3.2 Playing at Altitude and Considerations for Travel

This unit will discuss the physiological challenges and nutrition interventions relevant to playing football at altitude. In addition, travelling away from "home" for pre-season training and international tournaments is now common practice for most professional football players. Significant nutritional challenges are encountered by players when travelling. Therefore, it is important to recognise those challenges and introduce specific strategies to minimalize the disruption to the player's schedule.

Altitude

A common misconception when playing at altitude is that there is an alteration in the composition of atmospheric air. This is not true. The composition of air remains the same, i.e. oxygen content of air remains at 20.93%, be it at sea level or 4,000 m. Instead, it is the reduction in the partial pressure of oxygen (and other ambient gasses which decrease the higher the ascent), a reduction in the total number of oxygen molecules inspired, with each breath. The low oxygen pressure of ambient air is known as hypoxia, which is induced by a reduction in barometric pressure. Barometric pressure is a measure of the pressure exerted by the weight of the air above us. There is an inverse relationship between barometric pressure and altitude, i.e. the higher the altitude, the lower the barometric pressure.

KNOWLEDGE CHECK

Hypoxia refers to a low oxygen pressure in the ambient air, caused by a reduction in barometric pressure. Hypoxaemia generally refers to a decrease in the oxygen content of air.

Table 1: Altitude classification, implications and potential action

Altitude (m above sea level)	Classification	Implication	Action
0-500 m	Near sea level		
> 500 – 2,000 m	Low altitude	Minor impairment in aerobic performance	3-5 d acclimation Dietary Nitrate
> 2,000 – 3,000 m	Moderate altitude	Mountain sickness begins to occur and acclimation gets increasingly important.	1-2 weeks acclimation Dietary Nitrate
> 3,000 – 5,500 m	High altitude	Performance considerably impaired, acclimation becomes clinically relevant.	>2 Weeks acclimation Dietary Nitrate
> 5,500 m	Extreme alltitude	Prolonged exposure results in progressive deterioration.	

Source: Prepared by author.

Hypoxia and Football

Although less extreme in Europe, players may still be required to play at various altitudes. For example, Figure 3, shows the altitude of club stadiums in the Spanish first division "La Liga" 2018-2019. The players body will make both physiological and metabolic adjustments when playing in low oxygen environments. However, depending on the degree of altitude, these compensatory changes are usually not enough to off-set the negative influence of a reduction in the partial pressure of oxygen.

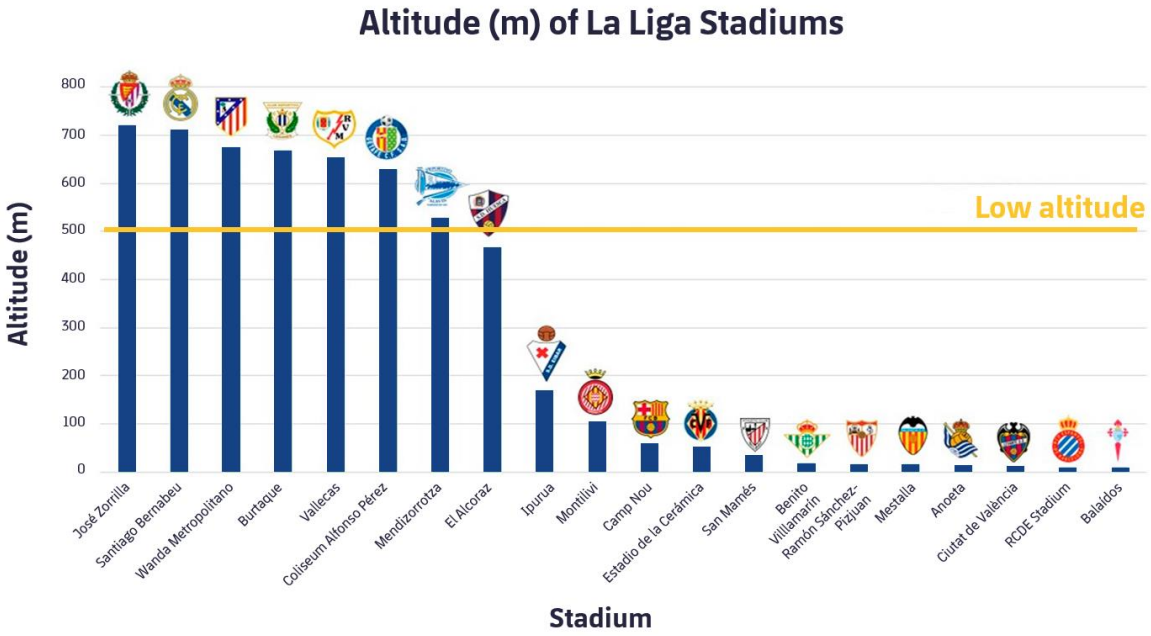
A reduced oxygen supply (lower total number of oxygen molecules inspired per breath) compromises the player's aerobic capacity by reducing the maximum oxygen delivery to the skeletal muscle (Billaut & Aughey 2013). The reduced maximal oxygen supply also increases the time required to recover between high intensity intermittent efforts, such as sprints (Garvican et al., 2013). The arterial hypoxaemia (3% reduction in arterial blood oxygen saturation compared to pre-exercise or sea level values) impairs the players ability to run at high intensity and complete repeated high intensity efforts (Billaut & Aughey 2013). These activities have been reported to be key for player performance and match defining moments.

Elite players who live at sea level may experience a performance decrement (ability to complete and recover from high intensity runs) when asked to play football at low altitude (Table 1) (Nassis 2013). Data on player physical performance was captured throughout the FIFA World

Cup 2010 (South Africa), where matches were played at a variety of altitudes (0 m-1,753 m).

During the tournament it was reported that an altitude in excess of 1,200 m significantly reduced the total distance covered by players during a match (-~3.1%), in comparison to sea level (0 m) (Nassis 2013). Furthermore, the players capacity to complete high speed runs, i.e. repeated sprinting, is reduced approximately 150% fold at 1,600 m compared to near sea levels controls, in elite youth football players (Garvican et al., 2013). It is important to check that decrements in high speed running capacity observed when playing at 1,200 m – 1,750 m are not accompanied by reductions in technical skill proficiency (Nassis 2013).

Figure 3: Altitude of club stadiums participating in the Spanish first division "La Liga" (2018-2019)



Source: Prepared by author.

On three separate occasions FIFA has banned international football matches which were proposed to be played at altitudes in excess of 2,500 m (Gore et al., 2013). One of these vetoes (May 2007) was reversed shortly after its announcement (Gore et al., 2013). This sequence of announcements as well as retractions were made without consideration of the football-specific research on player match performance at low, moderate and high altitudes (Gore et al., 2013).

There has been a scientific approach and data gathered during matches played at altitude, completed by a project named the International Study on Football at Altitude 3,600 m, in 2012 (ISA3600) (Gore et al., 2013).

However, despite the novel and well organised approach of the ISA3600 research, poor reliability and high variability have been reported for key outcome measures (i.e. total distance covered and distance at high speed running) during football match-play due to other match-specific factors independent of altitude (tactics, opposition). Therefore, it is difficult to draw clear conclusions regarding the impact of altitude on football specific performance, derived from football match-play data.

On pitch or laboratory based football simulations, which mirror the physical match demands of football, have provided valuable insights on the impact of altitude. This is because the physiological and performance response of the player can be assessed without confounding match factors such as tactics, formation and opposition. For example, to investigate the impact of hypoxia (1,000 m) on player running performance, researchers have validated a intermittent soccer performance test (iSPT) (Aldous et al., 2015). Data using this exercise model suggests that total distance covered, and distance covered at high speed, are significantly reduced in hypoxic conditions in comparison to sea level (control). Interestingly, the final 15 minutes of iSPT, saw the greatest reductions in high-speed running compared to all other 15-min blocks of the protocol.

Thus, it is very likely that the time-dependent decline in high-speed running at altitude could influence the outcome of a match. This is because data from the FIFA World Cups (1998, 2002) has shown that most goals are scored in the second half of the match (Armatas et al., 2007). With respect to the influence of altitude, compared to all other 15-min time phases, more goals were scored/conceded within the final 15 minute of game play (76-90 min). This phenomenon in goals scored is likely due to the factors of fatigue discussed in later courses. However, these decrements in performance appear to be exacerbated within hypoxic environments (Garvican et al., 2013; Taylor et al., 2014).

Whether players are native to altitude (Bolivian) or sea level (Australian) appears not to influence total distance covered in either environment. For example, total distance covered was reduced similarly in both groups across three matches played at 3,600 m, compared to performance close to sea level (Aughey et al., 2013). This reduction was not positively influenced by 14 days altitude acclimation by sea level natives, nor lifelong residency at altitude within the high landers group (Aughey et al., 2013).

Table 2: Examples of stadiums and the associated teams who play at moderate to high altitude

Stadium	Team/Club	Altitude (M)	Country
Estadio Daniel Alcides Carrión	Unión Minas (3 Ra division of Peruvian league)	4380	PERU
Estadio Victor Agustín Ugarte	Club Bamin Real Potosí (Bolivian 1st division)	3960	BOLIVIA
Lhasa Recreational and Sports Centre	Lhasa Chengtou (China league two)	3658	CHINA
Estadio Hernando Siles	Bolivia national team	3637	BOLIVIA
Estadio Garcilaso	Real Garcilaso (Peru 1st division)	3360	PERU
Estadio Olimpico Atahualpa	Ecuador national team	2782	ECUADOR

Source: prepared by author

Altitude: practical recommendations

Hypoxic environments, induced by altitude (>1,200 m, match-play) (Garvican et al., 2013; Nassis 2013); or simulated laboratory studies (>1,000 m) (Taylor et al., 2014) limit football-specific physical performance. Current advice recommends that players acclimatise for several days and include 1-2 weeks training at or near the competition venue when located at moderate/high altitude (Gore et al., 2008). This strategy is aimed to promote adaptation to altitude, i.e. to increase the oxygen carrying capacity of the blood. This is achieved by an increase in red blood cells and an increase in haemoglobin mass. However, the nutritional status of the player may influence how they respond to altitude driven adaption. Furthermore, when a period of acclimation is not realistic/possible due to the transient nature of a football team's fixture schedule, acute nutrition strategies may be considered.

To this end, in addition to the "core" sports nutrition recommendations of "fuelling and hydration," specific nutrition interventions should be considered when preparing for and playing at altitude.

KEY POINT

Even at moderate to low altitude, players may be at increased risk of becoming significantly hypohydrated (>2% pre-exercise body mass losses) and increased risk of fatigue through depletion of carbohydrate stores. Thus, additional nutritional strategies should be incorporated in addition to the "core" carbohydrate and hydration strategies discussed in previous courses.

Preparation

Nutritional recommendations for supporting performance at altitude would include ensuring players have an adequate iron status (Table 3). Iron is the functional component of myoglobin, haemoglobin and is also an essential constituent of mitochondrial enzymes. Iron is also required for the proliferation of red blood cells in response to altitude. Therefore, the player's iron deficiency will benefit from increasing their intake of dietary iron, prior to (several weeks before) and during periods of acclimation at altitude.

Current recommendations are to assess the player's iron status 4-6 weeks prior to going to altitude. A typical routine involves the ingestion of 100-200 mg of elemental iron per day (Hall et al., 2018). Vitamin C (200 mg/d) should be co-ingested with iron to enhance absorption, whilst foods or fluids that impair iron absorption such as tea and coffee should be avoided around player meal times (Armstrong 2006; Gore et al., 2008).

Table 3. Haematological assessments of iron deficiency and iron anaemia

	Normal	Deficiency
Serum ferritin (µg/L)	>110 (M) >35 (F)	<35
Haemoglobin (g/L)	135-175 (M) 120-155 (F)	125-134 (M) 115-119 (F)

Source: Modified from Peeling et al., 2008, pp. 381-391

Values will vary for male (M) and female (F) players(Peeling et al., 2008).

If an iron deficiency has been clinically diagnosed, a supplementation period may be considered at levels above the recommended daily allowance, following consultation with a qualified medical practitioner/ club doctor. If specific iron supplementation is recommended, then guidelines surrounding dietary supplementation should be followed (Module 2).

Performance

Dietary nitrate ingestion may be a potent acute sports nutrition strategy when preparing for exercise at altitude (Shannon et al., 2017).The ingestion of dietary nitrate has been shown to result in several positive physiological responses which may positively impact on player performance at altitude. Specifically, dietary nitrate ingestion has been reported to:

- Improve muscle oxygenation during submaximal and maximal exercise in acute severe hypoxia (Masschelein et al., 2012).
- Reduce negative muscle metabolic perturbation during high-intensity exercise within hypoxia (Vanhatalo et al., 2011).
- Improve intense intermittent exercise performance at sea level (Wylie et al., 2013).

Practical recommendations to optimise nitrate supplementation (dose, nitrate source, acute or chronic supplementation) specific to football within hypoxia are still being refined. This is because of the variability in supplementation strategies seen across studies which have demonstrated worthwhile effects of supplementation on exercise and the lack of nitrate and exercise based studies specifically in hypoxic environments (Vanhatalo et al., 2014).

Based on the available literature, players would be advised to ingest inorganic nitrate delivered by ingesting approximately 140 ml, nitrate-rich vegetable products (such as beetroot juice) daily on the 3-4 days prior to competing at altitude. In addition, players may also benefit from the ingestion of 140 ml (providing ~8.4 mmol Nitrate) of inorganic nitrate with the pre-match meal (i.e. ~3 h before exercise). Although there is potential for performance improvements with a single pre-exercise dose, chronic supplementation of at least several days may increase the likelihood of exercise performance benefits being observed (Hoon et al., 2013). During nitrate supplementation, the player's urine may turn a "pinkish" colour. Players should be warned about this side effect. There is no harm in the urine changing colour, but self-monitoring of hydration status, via urine colour, may be compromised.

Travel

For a professional football player, domestic and international travel is common. Players may travel to weekly matches and routinely to different countries during the season for European or International commitments. In addition, players are now required to participate in pre-season training camps or organised tours which also require significant international travel. It is essential that strategies are put in place to minimize the impact of travel on a football player's food intake. Regardless of whether the player is embarking on a long bus trip or overseas, the key to successful eating while on the move is planning and preparation.

Ensuring a quick adjustment to the "new" environment takes on greater importance if the player must perform soon after arrival. This is because jetlag, unaccustomed environmental conditions, illness or inappropriate dietary intake have the potential to negatively affect player performance (Halson et al., 2019). The sports nutritionist can oversee specific strategies to ensure appropriate hygiene and mange travel fatigue and jetlag. Some objectives may be achieved indirectly by player education, but others require the direct involvement of the nutritionist, for example, directly ensuring adequate health and safety standards are met by the catering staff/facilities of kitchen/restaurant environments.

Travel Hygiene

During travel to destinations with greater than a five-hour time difference, the incidence of illness (i.e. upper respiratory tract infection and gastrointestinal tract and infectious illness) is increased two to three-fold (Schwellnus et al., 2012). This of importance for those nutritionists who work with players who frequently travel long distances "home", i.e. Europe to Asia or Latin America and vice versa.

When traveling, the player is frequently exposed to situations where they are in contact with many people and often in a confined space. In addition, players are often demanded/expected by fans to shake hands, "high-5", meet sponsors/hosts and pose for photographs. These factors theoretically expose the player to new and more pathogens in comparison to a "non-player".

DID YOU KNOW?

A pathogen is anything that can produce illness or disease.

If players experience illness when traveling, it can create numerous problems for the individual player as well as the support staff and teammates. Beyond the inability to train and play matches, illness may require the player to be isolated to reduce the risk of passing the illness to staff and teammates.

An example of a common illness associated with frequent or long-distance travel is Traveller's diarrhoea. Traveller's diarrhoea may be defined as three or more unformed bowel movements within 24 hours. This illness is associated with nausea, cramps, blood in stools and vomiting. It is typically caused by contamination from faecal matter containing microbes such as salmonella, virus and pathogens and food or water contamination by E. Coli. The duration of symptoms of Traveller's diarrhoea is usually 3-4 days. In some cases, it may be more severe resulting in bowel complaints affecting the player's ability to train and compete in the weeks following the initial incident (Reilly et al., 2007).

Gastrointestinal distress and illness related to travel in some countries may be associated with poor hygiene practices such as hand washing. It is important to emphasise that picking up illness can occur in both developing countries and destinations considered 'safe'. Thus, adopting good personal hygiene and food safety practices for all travel will help to decrease the risk of infection and illness over the duration of a season. In all situations, players should avoid sharing cups or utensils as infections and illness may spread this way. During training and matches, ensure players have their own designated drinks bottle. Below are key points to consider for the travelling player:

- Wash hands regularly and before all meals.
- Wash hands following contact with many people, meeting fans, hosts etc.
- Drink bottled water or beverages from sealed containers.
- Avoid ice in beverages.
- Clean teeth with bottled water.
- Eat fruits only if they can be peeled.
- Aim to eat only from reputable hotels or franchises.
- Avoid markets and street stalls.
- Only consume food that is prepared properly, i.e. steaming hot.

In the event of a player experiencing an illness, it should be immediately reported to the medical team/club doctor. The aim will be to ensure the player receives the appropriate medical care but also to avoid

contaminating the other members of the team and finally identifying the root cause of the illness. As a general guide, the nutritionist is advised to be prepared with specific re-hydration salt sachets, which may be used in the treatment of players with gastrointestinal illnesses.

Jetlag

Jetlag (circadian desynchronization) occurs due to a mismatch between the player body's circadian rhythm(s) and the external 24-hour light-dark cycle. Jetlag results from rapid travel across multiple time zones. Jetlag is influenced by the number of time zones crossed as well as the direction of travel. There are numerous negative consequences of jetlag which could impact on a player's performance, including:

- disturbed sleep
- fatigue
- insomnia
- decreased alertness
- headaches
- mood disturbance
- decreased motivation

Light is the most powerful cue to synchronise the player's internal body clock. The aim is to realign the player's circadian systems as quickly as possible. This is vital if there is a short period of time for transition prior to competition. One key symptom of jetlag includes appetite loss. Thus, the nutritionist should plan meals carefully to ensure players are meeting energy requirements. In addition, certain nutrition strategies may be considered to help speed the player's body clock synchronisation.

DID YOU KNOW?

The circadian rhythm is also known as the "body clock". The player's circadian rhythm informs the player's body behaviour, for example, when to sleep, wake and eat.

Nutrition planning

Prior to travel, the nutritionist should develop a general plan which details where, when and what the players are going to eat on each day. It is important to research the destination and investigate the catering

options as thoroughly as possible. A common problem when dinning in a “new” venue is that it results in a change in the availability, type and quality of food as a result of differences in the local food supply and catering capabilities. In these circumstances, players may avoid foods creating challenges to the achievement their specific nutrition goals. The quality of the food and food availability can be critical to the success of the trip, especially during prolonged pre-season camps. Ideally, menus can be shared with the hotel chefs in advance and followed up with a telephone conversation prior to arrival. This process will allow you to discover which foods are available and if menus need to be modified. Researching the travel destination will allow you to determine the hygiene and food safety risks, but also potential culinary opportunities. It is important not to forget that travel provides the opportunity for the sports nutrition to learn about new foods, recipes and cultural etiquettes.

TRAVEL TIP

When traveling regularly, delays are guaranteed, both on the roads and at the airports. As the nutritionist, plan for these eventualities by packing enough food to cater for the players “just in case”. For example, cereal bars and bottles of water can be easily stored on the team coach and used if needed.

The teams travel schedule will determine the opportunities for players to eat. Even short-haul travel may result in poor eating practices. Preparing food for the team bus reduces the need for unscheduled stops which may result in the selection of less appropriate “convenience” options. Food should be stored appropriately, i.e. in chilled containers, when traveling.

When planning for a flight, knowledge of the duration is the priority. Two meals are typically provided during long haul flights. The first is provided following departure and the second usually two hours before arrival. Examples of appropriate snacks to provide players include fresh and dried fruit, nuts, and milk. These supplies may need to be purchased once customs is cleared. These snacks should be easily accessible; however, eating out of “boredom” should be discouraged.

Changes in bowel habits of players are common with travel. This may be due to a change in the common foods in the player’s diet (reducing fibre intake) and also hypohydration due to a change in the type/volume of food and fluid ingested. In addition, insensible fluid losses may be increased by cabin pressure and air dryness (Leatherwood & Dragoo 2013).

Nutritionists traveling with the team should ensure that the players have easy access to fluids and may remind cabin staff to routinely provide

drinks. To encourage voluntary fluid intake, one strategy is simply to place a water bottle on each of the player's seat, before they board the airplane (or coach). This forces the player to move the bottle and reminds them to drink.

On arrival at the destination, the ingestion of caffeine is a common means of alleviating daytime fatigue experienced as a consequence of jetlag (Halson et al., 2019). For example, 300 mg of caffeine ingested at 08:00 (destination time) for 5 days resulted in a more rapid resynchronization rate compared to placebo (Pierard et al., 2001). Caffeine ingestion (300 mg) has also been reported to decrease sleepiness in comparison to placebo but resulted in more objective and subjective sleep complaints (Beaumont et al., 2004).

DID YOU KNOW

A "Zeitgeber" is the term given to a rhythmic cue in the environment that helps synchronize the internal body clock to the external environment (Choy & Salbu 2011).

Summary

- Football may be played in extremes of altitude.
- An immediate solution to the demands of hypoxic match play is challenging, though dietary nitrate supplementation alongside items of "best practice" are recommended.
- Frequent travel is common in football; player education surrounding hygiene may reduce the risk of infection.
- Dedicated planning by the nutritionist is essential for all travel.

Module Summary

FIFA endorsed football matches may be completed at environmental extremes of hypoxia and/or heat. The environmental conditions of hypoxia and hot are associated with reduced high-speed running and sprint distances, both of which may influence the outcome of a match. An immediate solution to the demands of hypoxic match play is challenging, though dietary nitrate supplementation alongside items of "best practice" are recommended.

Players may combat some of the heat mediated reductions in football performance, by considering the use of specific strategies including heat acclimation and mixed methods of cooling (pre-match and at half-time). Further research is required to modify and optimise these interventions to meet football specific match demands.

Disclaimer: Ian Rollo is an employee of the Gatorade Sports Science Institute, a division of PepsiCo, Inc. The views expressed in this course are those of the authors and do not necessarily reflect the position or policy of PepsiCo, Inc.

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