinking solely at aid stations) but carriage systems could theoretically increase risk for symptomatic overhydration given constant access to fluids. Hoffman et al. (26) recommends against use of routine postevent IV hydration to prevent overhydration and instead using antiemetics to encourage oral intake in those athletes experiencing nausea.

Multiple studies have examined supplements as ergogenic aids for ultraendurance events. A placebo-control trial showed riboflavin may improve muscle soreness and aid in earlier recovery (55). Other vitamins and minerals, however, have not been proven to enhance ultramarathon performance (42). Beetroot juice has demonstrated improved exercise performance through the presence of nitrate which reduces to nitric oxide (56,57). Nitric oxide increases blood flow, and therefore oxygenation, of muscles. Casazza et al. (51) suggests that beetroot is most beneficial about 150 min after consumption at doses of 6 to 8 mmol. Caffeine, another ergogenic aid, is used by up to 89% of competitors (58). It can attenuate the perception of pain (19,51) and increase energy (46,51) in doses of 3 to 6 $mg \cdot kg^{-1}$ about an hour prior to exercise (51). A recent meta-analysis shows that, with such high prevalence in competition, caffeine use may be recommended to avoid losing an advantage (58).

## Psychology

As the popularity of ultramarathon participation increases, there is still limited understanding of the psychological characteristics of ultramarathon runners. Ultramarathoners must devote a significant amount of time to training and competition. Given that the average age is 45 years (59), these athletes often have to balance their running with an already busy lifestyle. This could potentially exacerbate underlying mental health issues, or they may be using running as self-treatment for these problems. Recent literature suggests that ultramarathoners may have high rates of psychological issues, including exercise addiction and depression (60). Exercise addiction has been examined in recent years using a validated screening tool called the Exercise Addiction Inventory (61). It appears to be relatively rare in habitual exercisers (3.2%) and in the general population (0.5%), although obsessive passion and dedication to athletic activity are strong predictors of exercise addiction. As such, some recent small studies indicate that rates of exercise addiction in ultramarathoners may be as high as 20% (60). Along these same lines, participants in the ULTRA Study were asked the question: "If you were to learn, with absolute certainty, that ultramarathon running is bad for your health, would you stop your ultramarathon training and participation?" Of the 1,349 respondents, 74.1% responded "no" (62). Despite good health literacy in the majority of ultramarathoners, psychological and personal achievement motivations appear to outweigh health risks in the minds of these athletes (62). Depression also may be present in ultramarathoners at slightly higher rates than the general population, with about 20% of respondents in one study reporting anhedonia or depressed mood in the past 2 wk on PHQ-2 screening (60). In addition, more than 70% of the ultramarathoners reported using running to help manage their mood (60).

## Training Methods and Equipment

Given the variability of ultramarathon race settings, distances, and courses, the training methods for ultramarathon races also vary widely. Even though training specifics are not well studied, there is a positive correlation with higher training volume (distance and duration), faster marathon personal best times, and increased training intensity (faster mean training pace) on race performance (6). Therefore, working on both distance and speed during training may be helpful in ultramarathon competition. There also is a significant improvement in race performance with prior race experience, suggesting that participation in ultramarathon competitions may be a helpful way to train for future races. There is a dearth of data regarding the amount and type of nonrunning (cross-training) exercise used by these athletes during training. The authors hypothesize that utilization of cross-training activities may help prevent or limit injuries during training, thus improving race performance and completion.

Sleep has drawn widespread attention in athletics, as poor sleep may negatively impact performance. Although data are limited, sleep duration in ultramarathoners appears comparable to that in the general population although there may be a lower rate of sleep disorders and daytime sleepiness (63). Sleep extension (increasing nighttime duration and daytime naps) is the main sleep strategy used in preparation for ultramarathon competition (63).

Clothing and equipment are always evolving in ultramarathon running, but there are little data regarding effects on performance. Many ultramarathoners wear below-knee compression garments in hopes to prevent leg swelling and exercise-associated collapse due to venous pooling when they stop running. A prospective, randomized controlled trial of 41 ultramarathoners showed less ankle swelling at 2 d postrace for those wearing compression garments (the control group did not wear compression garments) but increased subjective pain ratings. There was no difference in race performance between the groups (64). Footwear in ultramarathoners has a broad spectrum from barefoot/minimalist to maximum cushioning. There is minimal data regarding shoe-type and performance, as there are likely many other influencing factors including foot strike pattern and gait mechanics. Additionally, little is known about use of hiking poles, which are used frequently in races with extreme elevation changes or over long distances. More investigation is certainly needed regarding equipment use.

### Medical Coverage for Ultramarathons

Given the variability of ultramarathon race courses in regard to location, altitude, type (loop vs point-point vs out-and-back), weather, environmental hazards, and so on, medical coverage for these events can be quite a challenge and difficult to generalize. This requires considerable prerace planning, starting with a determination of the level of medical support that is appropriate for the event. Once that is defined, there are various legal and organizational issues to be addressed, and medical guidelines and protocols should be developed. As events become increasingly popular, race organizers can make larger amounts of money on entry fees and sponsorships and may try to minimize resources and funds for the medical team. The medical directors and team must not allow this to conflict with providing excellent medical care for the participants. Adequate team members, medical supplies, and emergency resources should be available. Medical liability needs to be worked out beforehand — specifically whether the race directors or the medical providers will be providing malpractice coverage for the event. Ideally, the medical personnel group will have a broad combined set of skills. Arguably, the most important of these is the ability to perform an accurate patient assessment. Personnel should be able to provide definitive treatment for uncomplicated illness and injury, and stabilize, package, and facilitate evacuation for more serious illness or injury (65). Some of the most beneficial roles that the medical team can play, involve prerace runner education and prerace medical clearance. These strategies can hopefully prevent or limit injury and identify high-risk athletes to monitor closely during the race (65). Due to the increasing age of elite and recreational ultramarathon runners, more athletes are at risk of medical illness. A pilot preparticipation self-assessment online tool found that administration led to a 29% reduction of any illness with a 64% reduction in life-threating events, showing that there is possibly a role for preparticipation screening in recreational as well as elite runners (66). For during race injury prevention, one study examined the effects of implementing mandatory rest stops during the Jungle Marathon in Para, Brazil (a hot, tropical ultramarathon). After implementation of the strategy, there were significantly less athletes that had a heat-related did not finish (DNF) (67). These data suggest that medical directors for events at extremes of temperature, altitude, or other conditions could consider using a similar strategy to reduce event-specific DNF. Hopefully more generalizable strategies and standards for outstanding medical care can be developed as ultramarathon popularity continues to grow.

### Summary

Ultramarathon running has become increasingly popular in recent years, and, as the sport grows in popularity, more literature has become available regarding ultramarathon-specific illnesses and injuries, nutrition guidelines, psychology, physiologic changes, training methods, and equipment. Most of these data are limited in number of studies and sample size, but do help guide participation and medical care for these athletes. This article provides a brief overview of the recent literature and trends in ultramarathon running, and the authors hope that it stimulates more thought, interest, and research in this fascinating, unique sport.

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