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# Nutrition for travel

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**Abstract**

The training and competitive programmes of elite athletes incorporate travel schedules, often long journeys, across multiple time zones. In such cases, travel causes both transient fatigue and a malaise known as "jet-lag" that persists for some days. Jet-lag is due to the disturbance of the body's circadian rhythms: diurnal and performance rhythms are displaced, depending on the direction of travel and the number of time zones crossed in flight. Attention to diet and hydration is relevant during the flight and following disembarkation until adjustment to the new meridian is complete. The consequences of jet-lag on rhythms in digestion may be compounded if food preparation and hygiene are inadequate in training camps or competitive venues overseas. The irony of travel is that it often places athletes at a greater risk of failing to meet their specific nutrition goals or succumbing to illness, at a time when the demands or outcomes of performance are of greatest importance. In addition, gastrointestinal infections related to travelling are frequent among athletes. Fastidious planning and organization among the support staff is recommended before the journey to prevent any such problems arising. Equally, athletes often need special education initiatives to assist them to cope with the challenges of a new and unusual food supply, or altered access to food.

**Keywords:** *Body clock, circadian rhythms, hydration, infection, jet-lag*

## Introduction

Athletes are regular and frequent travellers, moving temporarily to different countries for purposes of acclimatization, training, and competition. Competing at an international level forms an important part of the aspirations of all elite track-and-field athletes, whether representing their club, country or participating individually for prize money or personal goals. Athletes also seek out suitable venues for warm-weather training, acclimatization to altitude or facilities where preparation for major competitive engagements can be fine-tuned. During such sojourns, fatigue may be encountered during the journey to destination and for some time afterwards, and difficulties may be experienced in the acute adaptations to the new environment. Weather, climatic conditions, ambient temperature and pressure, and cultural variables all might affect normal homeostasis. Among these culutural variables are diet and nutritional practices, quality and quantity of food available, standards of hygiene including the preparation of food, and the potential for infections. These factors all require specialist input from nutrition, chronobiology, physiology, and medicine.

Travel fatigue is related to the duration of the trip, the length of time since rising from the last full night's sleep, and the discomfort from a prolonged period in cramped aircraft conditions. The longer the period of wakefulness, the greater the homeostatic drive to sleep, subject to moderation by the time of day (Reilly & Edwards, 2007). Travel fatigue is compounded by disturbances of circadian rhythms that result from a dissociation of the natural "body clock" and the normal light–dark cycle in the country being visited when the journey has taken place over multiple time zones. This desynchronization is referred to as jet-lag.

## The body clock

The cells of the suprachiasmatic nuclei located in the base of the hypothalamus constitute the biological

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site of the "body clock". Neural input pathways provided by the retinohypothalamic tract and the intergeniculate leaflet transmit photic and non-photic signals from the retina to this cluster of time-keeping cells. The cells of the suprachiasmatic nuclei are in turn neurally connected to the pineal gland by means of multi-synaptic pathways. The hormone melatonin is secreted from this gland at night, its output being stimulated by dim light at the onset of darkness. Receptors for melatonin are located on the suprachiasmatic nuclei, which means that endogenous and exogenous melatonin might both influence its activity.

The suprachiasmatic nuclei induce circadian rhythmicity but their timing is not exactly equal to the solar day. The endogenous circadian rhythm is marginally longer than 24 h, the natural period in isolated or "free-running" conditions being about 25 h (see Reilly, Atkinson, & Waterhouse, 1997). For the body clock to synchronize individuals to their environment, therefore, the suprachiasmatic nuclei have to be adjusted to the solar day. This adjustment is achieved by rhythmic signals in the environment, termed "zeitgebers". Natural daylight is the predominant signal for the body clock, although artificial light can also exert an influence (Waterhouse, Reilly, & Atkinson, 1997). Light inhibits the secretion of melatonin, with secondary effects of distal vasoconstriction and an accompanying increase in alertness (Krauchi, Cajochen, & Wirz-Justice, 2005). Conversely, melatonin promotes drowsiness through its vasodilatory effects; in the evening at the time of "dim-light melatonin onset", this causes a fall in core body temperature that prepares the body for forthcoming sleep.

While bright light and melatonin have effects that are in opposition to each other, each has its own phase – response curve. Exposure to light early in the morning can advance circadian rhythms to display an earlier peak; light in the evening can displace circadian rhythms to reach a high point later in the day (Cajochen, Krauchi, & Wirz-Justice, 2003). In contrast, administration of melatonin in the evening can cause a phase advance. The normal phase advance that occurs to the body clock each morning (to change its free-running period to one of 24 h) is produced by the natural light – dark cycle acting in combination with the depression of melatonin secretion caused by the light. These effects are relevant after crossing a number of meridians when a phase advance is required following an eastward flight and a phase delay following a flight westwards.

In addition to light and melatonin, external factors that set the period to an exact harmony with the light – dark cycle include environmental temperature, physical activity, and social factors. The pattern of eating and drinking is also relevant. Under normal circumstances, all these rhythmic influences act synchronously. Physiological rhythms incorporate both endogenous (clock-driven) and exogenous (driven by lifestyle and environment) components. The relative size of these components depends upon the variable. Melatonin, for example, has a pronounced endogenous origin, whereas the circadian rhythm in temperature is influenced by external and internal factors about equally. Rhythms of feeding and digestive functions are influenced more by exogenous than endogenous factors.

Many human performance measures display a circadian rhythm that is in close correspondence with the 24-h cycle in body temperature. Such rhythms have been demonstrated for muscle strength and power output, self-chosen exercise intensity, joint flexibility, and reaction time (see Reilly, 2007). Drust and co-workers (Drust, Waterhouse, Atkinson, Edwards, & Reilly, 2005) provided strong evidence for an endogenous component to circadian rhythms, citing data from time-trials for swimming and cycling. However, athletes organize their exercise and eating patterns to provide energy for training, to enable food to be digested before exercise, and to provide energy soon after exercise to facilitate recovery. These rhythms in performance and in digestion are likely to be affected after travelling over multiple time zones. The consequential jet-lag describes a global syndrome with separate entities that include sleep disruption, impaired mental performance and mood, and altered sensations of fatigue and responses to food (Waterhouse, Reilly, Atkinson, & Edwards, 2007).

## The rhythm in digestion

Meals are normally distributed more or less equally throughout the day for reasons of custom, habit, ease of digestion, diurnal work schedule, and maintenance of energy. An overnight fast following supper means an absence of energy intake for about 40% of the 24-h solar day. The frequency of eating is typically higher in athletes than in non-athletes, as snacks are taken to top-up energy levels and maintain energy balance in the face of the high energy expenditure associated with hard training, or to consume nutrients in preparation for, or recovery from, a specific session of exercise.

The patterns of activity and feeding vary between countries. Feeding can be viewed as an exogenous influence on human circadian rhythms, since the timing of meals can be voluntary. It can also be considered as an ultradian rhythm; that is, one possessing a rhythmic component with a period of less than 20 h (see Reilly & Waterhouse, 2007). Ultradian rhythms reflect both external and internal influences, the afternoon siesta in Mediterranean countries coinciding with the time of the so-called post-lunch dip in performance associated with occupational work (Colquhoun, 1971). As this afternoon phenomenon occurs irrespective of whether lunch is taken or not, it represents a sub-harmonic in the normal circadian rhythm. The post-lunch dip is accentuated when alcohol is ingested with the meal (Horne & Gibbons, 1991). This time of day also coincides with the time at which napping is most popular with athletes.

The normal circadian and ultradian patterns of feeding in adults are mirrored by the similar rhythms in gut motility, digestive secretions, and absorption of food digested. There are parallel rhythms in blood concentrations of glucose, lipids, and amino acids (Mejean, Bicakova-Rocher, & Kolopp, 1988). Circadian variation is also evident in the metabolic and gastrointestinal responses to meals. Many of these rhythms have a marked exogenous component and so reflect meal times. However, some rhythms also have a substantial endogenous component. For example, gastric emptying and blood flow are lower at night-time than during the day, and are likely to cause a delay in the absorption of food from the gastrointestinal tract after eating at night (Sanders & Moore, 1992). A large meal eaten late in the evening may lead to feeling bloated and could disrupt subsequent sleep. Moreover, some of the hormones promoting the metabolism of digested food absorbed from the gut (e.g. cortisol) have significant endogenous components. Energy intake has been correlated with the duration of the following sleep in rats but the relationship is less clear in humans. Bernstein and colleagues (Bernstein, Zimmerman, Czeisler, & Weitzman, 1981) studied humans living in isolation: they reported a positive relationship between meal size and the interval to the next meal. This observation suggests that metabolic factors, as well as habit and an endogenous mechanism, normally determines the choice to eat, the appetite for food, and the amount of food ingested at different times of day.

## Coping with jet-lag

Methods of attenuating the symptoms of jet-lag can be divided into pharmacological and behavioural approaches; the latter includes manipulation of nutrition as well as activity. Drugs that promote alertness or induce drowsiness have been investigated for their ameliorative properties (see Waterhouse *et al.*, 2007) but many of these agents are on the prohibited list for athletes. Chronobiotics and soporifics, such as melatonin and benzodiazepines, have been effective for some travellers, but have not been recommended for athletes due to difficulties in correct timing of ingestion (Reilly *et al.*, 1998; Reilly *et al.*, 2007). In many countries, melatonin is only available on prescription and the purity of "off-the-shelf" melatonin cannot be guaranteed. In addition, the potential for toxic effects in habitual users is currently unknown. Consequently, the emphasis has been placed on behavioural strategies for coping with jet-lag.

### *Pre-flight adjustments*

Pre-adjustment of the sleep–wake cycle has been advocated by retiring to bed earlier than normal when a phase advance is envisaged and retiring late before flying westwards. The disruption in lifestyle, including the dislocation of meal times, necessitated by such behavioural changes outweighs their possible benefits when an alteration of more than 2 h for more than 1–2 days is involved (Reilly & Maskell, 1989). Consequently, an emphasis on arriving in the new time zone well in advance of competitive engagements is preferable.

The Argonne diet has been presented as a means of reducing jet-lag by manipulating the macronutrient intake in the days before flying. This programme consists of alternating days of fasting and feeding on a protein-rich breakfast and a carbohydrate-rich evening meal. Reynolds and Montgomery (2002) studied soldiers using the diet for 4 days before a trans-meridian flight, reporting slightly reduced effects of jet-lag as a result. The methodological weaknesses in this study, and the restrictive nature of the regime when applied to athletes, would make it impractical as a strategy pre-flight or post-flight.

### *On-board nutrition*

The majority of flights eastwards from Europe to Asia and Australia, and from the Americas to Europe, are overnight. This schedule involves a late meal shortly after embarkation, a short night in the environment immediately outside the aircraft, and an opportunity to gain a few hours sleep. In contrast, westward flights entail longer than normal hours of daytime and, because of the relative ease of phase delays compared with phase advances, jet-lag is less severe and adjustment is faster. Irrespective of the direction of travel, there are some common aspects of on-board nutrition.

The dry air on board an aircraft causes an increased loss of moisture from respiration, leading to a gradual and unperceived dehydration. This added fluid loss can be countered by drinking more than normally expected for a day of sedentary activity. An estimate of 15–20 ml extra for each hour of flight should be acceptable. The typical advice is that fruit juices, lemonade, and water are preferable to cola drinks, tea, and coffee because of the potential diuretic effect of the caffeine contained in the latter drinks. Warnings about restricting alcohol-containing drinks are usually given because of a similar concern about increased urine losses; in contrast, sports drinks or oral rehydration products are encouraged due to the positive effect of sodium replacement on fluid retention. Although there is evidence to support the physiological principles underpinning this advice (Shirreffs, Casa, & Carter, 2007), several practical issues may reduce its real importance. A recent review of the intake of small to moderate amounts of caffeine concluded that its effect on diuresis or hydration status is negligible in habitual caffeine consumers (Armstrong, 2002). Furthermore, since overall hydration status is a balance between the voluntary intake of a fluid and its effect on urine losses, the desirability or palatability of the drink chosen needs to be considered. It is possible that people who normally consume substantial amounts of cola drinks, tea or coffee will not replace the volume that these contribute to their total daily fluid intake if forced to avoid these drinks in favour of fluids that are perceived as less enjoyable. Nevertheless, the effects of caffeine on wakefulness or the intoxicating effects of alcohol are important factors to consider when deciding to avoid or limit certain fluids.

Finally, athletes may find that their opportunities to drink certain volumes or types of fluids during a flight are challenged by recent anti-terrorism laws that prevent passengers from bringing their own liquids on board, or from moving around the aircraft to locate drink fountains. Despite good knowledge and intentions, athletes who travel by air may find that their fluid intakes are ultimately determined by the airline service provided to passengers, especially when travelling in economy class or budget airlines.

The times of food intake are also decided by the carrier; depending on the times of embarkation and disembarkation, the travelling athlete may need to plan in advance which meals to take and which to avoid. For long-haul flights, a full meal is served soon after embarkation and another is offered soon before landing. This second meal has been found to be less palatable than the first, particularly during eastward flights (Waterhouse, Kao, Edwards, Atkinson, & Reilly, 2006). Decreased enjoyment of a meal might result from dehydration and an alteration to taste mechanisms (due to the cabin air), jet-lag (eating during the "night" by body time) or feeling tired after having been woken from a fitful sleep. Overall, the food offered by airlines tends to be low in volume and fibre and may not meet the athlete's nutritional needs in terms of energy provision (either being too low or too high in view of the forced inactivity during travel), carbohydrate or protein. Athletes may try to address these problems by ordering the special menus offered by some airlines or by bringing their own food supplies within airline or quarantine regulations.

*Following arrival*

The most powerful signals for promoting adjustment to the new time zone are exposure to light and avoidance of light. The times of day in which light can accelerate or slow resynchronization of rhythms have been established for different directions and numbers of meridians traversed (Reilly, Waterhouse, & Edwards, 2005). Light of domestic intensity and some commercially available light visors may also be effective (Waterhouse *et al.*, 1998). Exercise in the new environment can act as a zeitgeber, although it is likely to be more effective when a phase delay rather than a phase advance is required (Edwards, Waterhouse, Atkinson, & Reilly, 2002). After a time-zone transition of about 7–9 h eastwards, it is prudent to avoid training in the morning for 2–3 days, since exercise in the hours preceding the trough of core body temperature (a reflection of "body clock time") is more likely to cause a phase delay rather than induce the required phase advance.

Caffeine is a stimulant that is widely used to maintain daytime alertness in the general population and has ergogenic properties for athletes (Graham, 1997). Both fast-acting and slow-release forms of caffeine can temporarily offset tiredness. The stimulatory effect of caffeine is beneficial during the day while the body clock is being readjusted, but ingestion late in the evening can cause undesirable effects on recovery sleep (Beaumont *et al.*, 2004).

Caffeine can modify the endogenous secretion of melatonin by inhibiting $\alpha$2G adenosine receptors in the pineal gland. The usefulness of slow-release caffeine administered in the morning and melatonin given in the evening was compared with a placebo by Lagarde *et al.* (2001) in volunteers travelling eastward over seven time zones. Grip strength, squat jump, and a 15-s multiple jump test were monitored twice each day A decrease in performance was observed in the evening for the first few days in the placebo group, confirming the performance impairment due to jet-lag. A satisfactory level of performance in the experimental group was maintained only for grip strength of the non-dominant hand, the results for the dynamic tests being considered variable. In what appears to be a further report based on the same trip, slow-release caffeine was found to reduce daytime sleepiness but recovery sleep was impaired (Beaumont *et al.*, 2004). The study did not yield convincing evidence that the combined use of these drugs alleviated symptoms related to jet-lag.

Ehret and Scanlon (1983) proposed that the elevation in tyrosine following a high-protein meal would help adjustment to the new time zone by increasing arousal in the morning. In contrast, the elevation of circulating tryptophan levels secondary to carbohydrate ingestion in the evening would induce drowsiness and promote sleep. There is little experimental support for this dietary programme to aid readjustment of the body clock after time-zone transitions. Krauchi and colleagues (Krauchi, Cajochen, Werth, & Wirz-Justice, 2002) claimed that carbohydrate in the morning appeared to advance circadian rhythms compared with carbohydrate in the evening, an effect that would be linked to the provision of energy rather than fit the tyrosine–tryptophan theory. In view of the inconsistencies in the results of these macronutrient manipulations, Reilly and Waterhouse (2007) concluded that the timing of meals in the habitual routines in the new environment was more important than the energy source content of the meal.

Hydration status can also influence subjective symptoms following long-haul flights, especially as dehydration can accentuate the malaise of jet-lag. Consequently, particular attention should be placed on the fluid needs of travelling athletes. Since the circadian rhythm in renal function is also displaced by trans-meridian travel, care should be taken to avoid drinking too late in the evening, thus preventing the need to wake from sleep repeatedly for micturation purposes. This problem may occur in particular in wheelchair athletes who compensate for a residual dehydration post-flight due to the inconvenience of visiting the aircraft toilets during the journey.

Food intake at the destination can be decreased for the first day or so, due possibly to the unadjusted clock but also to feeling tired during the daytime (Waterhouse *et al.*, 2000). Furthermore, energy expenditure is likely to be decreased below normal training levels, since a reduction in training loads for a few days in the new time zone is advised to aid readjustment. Individuals might have a decreased appetite for, and enjoyment of, food they are not familiar with, or with food that has been prepared in a different way. However, most of these factors can be combated by education or, if thought desirable, by ensuring that meals of a type the traveller is accustomed to are provided. Bowel movements can become irregular and the consistency of stools can change, becoming abnormally hard or loose.

Alternative therapies proposed as antidotes for jet-lag include homeopathic remedies, massage, and relaxation, without any evidence of their effectiveness. Chiropractic methods were found to have no effect on jet-lag experienced by elite junior Finnish athletes (Straub *et al.*, 2001). Similarly, medicinal plants and aromatherapy have been proposed to overcome difficulty in sleeping but results have been unpromising (Wheatley, 2005). It is not likely that nutritional supplements will produce any better outcomes.

## Nutritional issues at the destination of travel

Once athletes have completed their journey, they must be able to train effectively or to achieve peak performance for competition in an environment that is often both far away and different from the home-base. The principles of optimal nutrition for the various events and training programmes undertaken by track and field athletes have been outlined in other reviews within this special issue. A range of challenges may prevent the travelling athlete from meeting these goals (Burke, Millet, & Tarnopolsky, 2007):

- A change in environment – sudden exposure to altitude or a different climate – may alter the athlete's nutritional needs and goals. The exercise intensity may be reduced to cope with the environmental stress; at a given intensity there is an increased reliance on muscle glycogen stores, both during exercise in the heat and at altitude (Armstrong, 2006). The athlete may not be fully aware of these changes.
- The new environment may provide reduced access to food and food preparation opportunities compared with the flexibility of the athlete's home kitchen and normal routine. The travel destination may not provide some of the athlete's important or favourite foods.
- A substantial part of an athlete's new food intake may be coming from hotels, restaurants, and takeaway outlets rather than being tailored to the special needs of athletes. This catering plan or the athlete's daily intake may not cover the individual's total nutritional needs, especially snacks and sport foods that are consumed outside meals.
- A new food culture and different foods can be overwhelming to young athletes and those with fussy palates.
- Differences in hygiene standards with food and water in different countries may expose the athlete to the risk of gastrointestinal pathogens.
- Reading food labels or asking for food may require the mastery of a new language. There is a risk that the guidance may be misinterpreted or the request may be misunderstood.
- The excitement and distractions of being away make it easy for the athlete to lose sight of nutritional goals. Common challenges include overeating in "all you can eat" buffets and athlete dining halls, being away from super-

vision, and being confronted with a whole new array of food temptations.

A variety of strategies can be implemented by the athlete or the manager who is organizing team travel. Being aware of, and prepared for, the likely challenges is a key strategy. The internet contains many sites that provide information on travel *per se* or a destination in particular. Other athletes and coaches who have previously travelled to a destination can also be a good source of information about likely problems or creative solutions. Food needs should be discussed in advance with the agencies that will provide catering to the travelling athlete (e.g. airlines, hotels, athlete villages). It is often possible to organize menu plans and meal timing that suits the special nutritional needs of the athlete(s); this is best done before the travel. Being aware of suboptimal catering arrangements that cannot be changed allows the athlete to be educated about alternative strategies or food supplies.

Differences in food cultures and food supplies around the world may mean that foods that provide important nutritional characteristics or psychological value to the athlete are not available in a new environment. Since the athlete's nutrition goals are likely to include well-timed and well-chosen snacks, additional foods supplies may be needed as a supplement to the catered meal plan. It is often possible for athletes to bring or send supplies of portable and non-perishable foods to their travel destination to replace important items that are otherwise missing. Examples of foods or dietary products that are practical and valuable for the travelling athlete are summarized in Table I, but are subject to customs and quarantine laws in each country. There may also be some merit in the use of a broad-range, low-dose vitamin/mineral supplement when an athlete is travelling for long periods to places with a restricted or unreliable range of nutrient-rich foods.

The athlete should choose the best of the local cuisine to meet individual nutritional needs. This may mean showing some restraint with the quantity or type of foods that are otherwise outside the athlete's nutrition plan, as well as following guidelines for good hygiene that minimize the risk of succumbing to gastrointestinal illnesses. Athletes should be pro-active in finding out about the nutritional characteristics of the local food supply or asking for what they need at catering outlets (e.g. low-fat cooking styles or an extra carbohydrate choice). Preparation before travel to an unfamiliar country may include investigation of the local cuisine, such as to identify staple sources of carbohydrate, protein, fruits and vegetables, and the typical cooking styles. It may be possible for the athlete to eat at a restaurant featuring this cuisine as a familiarization for the forthcoming trip.

Table I. Examples of food and dietary supplies that may be useful for the athletes to bring or send to their travel destinations.

- Breakfast cereal
- Powdered milk
- Cereal bars, muesli or granola bars
- Dried fruit and nut mixes
- Powdered/concentrated juice mixes
- Quick-cook rice and noodles
- Baked beans
- Crackers or rice cakes and spreads (honey/jam/vegemite/peanut butter)
- Liquid meal supplements (powdered form for reduced travelling weight)
- Sports drinks (powdered form for reduced travelling weight)
- Sports bars

The challenges of "all you can eat" dining should also be recognized. "Cafeteria" or "buffet" style eating is a common catering plan for groups of athletes, especially in the dining halls organized in athlete villages at major competitions. Such food service offers the advantages of fast service for athletes who are hungry and challenged for time, maximum flexibility in allowing athletes to choose the quantity and type of food they need from the menu selection, and cost-savings because of bulk cooking, reduced staffing requirements, and low food wastage (Cummings, Crawford, Cort, & Pelly, 2006). However, this style of eating provides different prompts to the athletes and may alter their habitual eating patterns. Challenges include the opportunity to overeat when offered a large variety of foods in relatively unlimited amounts and the absence of the normal supervision or constraints to food intake (e.g. cost, availability). Social scientists are aware that many factors underpinning the ambience of an eating occasion, such as the environment, number of eating partners, and the presentation of food, alter food choice and intake. Athletes may not be aware of the factors that influence their eating patterns and dietary intake in different eating environments. Education may help athletes to be firmly aware of their nutritional goals and to learn behavioural strategies that will allow them to achieve their goals regardless of the food environment or the distraction of other people.

## Gastrointestinal infections when travelling

All athletes are at risk of acquiring infections from unusual organisms when travelling (Young & Fricker, 2006). "Traveller's diarrhoea" is a common nuisance but is particularly distressing for athletes because it affects their performance. Although episodes of traveller's diarrhoea are nearly always benign and self-limiting, the dehydration caused by diarrhoea can be detrimental to athletes (Boggess, 2007). Traveller's diarrhoea has been defined as the passage of more than three unformed stools in 24 h with discomfort, occurring in a person visiting another country where food contamination may occur (Gudjónsson, 2006). Travel-related gastrointestinal disturbances range from 14.1 to 21.9% in visitors travelling to developing countries (Prazuk *et al.*, 1998), representing the main cause in calling on emergency medical care (Fisch *et al.*, 1998). As many as 60% of athletes who travel internationally develop diarrhoea (Halpern & Keogh, 1995). Food or water contamination with faecal matter containing bacterial, viral or protozoan pathogens is the most common cause of traveller's diarrhoea (Gudjónsson, 2006; Boggess, 2007). These pathogens are transmitted in food, water, and from other people, and arise from poor sanitary conditions, and from poor personal and food hygiene practices (Young & Fricker, 2006). Enterotoxigenic *Escherichia coli* account for approximately 50% of cases (Halpern & Keogh, 1995). *Staphylococcus aureus*, *Shigella*, *Campylobacter jejuni*, *Salmonella*, rotavirus, *Giardia*, and *Lamblia* are other agents that can cause traveller's diarrhoea (Boggess, 2007; Brukner & Khan, 2001; Gudjónsson, 2006; Halpern & Keogh, 1995; Prazuk *et al.*, 1998; Young & Fricker, 2006).

Symptoms most frequently start suddenly on the third day abroad (Pasvol, 1998). Stools are often watery and, in approximately 20% of cases, bloody (Gudjónsson, 2006). This commonly lasts between 24 and 48 h (Brukner & Khan, 2001) and about 20% of cases will have a second bout during the second week (Pasvol, 1998). Abdominal cramps, nausea, vomiting, mild fever, and malaise are often associated with traveller's diarrhoea (Brukner & Khan, 2001; Gudjónsson, 2006; Pasvol, 1998). Although the majority of these illnesses settle quickly, athletic performance may be affected during the attack and for some time afterwards (Brukner & Khan, 2001).

To prevent traveller's diarrhoea, athletes should avoid contaminated food, including raw and unpeeled fruits and vegetables (some of these may have been washed in potentially contaminated water), unpasteurized dairy products, shellfish, reheated foods, and other uncooked fresh foods (meat, fish, and eggs) (Brukner & Khan, 2001; Gudjónsson, 2006; Pasvol, 1998; Young & Fricker, 2006). Avoidance of local water, including ice cubes and water for brushing teeth, is recommended (Brukner & Khan, 2001; Halpern & Keogh, 1995; Young & Fricker, 2006). Many of the infections by these pathogens can be prevented by attention to personal hygiene, including washing the hands thoroughly with soap before meals (Young & Fricker, 2006). Schlim (2005) considered that personal hygiene precautions, with strict supervision of kitchen activity, can prevent traveller's diarrhoea, but poor restaurant hygiene in most developing countries continues to create an insurmountable risk for this condition. A summary of guidelines to reduce the risk of contracting the condition is provided in Table II.

Antibiotic prophylaxis for traveller's diarrhoea remains a controversial issue (Brukner & Khan, 2001). The risk of serious allergic reactions, side-effects such as photosensitivity, as well as the fears of developing resistant organisms should be taken seriously into account (Brukner & Khan, 2001; Gudjónsson, 2006; Halpern & Keogh, 1995; Pasvol, 1998). When deciding whether or not to use antibiotics, the athlete and the physician must take into account any underlying medical illnesses, the importance of the competition, compliance of the traveller with food precautions, and individual preferences (Brukner & Khan, 2001). Prophylactic antibiotics may be indicated only in athletes who are staying abroad for less than 2 weeks, travelling to a high-risk area, and for whom it is vital that peak performance is assured (Brukner & Khan, 2001; Gudjónsson, 2006; Pasvol, 1998). Recommended antibiotics include fluoroquinolones such as norfloxacin ($400\ mg \cdot day^{-1}$) and ciprofloxacin ($500\ mg \cdot day^{-1}$). However, fluoroquinolones should be used with caution in athletes because of the increased risk of tendon rupture (Seeger *et al.*, 2006). If prophylactic antibiotics are indicated, rifaximin is the preferred choice because it is a non-absorbed antibiotic, is well tolerated, and is receiving increasing interest due to the concerns about resistance to fluoroquinolones (Boggess, 2007). Trimethoprim sulphamethoxazole and doxycline were popular in the 1990s but resistance is common now (Brukner & Khan, 2001). Bismuth subsalicylate was thought to reduce traveller's diarrhoea and the frequency of attacks (Halpern & Keogh, 1995; Gudjónsson, 2006) but is less effective than antibiotic prophylaxis (Brukner & Khan, 2001).

Prevention of traveller's diarrhoea with probiotics is a promising field of research. Probiotics are either monocultures or mixed cultures of live organisms which, applied to animals or human beings, beneficially affect the host by improving properties of indigenous microflora, hampering the growth of diarrhoeal pathogens, and boosting cellular and humoral immunity (Surawicz, 2003). Administered for 4 weeks before travel, they have been advocated as a safe preventive measure. Huebner and Surawicz (2006) concluded that studies of probiotics for the prevention of traveller's diarrhoea have yielded conflicting results, so their routine use cannot be recommended in this setting. In contrast, a recent meta-analysis suggests that probiotics are efficacious in preventing acute diarrhoea with a variable magnitude of the effect in the trials studied. This effect is dependent on the age of the host and genera

Table II. Preventing "traveller's diarrhoea".

- Wash hands with soap for 30 s before each meal. Use a clean towel or dryer to dry hands
- Drink cool fluids, such as water, soft drinks or juice, only from sealed bottles
- Avoid ice in drinks. Avoid use of tap water for brushing the teeth
- Avoid salads and raw vegetables
- Peel all fruit
- Avoid raw, uncooked fresh foods (meat, fish, shellfish, and eggs), unpasteurized dairy products, and reheated foods
- Avoid buying food in local markets
- Select foods that are well-cooked and served hot (not warm)
- Avoid buffet food that is not served very hot or chilled or which has been sitting in warm places for extended periods of time (more than 2 h)

of strain used (Sazawal *et al.*, 2006). Recently, McFarland (2007), in a further meta-analysis of relevant studies, also concluded that several probiotics demonstrated significant efficacy in preventing traveller's diarrhoea, with no side-effects in the 12 studies that met the inclusion criteria. Although the available data from the medical literature provide sufficient evidence for the role of probiotics in the prevention of acute diarrhoea, they are insufficient for extrapolation for global recommendations (Sazawal *et al.*, 2006).

In most cases, the management of traveller's diarrhoea is symptomatic (Pasvol, 1998). The patient should rest and replace fluid and electrolytes as appropriate (Brukner & Khan, 2001). In most instances, water, electrolyte rehydration salts, and carbonated drinks are sufficient if consumed in small amounts, but often; intravenous fluids are rarely needed (Gudjónsson, 2006; Young & Fricker, 2006). Withholding solid foods for the short term (up to 24 h) is also recommended. A valid alternative is consuming a bland diet, consisting of dry toast, biscuits, rice and bananas, avoiding alcohol, fat-rich foods and dairy products until the diarrhoea settles (Young & Fricker, 2006). Anti-diarrhoeal medications (e.g. loperamide) are recommended for symptomatic relief (Brukner & Khan, 2001). If diarrhoea is severe, dysenteric, persists for more than 48 h, or is associated with fever, mucus or blood, antibiotics such as norfloxacin (800 mg to start and then 400 mg twice a day for 3 days) or ciprofloxacin (1000 mg initially and then 500 mg twice daily for 3 days), which can shorten symptoms, may be required (Brukner & Khan, 2001; Young & Fricker, 2006). Rifaximin has become available for the treatment of non-invasive diarrhoea caused by *E. coli* (Centers for Disease Control and Prevention, 2005; Steffen *et al.*, 2003), has been demonstrated to be effective in the treatment of traveller's diarrhoea, and has equal efficacy to fluoroquinolones (DuPont *et al.*, 2001). Rifaximin use is becoming more common due to concerns about fluoroquinolone resistance. However, it is not effective against infection associated with fever or blood in the stools such as caused by *Campylobacter* species (Adachi & DuPont, 2006). Rifaximin could also be considered an alternative to fluoroquinolones in athletes due the increased risks of tendon ruptures with the latter. A recent trial showed that the combination of rifaximin and loperamide provided rapid symptomatic improvement and greater overall wellness compared with either agent alone (DuPont *et al.*, 2007). If low-grade diarrhoea persists for more than 5–7 days, giardasis should be considered and this can be treated with a single dose of tinidazole (2 g) (Brukner & Khan, 2001; Young & Fricker, 2006). Any athlete should be advised to seek medical advice in any case of post-travel or persistent diarrhoea.

## Overview

Travel is a frequent and necessary experience for the elite athlete. Challenges include the interruption to chronobiology from changing time zones, loss of access to usual and important foods and eating practices, and the risk of contracting traveller's diarrhoea. Many of these challenges can be overcome with careful planning and preparation, and sound practices of eating and light exposure strategies in the new destination. Nevertheless, athletes should remain vigilant about their food and drink when visiting other countries. Recommendations for the travelling athlete are summarized below. While guidance is clear with respect to the majority of the issues addressed, there are some unresolved questions. The British Olympic Association advised its athletes against using sleeping pills or melatonin when travelling overseas (Reilly *et al.*, 1998) but acknowledged that some athletes use sleeping drafts or melatonin. It was emphasized that sports science support staff and the team physician should be consulted on any individual strategy based on personal experience with these drugs. Attention to the timing of meals, the maintenance of hydration status and personal standards of hygiene, and the adjustment of behaviour and training, should all be part of a strategy to overcome the stresses consequent to travelling for athletic encounters. The successful adjustment should then be a prelude to a rewarding sojourn.

## Summary: General recommendations to travelling athletes

*Consensus for:*

- The athlete should investigate food issues on travel routes (e.g. airlines) and at the destination before leaving home. Caterers and food organizers should be contacted well ahead of the trip to let them know meal timing and menu needs.

- When moving to a new time zone, athletes should adjust their eating times as quickly as possible and use well-planned exposure to light to enhance the readjustment of the body clock.
- The athlete should recognize the unseen fluid losses in air-conditioned vehicles and pressurized plane cabins and organize a drinking plan that achieves a suitable level of hydration (neither overhydrating nor becoming substantially dehydrated).
- The athlete should investigate issues of food and fluid hygiene in the new environment, and adhere to guidelines such as drinking only boiled or bottled drinks, and eating foods that have been peeled or cooked.
- The athlete should organize a suitable supply of portable and non-perishable foods to be taken or sent to the destination to replace important items that are otherwise missing.
- Athletes should use special strategies to ensure that they achieve their nutritional goals within the new circumstances of their eating environment – e.g. the challenges of "all you can eat" in athlete dining halls, the need to be assertive when ordering in restaurants.

*Consensus against:*

- The athlete should not ignore or under-play recommendations for hygiene practices with food and fluid intake in foreign countries. Gastrointestinal infections are common and can cause a major disruption to training and competition.
- Athletes should avoid taking alcoholic beverages during and after flights.

*Issues that are equivocal:*

- Alterations to macronutrient intake before, during, and after long-haul travel appear to have little effect on readjusting the body clock.
- Behavioural approaches are considered preferable to the use of sleeping agents and putative chronobiotics to aid readjustment of the body clock.
- Probiotics hold promise for preventing traveller's diarrhoea but definitive evidence of efficacy in this setting is awaited.

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