Module 1. Sports nutrition for player well-being and sleep

Unit 1.1 Sports nutrition for player well-being in football

The term "well-being" encompasses many aspects of a player's life —both physical and mental. If a player is happy and healthy, then this will set a positive precedent for consistent training and match performances. This unit will discuss new thinking with regard to nutrition strategies aimed at maintaining player health. General good health is intuitively a prerequisite for performance. Nevertheless, players will experience periods of illness over the duration of a season. The sports nutritionist should be aware of nutrition strategies to support immune function, as well as potentially reducing the duration and severity of the illnesses experienced. The methods used to monitor player's health over a season will be covered, as well as other factors contributing to a players "well-being" such as the gastrointestinal tract, bone and oral health.

Player immunity

Participating in training and matches (either acutely or chronically) will influence a player's immune system and its functions (Bermon et al., 2017). Completing intensified training (greater than usual) for one week or more may modify several aspects of immune function (Gleeson, 2013). Nonetheless, the resistance of the immune system to infection is not suppressed (Walsh, 2019). Nonetheless, players may be at increased risk of illness when engaged in intensive pre-season training, periods of fixture congestion, or during major competitions (World Cup) (Nieman, 2000). This is likely due to the increased travel (exposure to pathogens), increased anxiety/stress of travel and disturbances to sleep.

Common illnesses for players, as well as the general population are Upper Respiratory Tract Infections (URTIs). Examples of these infections are influenza and the common cold, which are most frequently experienced in the winter months (Morgans et al., 2014). Players may experience 2-4 episodes of an URTI per year (Gleeson, 2016). Although these symptoms are often trivial, they may cause a lower level of performance or a player to miss training or a match. Furthermore, URTI are highly transmissible, passing from player to player through respiratory droplets or hand-to-hand contact. Sickness and subsequent absence from training is incompatible with success in football, which demands consistent training and match performances. The less illness experienced by the player the more they can train and compete.

Did you know?

White blood cells (WBC) or leukocytes work as part of the immune system to defend against infectious disease. There are five different types of leukocyte that have specialised roles depending on the infection they are fighting.

The preservation of players' "health" is essential in avoiding illness and injuries, limiting stress and preventing "burnout" (where players underperform and lose motivation). Stresses placed on a player during a season may be both physical and mental. Stress and anxiety is associated with a decrease in immune function that, in turn, increases the risk of infection (Cohen et al., 1991; Edwards et al. 2018). Common causes of physical and psychological stresses in football are displayed in table 1.

Table 1. Sources of physical and psychological stresses over a football season

Physical stresses	Psychological stresses
Excessive matches: 60-70/season	Competition anxiety
Mismanagement of training load	Losing matches
Limited recovery time	Team selection
Inadequate diet	Contract talks/disputes
Playing with injuries/infections	Loss of form
Inadequate sleep	Commercial/media attention/commitments
Rapid body mass loss	Family/personal conflicts

Source: own elaboration.

Monitoring

The sports nutritionist should be aware of the sources of stress and plan appropriate recovery strategies to help combat risk factors. To achieve this, a close partnership with

the sports medicine and sports science staff is required to implement appropriate monitoring of players' stress and recovery.

A common way to monitor players' stress includes the use of tablet/electronic questionnaires, assessing mood, muscle soreness and "readiness". Empirical evidence suggests that asking the players to routinely complete prolonged assessments does not work. Instead, it is advised that the sports nutritionist works with the sports medicine department to devise 3-5 pertinent/validated questions, which the players can respond to rapidly. Other methods to assess a player's stress/recovery include muscle function (maximal voluntary contractions) and blood markers (creatine kinase, cortisol/testosterone ratio, blood neutrophil). Of most relevance to this module is also the monitoring of sleep (Unit 2).

Some practitioners within football use salivary IgA to monitor a player's immune status over the season. This is because approximately 95 % of all infections begin at the mucosal surfaces (typically mouth and nose) (Boschet al., 2002). The mucosal surfaces are protected by antimicrobial proteins of which secretory immunoglobulin A (IgA) is the most abundant (Brandtzaeg, 2003). Secretory IgA provides an immunological barrier by neutralising and preventing viral pathogens from penetrating the body through the mucosal surfaces. Studies have investigated the synthesis and secretion of IgA most commonly in saliva in the mouth (salivary IgA). Salivary IgA responds almost instantaneously to stress and, as a consequence, transient fluctuations have been reported in concentration and secretion rate (Stone et al., 1987). As with all biological samples, the method and collection of saliva should be standardised.

Although changes in salivary IgA response may be of interest after prolonged training and matches (extra-time), the real value is monitoring the individual player's IgA response over a prolonged duration (Sari-Sarraf et al., 2007; Sari-Sarraf et al., 2008). This is because the salivary IgA response to acute exercise is variable. Players are likely to have individual thresholds. Deviation from "normative" values may provide better indicators of compromised immune function (Moreira et al., 2014).

Did you know?

The term health is defined by the World Health Organization (WHO) as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (n.d., https://lc.cx/EmwER4)

Nutrition

Nutrient availability influences the player's immunity because macronutrients and micronutrients are involved in a multitude of immune processes. Specifically,

macronutrients are involved in immune cell metabolism and protein synthesis and micronutrients are involved in antioxidant defences (Walsh, 2019).

The ability of the immune system to clear viruses, bacteria and other pathogens, termed 'resistance', is dependent upon an adequate supply of energy from dietary sources. Specifically, the ingestion of macronutrients carbohydrate, protein and fat (Course Macronutrients and Fluid for Football) provides the respective glucose, amino acids and fatty acids to fuel the immune system.

In addition to fuel requirements, immune cell proliferation requires nucleotides for DNA and RNA synthesis and amino acids for protein synthesis. Therefore, an adequate dietary intake of protein is required for the production of immunoglobulins, cytokines and acute-phase proteins, which coordinate the immune and inflammatory response (Calder, 2013).

From a nutrition perspective, much of the core advice for supporting immune function aligns with recommendations provided in the other Sports Nutrition for Football courses. General advice includes consuming a diet that meets energy needs of training matches. Players should ingest a variety of fresh fruit and vegetables, prevent significant hypohydration and avoid a dry mouth during exercise or travel. Specific nutrition interventions are discussed below, but it is important to frame nutrition in the context of other prevention measures. To this end, other parameters to reduce the risk of illness are also displayed in table 2.

Table 2. Advice on reducing risk of immunosuppression and transmitting infections during the competitive season

Reduce risk of immunosuppression during training and matches	Reduce risk of transmitting infections
Avoid very prolonged training sessions (> 2 hours)	Avoid sick people and large crowds in enclosed spaces
Reduce other life stresses	Wash hands (before eating) and brush teeth regularly (good personal hygiene)
Achieve adequate sleep (Unit 2)	Never share drink bottles

Avoid rapid weight loss	Avoid putting hands to eyes and nose especially during long travel as these are the major routes of viral self-inoculation
Vaccinate against influenza during the winter months	Manage stress and anxiety

Source: own elaboration.

Never share drinks bottles

The sports nutritionist should ensure players have individual drinks bottles to reduce the risk of illness being between players.

Carbohydrate

Carbohydrates provide fuel for the immune cells. Thus, the ingestion of carbohydrates is a partial countermeasure against exercise-induced immune impairment. Carbohydrate ingestion is likely to be more effective in preserving immune function when consumed during training and matches in comparison to increasing the total dietary content of carbohydrate per se (Bermon et al., 2017). This is particularly important during prolonged exercise or if the player is at risk of experiencing low blood glucose concentrations. Low energy availability is associated with increased risk of illness, and restricting carbohydrate intake ('training low') may increase immunosuppressive stress hormone responses (Walsh, 2018). Therefore, the player should be advised to follow the carbohydrate ingestion guidelines for training and matches outlined in previous courses.

Protein

Protein ingestion of at least 1.2 g/kg BM/day is required for optimal immune function (Wu, 2016). The non-essential amino acid glutamine is used as a fuel by the immune cells (Ardawi and Newsholme, 1983). Concentrations of glutamine in the circulation are lowered after prolonged exercise and very heavy training. However, despite the rationale for additional provision via dietary supplementation, there is no conclusive evidence to support the ingestion of additional glutamine for improved immune function (Keast et al., 1995). Instead, glutamine may be considered in the player's gut health, as discussed below.

Bovine colostrum

Bovine colostrum is the term given to the milk produced by the mammary glands of cows in the days immediately following the delivery of a newborn calf. This milk is rich in specific types of protein involved in promoting the immune system, to protect the newborn against disease. As such, bovine colostrum exhibits antibacterial, anti-inflammatory and antiviral properties. Some research studies have reported a reduction in self-reported URTI incidence in athletes following a period greater than four weeks of bovine colostrum supplementation (Shing et al., 2006; Shing et al., 2007). However, it is important to note that not all studies report positive results or statistically significant findings (Buckley et al., 2009). Furthermore, the incidence of URTI has not been clinically verified, as it has been self-reported data. To this end, based on the available evidence, it is not possible to make specific recommendations regarding the use of bovine colostrum supplementation to promote players' health or immune function (Bermon et al., 2017).

Micronutrients

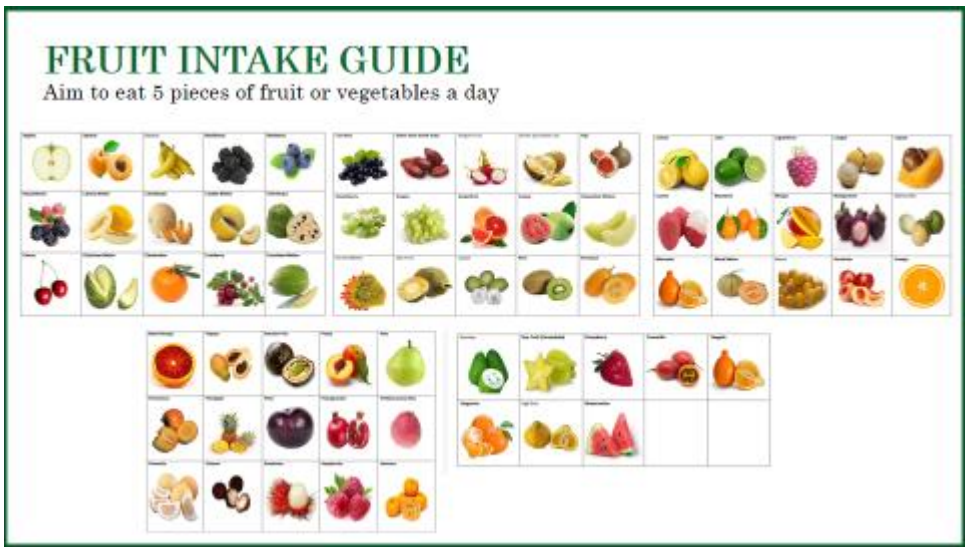
Deficiencies in certain micronutrients (iron, zinc, magnesium, manganese, selenium, copper, vitamins A, C, D, E, B6, B12 and folic acid) decrease immune defences and will make the player more susceptible to infection (Bermon et al., 2017). Important minerals for immune function are zinc (Zn), magnesium (Mg) and iron (Fe). However, there is no evidence to suggest that supplementing non-deficient players with these minerals will boost the immune system (Bermon et al., 2017).

Nonetheless, these minerals may have reduced concentration/availability during intensive training. At the onset of URTI symptoms, it is advised that players have adequate vitamin C, vitamin D (discussed below) and zinc status. The ingestion of 200 mg of vitamin C per day should sufficiently saturate body tissues. Allowing zinc lozenges (75 mg/day elemental zinc) to dissolve in the mouth may reduce the duration and severity of common cold symptoms by ~33 %, when taken within 24 hours of the URTI onset (Bermon et al., 2017).

The sports nutritionist should plan menus and provide opportunities for players to ingest at least five portions of fruit and vegetables per day on

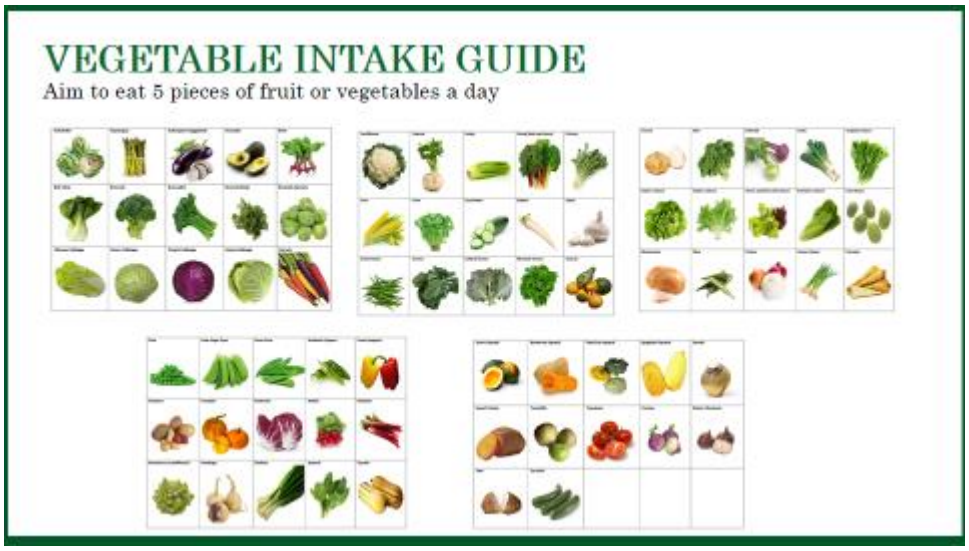
at least 5 days per week. This is because high intakes of fresh fruit and vegetables are associated with reduced infection risk in highly physically active people (Bermon et al. 2017). Figures 1 and 2 provide examples of fruits and vegetables, which can be included in the players diet.

Figure 1. Example of fruits to include in the diet



Source: own elaboration.

Figure 2. Examples of vegetables to include in the diet



Source: own elaboration.

Vitamin D

Vitamin D has an influence on the function of a variety of immune cells (Bermon et al., 2017). Of relevance to the football player, circulating 25-hydroxy vitamin D concentrations equivalent to, or higher than, 75 nmol/l has been reported to be associated with a lower incidence of URTIs, in comparison to individuals with vitamin D concentrations of around 50 nmol/l (Owens et al., 2017). Furthermore, achieving adequate vitamin D status may reduce the risk of injury (stress fractures) when co-ingested with calcium (Knechtle et al., 2021).

Dietary supplementation with vitamin D, especially during the winter months, should be considered for players who are deficient or insufficient in vitamin D (Close et al., 2013). Dietary supplementation guidelines outlined in previous modules should be followed. The recommended dosage of Vitamin D will be relative to the player's clinically diagnosed vitamin D status (He et al., 2016). Current guidelines suggest the intake of vitamin D3 should be 2000 IU/day with 4000 IU being the current safe upper limit recommended by the European Food Standards Agency. Nutritionists should be aware that there is emerging evidence that too much supplemental vitamin D may have negative effects on the player's health. Thus, further research is required to understand the "optimal" vitamin D concentrations for immune function without the risk of compromising players' health.

Player gastrointestinal (gut) health

The human gastrointestinal tract is a complex ecosystem of microbes including bacteria, archaea, fungi, viruses, and microbial eukaryotes. Collectively, these microbes are known as microbiota, whereas the microbiome is defined as the set of their genomes (Mancin et al., 2021). There is much interest in the role of gut health on football performance. This is because gut "comfort" is a key consideration for players during a match. Furthermore, the profile of the intestinal microbiota can have a positive impact on the immune system, thereby reducing the risk of player illness.

Did you know?

The gut microbiota (also referred to as the gut flora) refers to the populations of microorganisms (bacteria) which live in the intestine. The trillions of microbes in the gastrointestinal tract play essential roles both in health and disease.

The intestinal microbiota is only one aspect of gut health. Gut health also involves intestinal permeability as well as the mucosal immune system. It is through the mucosal immune system of the gut that the intestinal microbiota may influence the immune activity at other sites in the body, including the upper respiratory tract (West et al., 2009). Given the incidence and risk of URTIs in players, nutrition to improve this aspect of player's immunity should be considered.

A healthy gut microbiome is required for the development of the immune system (Belkaid et al., 2014). Although we are yet to determine an "optimal" gut microbiome profile, improving the diversity and stability of the microbiota may be advantageous to supporting immune responses.

The gut microbiota will be influenced by many factors including exercise, environment, medication lifestyle and diet. Of course, it is the diet which the sports nutritionist should aim to influence.

Did you know?

The term "probiotics" is given to specific foods or dietary supplements that contain live bacteria. The term "prebiotics" is given to foods that provide fuel for the bacteria already in the gut.

Probiotics

A dietary intervention to support gut health is probiotic ingestion. Probiotic supplementation has been reported to contribute to the reduction in and modulation of the incidence and severity of URTI (Hao et al., 2015).

The ingestion of probiotics is among a popular nutrition strategy that may influence the player's gut health and immune function. Probiotics have been reported to favourably modulate the properties of both local and systemic immunity (Bermon et al., 2017). Common probiotics supplementation regimes include daily ingestion of bacterial strains of Lactobacillus and Bifidobacterium. A daily dose of ~1010 live bacteria is recommended (Collins et al., 2021). Nonetheless, there remains debate regarding the optimal duration of supplementation, as well as the potential benefits of selecting and mixing specific bacterial strains with or without prebiotics. The use of probiotics, may be considered for:

- players with a lack of food diversity in their diet,
- players who experience frequent illness,
- specific seasonal strategy. i.e. winter months,
- strategy to maintain gut health prior to and during travel,
- those players who suffer gut discomfort during training and matches.

Prebiotics

Prebiotics work by "feeding" the bacteria in the gut, which ferment starches to release metabolic by-products, including short chain fatty acids, vitamins and lipid metabolites that are associated with improvements in various aspects of the immune system (Colbey et al., 2018).

Specifically, bacteria in the gut are able to ferment specific fibres. Dietary fibre has historically been classified as soluble and insoluble. Insoluble fibre remains unchanged during food transit in the body. As an indigestible material, insoluble fibre sits within the gastrointestinal tract, absorbing fluid and sticking to other by-products of digestion that are ready to be formed into the stool. Thus insoluble fibre is important to maintain gut transit and avoid player constipation.

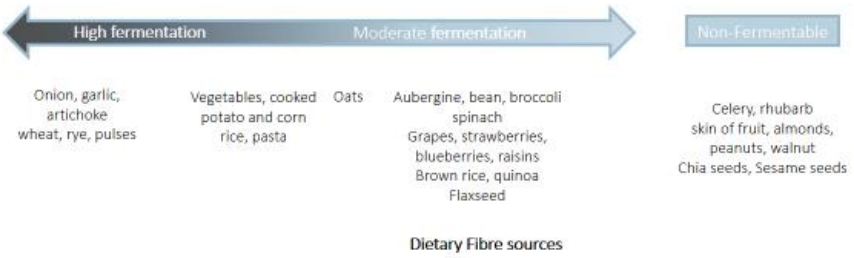
Soluble fibre dissolves in water and gastrointestinal fluids when it enters the stomach and intestines. The fibre is modified into a gel-like substance, which is available for bacteria

digestion in the large intestine. These types of fibre can be classified as Microbiota-accessible carbohydrates (MACs) (Morrison et al., 2020). The MACs have prebiotic properties as they promote the growth and activity of the gut microbiota.

The MACs act as the substrate for the gut bacteria to produce short chain fatty acids (SCFA). The SCFA that are produced include acetate, propionate, and butyrate. Of the SCFAs, butyrate has been studied most extensively, and has been found to directly nourish the cells of the intestine and decrease gut permeability (Mancin et al., 2021).

As a guide, players should aim to ingest a total of 30 g (25-50 g) of fibre a day. However, achieving a sufficient dietary fibre intake is challenging given the large proportion of the day dedicated to preparing for, participating in, or recovering from training or matches. This is because fibre dense foods decrease gastric emptying and increase the risk of exacerbating exercise-associated gastrointestinal symptoms. Therefore, it is recommended to avoid high fibre foods in the 3 hours before exercise, during exercise and in the recovery period after exercise (Thomas et al., 2016).

Figure 3. Dietary source of fibre and the relative gut fermentation properties



Source: own elaboration.

Consistent with the emergence of MACs is the concept of "fermentable oligosaccharides, disaccharides and monosaccharides and polyols - FODMAP", which describes certain fermentable foods that are able to trigger negative gastrointestinal symptoms (e.g., gas, diarrhoea and abdominal bloating) in individuals with irritable bowel syndrome (IBS). This diet is discussed in module 3.

Did you know?

Gut or intestinal permeability, also known as "leaky gut", refers to damage of the junctions (microvilli) in the intestinal wall which results in substances leaking into the bloodstream and mucosal inflammation of the affected area. Symptoms include the player feeling bloated or persistent pain.

Intestinal function

The intestines have a physical and biochemical barrier, which separates the contents of the intestinal lumen from the interior of the body. The intestinal epithelial cells are vital for the integrity and functioning of the intestinal barrier. They act to facilitate the absorption of nutrients into the body while simultaneously preventing the entry of bacterial toxins and pathogens (King et al., 2021).

Intense exercise, especially in the heat can compromise the intestinal cells and the tight junctions between them. When intestinal cells are damaged through physiological stress, the capacity to prevent the entry of specific molecules (lipids, proteins, microbial-derived peptides) into the bloodstream is compromised, which may initiate or exacerbate a systemic inflammatory response (King et al., 2021). This is more commonly referred to as "leaky gut". If this occurs in players, symptoms may manifest such as stomach pains and gastrointestinal discomfort.

Nutritional interventions that may protect against intestinal permeability during exertional heat stress include the ingestion of certain amino acids (glutamine), carbohydrates and fluid. Carbohydrate and the fluid intake guidelines are discussed in course 2. Both fluid and carbohydrate ingestion during exercise can help maintain blood supply to the intestinal cells acting to preserve the intestinal cell integrity (King et al., 2021). Players who experience significant gastrointestinal complaints during matches or training may improve gastrointestinal integrity by ingesting glutamine before exercise. Studies report that feeding glutamine 2 hours before intense exercise was associated with reduced gastrointestinal permeability. Although larger doses (0.9 g/kg BM) were found to be most effective, small doses (0.25 g/kg BM) also had a positive effect (Pugh et al., 2017). Therefore, if considering this intervention with players, it is advised to begin with the lower doses to assess the impact on feelings of gastrointestinal comfort before increasing the dose if necessary, using 0.5 g/kg BM as progressive steps.

Hygiene

It is important to emphasise that serious gastrointestinal illness can be caused by bacterial contamination as a result of the poor preparation and storage of food consumed in training ground, stadium, restaurants or venues used for pre or post match buffets (e.g., the changing room or team bus) (Collins et al., 2021). To reduce the risk of such issues

requires the sports nutritionist to be vigilant with regard to food hygiene. Resources that provide best practice with regard to the cross-contamination, cleaning, chilling and cooking are provided by the Food Standards Agency in the UK (www.food.gov.uk/businessindustry/food-hygiene).

Player's bone health

A player's skeletal system is obviously vital for the structure and function of all football movement. The development and availability of technology now allows for the use of duel-energy X-ray absorptiometry scanning to determine the bone mineral density (BMD) of players. It is important to recognize that bone tissue can be modulated by the dietary intake of the player (Clowes et al., 2002). Nutrition can have a significant effect on bone health across the players' life, especially as they progress from youth, to adolescents and into adulthood (Mitchell et al., 2015). Vital nutritional constituents required to support the growth and development of the players' skeleton include:

- calcium,
- protein,
- magnesium,
- phosphorus,
- vitamin D,
- potassium.

In addition to this list of nutrients, players should ensure an adequate intake of zinc, vitamin A, vitamin K, vitamin C and the B vitamins to support other metabolic processes important for bone health (Palacios, 2006). To meet these recommendations, the nutritionist should simply encourage the consumption of dairy, fish, fruits and vegetables (particularly of the green leafy kind). These foods are good dietary sources of the main nutrients (listed above) to support bone health.

Player oral health

Football players who are expected to eat regularly and often the foods recommended around training and matches may present a higher risk profile for dental erosion (Bryant et al., 2011). Poor oral health may result in missed training days and ultimately may impact player performance (Gallagher et al., 2018). The oral health of the player should be considered by the sports nutritionist. Therefore, alongside dietary guidelines, the sports nutritionist may simply remind the player to complete regular dental screenings. Players should be encouraged to use effective oral health promotion strategies, i.e. use dental floss and to brush their teeth twice a day (Bryant et al., 2011).

Meal times

It is important that players (and staff) have a feeling of connection and affiliation with their teammates, staff and ultimately the club (Ryan and Deci, 2000). Meal time occasions either at the training ground, stadium or away at hotels provides players with opportunities to bond and connect with relevant others. This environment can provide social support for player well-being to reinforce and celebrate when winning but also during times when the team is losing. It also helps players in the non-starting 11 or going through injury rehabilitation stay connected. The sports nutritionist can utilise these occasions to have conversations with players about nutrition, but also make astute observations about dietary choices, as well as player interactions. Inviting the sports psychologists and wider interdisciplinary team to be present during meals may help reinforce effective dietary strategies with the players. Finally, the team restaurant can also serve as an arena for distraction away from the focus of the sport. Understanding the culture of the team and players, the sports nutritionist should evolve the restaurant to be a safe place where players choose to spend time and enjoy food.

Summary

- The less illness experienced by the player the more they can train and compete in matches.
- Both physical and psychological stress has the potential to negatively impact a player's immune function and increase the risk of infection.
- The sports nutritionist should work with the medical team to implement strategies to reduce exposure to infection risks.
- The sports nutritionist should ensure players ingest an adequate intake of macro and micronutrients to support the immune system.
- The gastrointestinal health of the player is a key consideration for the sports nutritionist.

Unit 1.2 Sports nutrition for players sleep

Sleep is important to support the biological functioning of a player's body. Studies have reported that sleep may influence physiological processes and cognitive function (Cirelli and Tononi, 2008). Therefore, it is intuitive that sleep is important for the football player at all stages of their career, from youth to adulthood. Although the precise mechanisms have not yet been fully determined, it is generally accepted that "good" sleep will allow the player to recover from the day's exertions, as well as prepare for the next day. Numerous nutrition substances or remedies have traditionally been prescribed to

promote good sleep. However, only recently has science begun to investigate the effectiveness of nutrition interventions under controlled conditions. This unit will provide the background information on sleep research and then discuss potential nutritional strategies to promote and utilise sleep as a recovery occasion. This information will provide the sports nutritionist skills to consider an individualised approach to players' sleep, which includes sports nutrition recommendations (Walsh et al., 2020).

Defining and recording sleep

Sleep may be defined as a reversible behavioural state where an individual is perceptually disengaged from and unresponsive to the environment (Carskadon, 2011). Sleep is believed to have two states - Rapid Eye Movement (REM), and Non-Rapid Eye Movement (NREM), which are classified by physiological parameters. The NREM sleep is associated with a progressive increase in the depth of sleep. The REM sleep is characterised by a lack of muscle movement, but bursts of rapid eye movement. In REM sleep the brain is activated (dreaming) but the body is paralysed (Dement, 2005).

Key point: sleep definition

Sleep is a reversible behavioural state where an individual is perceptually disengaged from and unresponsive to the environment.

There are three methods, which can be used to assess sleep. The first is simply to ask players to complete sleep diaries. In this method, players keep daily records of where they sleep, and the start and end times of sleep. Daytime naps would also be recorded. The data from sleep diaries can be validated by combining the data with the second method of monitoring sleep, actigraphy. Actigraphy involves wearing a monitor, typically on the wrist. The actigraphy monitors resemble a wristwatch and, at set intervals (usually every minute), records the movement of the body. Both sleep diaries and actigraphy are likely the best tools for the sports nutritionist to use with football players. Both methods are non-invasive and do not interfere with the player's "normal" routine. Another consideration is expense. Sleep diaries have a low cost, as it only requires paper and a pen. Alternatively, it is possible to use electronic devices such as mobile phones or tablets to record the sleep data. Conversely, the actigraphy monitors can be relatively expensive (>$1000 per unit), and not all devices have been validated to measure sleep. Therefore, the sports nutritionist should research the system being used (Module 4). When using sleep diaries and actigraphy, a monitoring time of 2 weeks is recommended. It is advised that the monitoring period is during a period of the season "typical" for the player. Additionally, it may be of interest to monitor a player's sleep during a "home" and "away" fixture, to investigate and identify potential barriers to sleep. Popular sleep actigraphy devices used by players include, but not limited to, the following.

- Oura rings

- Whoop bands
- iPhone applications
- Bio-strap (wrist worn device)

The third method to monitor sleep is polysomnography (PSG). This involves measuring the electrical activity of the brain during sleep using an electroencephalogram (EEG). The EEG may be used to determine which of the two states of sleep a person is in. In addition, eye movements, muscle activity and cardiac activity are also measured. The PSG method provides information on sleep stages and is considered the "gold standard" for assessing sleep quality and quantity. However, PSG is unlikely to be a consideration for the sports nutritionist as the equipment is expensive, and it is time consuming to prepare the individual for evaluation. Thus, PSG is not appropriate for football settings, unless investigating a clinical sleep disorder.

Did you know?

Sleep latency refers to the time between which an individual "goes to bed" and "goes to sleep".

Sleep recommendations

The function of sleep is not fully understood, but it is accepted that sleep is one of the most important biological functions for the player. Getting sufficient sleep is essential for player performance, learning and physical/mental recovery (Halson et al., 2022). Healthy adults are advised to achieve 7-9 hours of sleep per night, with 8 h of sleep per night shown to prevent neurobehavioral deficits linked to sleep restriction (Hirshkowitz et al., 2015). In addition to sleep duration, sleep quality is important as it considers the number of sleep disturbances experienced during sleep. Paradoxically, despite regular exercise promoting better sleep duration and quality, athletes have been reported to experience worse sleep quality in comparison to the general population.

The importance of sleep is highlighted by understanding the consequences of inadequate sleep. We have found that ~19 % of all athletes self-reported a shorter sleep duration than that recommended (Randell et al., 2021). Consistently poor sleep can lead to mood disturbance, increased risk-taking behaviour and reductions in immune function. Sleep deprivation can also impact the player's physique due to poor nutrition choices.

There is limited research on sleep and football specific performance. Extrapolating data from relevant studies in athletes suggests a single night of restricted sleep can impair a range of psychomotor functions in male and females. This would translate as a reduction in reaction time on the pitch. However, gross motor skills, muscle strength and aerobic capacity are likely to be unaffected (Fullagar et al., 2023). It is natural for players to

experience nerves before a big cup final, or important match. Thus, in general, players should be able to "absorb" a single night of sleep restriction with no obvious consequences.

However, performance issues will arise if sleep is restricted for several days, weeks or months. Coordinated whole body movements, as well as submaximal aerobic performance will be impaired as a consequence of accumulated fatigue from sleep loss. In addition, other biological functions can be altered following chronic sleep deprivation. From a sports nutrition perspective, chronic sleep loss can result in unfavourable changes in the players glucose metabolism, appetite, food intake, and muscle protein synthesis. Ultimately these factors can contribute to a reduction in a player's performance (Fullagar et al., 2023).

Importantly, the effect of sleep on performance does not align with a one-size-fits-all approach. Instead, the players' sleep will be influenced by numerous factors such as time of the season, fixture congestion, match results, individual performance, contract negotiations, as well as a host of personal/non-football related issues (relationships, babies, bereavement). Because of this individualised advice for players is recommended (Fullagar at al., 2023).

Sleep hygiene

Nutrition interventions should be considered with respect to other practical strategies to improve sleep (www.sleepfoundation.org). Guidelines and recommendations for the player, independent of playing level, are listed below.

- Players should avoid "napping" for too long or too close to bedtime.
- Players' bedrooms should be kept cool, quiet and dark (eyeshades or blackout curtains should be considered).
- Promote natural light in mornings to regulate the players' "body clock".
- Players should avoid caffeine and caffeine-containing foods (coffee, tea, soda/pop and chocolate) close to bedtime as they can prevent sleep.
- Players should aim to establish a consistent bedtime and wake-up time routine. As a guide, players should aim for 8 h of sleep per night.
- Players should aim to avoid their mobile phone, television and computer screens in the hour before sleep.
- Establishing a routine before bedtime will help the players' bodies to recognize the signals that it is time for sleep.

Nutrition for sleep

Nutrition interventions are an effective way to improve sleep quality and quantity. Although further research is needed to determine the appropriate dose, source, and timing in relation to specific needs, general guidance can be provided to players (Gratwicke et al., 2021).

In the brain there are specific neurotransmitters that are involved in regulating the cycle of sleep. These neurotransmitters include serotonin, gamma-aminobutyric acid (GABA), orexin, melanin-concentrating hormone, cholinergic, galanin, noradrenaline and histamine (Saper et al., 2005). The rationale is that certain nutrition strategies may act upon neurotransmitters in the brain to influence sleep.

Melatonin is the hormone synthesised in the brain (pineal gland) which regulates sleep-wake cycles. Serotonin is a neurotransmitter that has various roles in the body but also serves as a precursor for the pineal gland to synthesise melatonin. Changes to the player's diet may influence the rate of synthesis and function of neurotransmitters, such as serotonin (Silber and Schmitt, 2010). For example, tryptophan is an essential amino acid that plays a key role in sleep. This is because when tryptophan crosses the blood brain barrier it is used to synthesise serotonin, which in turn is used to synthesise melatonin. As a reminder, essential amino acids can not be made by the body so the player must ingest tryptophan through dietary sources to impact sleep.

Did you know?

The player's body contains chemical messengers called neurotransmitters. The player's nervous system uses these molecules to transmit messages between neurons or from neurons to tissues in the body.

Studies have investigated the effect of habitually ingesting different quantities of macronutrients on sleep. It has been reported that energy intakes that are higher in carbohydrate were associated with shorter sleep latency (Lindseth et al., 2013; Lindseth and Murray, 2016; Vlahoyiannis et al., 2021). Diets higher in protein intake are associated with fewer wake episodes (Lindseth and Murray, 2016), and high fat diets were negatively associated with total sleep time (Grandner et al., 2010).

General guidelines suggest that "fast" carbohydrates such as white rice, pasta, bread and potatoes may promote sleep (Halson, 2014). However, these foods should be ingested in accordance to the player's daily carbohydrate requirements. Carbohydrate ingestion may increase tryptophan in the brain by stimulating insulin secretion, which promotes the uptake of amino acids from the circulation into the muscle (Fernstrom and Wurtman, 1971). The uptake of amino acids into skeletal muscle results in free tryptophan having less competition to cross the blood brain barrier (Fernstrom and Wurtman, 1971).

Ingesting small quantities of tryptophan in the diet may improve both the sleep latency and sleep quality of the player. Dietary tryptophan supplementation, equal to or more than 1 g ingested approximately 1 hour before bed can help improve sleep quality compared to having less than 1 g of tryptophan (Sutanto et al., 2022). The ingestion of 1 g of tryptophan can also be achieved by ingesting dietary sources such as approximately 300 g of lean turkey meat or approximately 200 g of pumpkin seeds (Halson, 2014).

Key point

Melatonin is a hormone that is connected to the sleep-wake cycle. In order for the brain to produce melatonin, serotonin is needed. The synthesis of serotonin is dependent on the availability of its precursor – tryptophan.

Some foods such as Montmorency cherries have naturally high concentrations of melatonin. Ingesting dietary sources rich in melatonin may decrease sleep latency (Cheikh et al., 2018). It has been reported that ingesting tart cherry juice concentrate for 7 days increased the total melatonin concentrations in the body. Furthermore, cherry juice ingestion was associated with significant increases in time in bed, total sleep time and reduced sleep latency (Howatson et al., 2012). As tart cherry juice may also have a role in player recovery, it offers a viable sports nutrition strategy for those players seeking to improve their sleep.

From a sports nutrition perspective, previous courses have discussed the use of caffeine as a dietary ergogenic aid, which may be used to support player performance. On training days, players should avoid coffee, tea, caffeinated soda/pop and chocolate late in the day (Gardiner et al., 2023). For evening matches, the ingestion of caffeine at the dosages recommended to aid performance are likely to negatively impact on player sleep. This is because caffeine will remain in the circulation for 3-5 hours after ingestion (Glaister et al., 2008). Therefore, when ingesting caffeine at 19:00 for a 20:00 kick off, the player may still feel its effects at midnight, which may delay the onset of sleep. In this situation the sports nutritionist should work with the player to determine if the intake of caffeine is affecting the sleep following a match. If not, then caffeine intake may continue to be considered. If late caffeine ingestion does appear to be impacting on sleep, then the sports nutritionist, together with the player's interdisciplinary medical team, must decide the risk/benefit trade-off between recovery and performance. There is no set rule for deciding this balance; however, when playing multiple matches in a week, recovery may be prioritised. In this situation, caffeine intake can be either stopped or modified for an earlier ingestion accounting for the sleep time of the player. In the event of a single late kick-off, when the player has a week to recover from poor sleep, then caffeine could still be ingested, if considered an important component of that player's performance.

Rehydration and recovery guidelines after a match should be followed (Course 2). However, players should avoid drinking large volumes of fluid before bed, which are

likely to cause disruption to sleep as a consequence of waking during the night to empty their bladder. Importantly, nutrition can serve as an effective step in the player's bedtime routine, to signal to the body that it is time for sleep.

Sleep as a recovery occasion

Optimising sleep presents an important opportunity to introduce nutritional strategies to facilitate player recovery. Specifically, ingesting protein prior to sleep has been reported as an effective method to increase the rates of muscle protein synthesis overnight. This finding is of particular interest to football players, as studies have shown that players are likely to be in a net negative protein balance when food is not provided before sleep (Beelen et al., 2008).

In the first study to investigate protein feedings prior to sleep, the method followed a pattern "similar" to that of an evening kick-off in football. Recreational male athletes performed resistance exercise in the evening followed by the ingestion of 60 g of carbohydrates and 20 g of whey protein immediately after exercise (similar feedings recommended following a match). However, in addition, the participants also ingested 40 g of casein protein or a placebo drink (water) immediately prior to sleep (Res et al., 2012). The ingestion of casein protein increased rates of muscle protein synthesis by approximately 22 % in comparison to the placebo trial. A follow-up study by the same research group repeated this study design, but this time feeding 30 g of casein protein with or without 2 g of additional leucine. They found that this did not increase myofibrillar protein synthesis overnight in comparison to the placebo (water) (Trommelen et al., 2018). The different results between the two studies may be explained by the smaller quantity of protein (30 g) ingested before sleep in the second study in comparison to the first study (40 g).

However, it is important to note that 40 g is a relatively large amount of protein to be ingested prior to sleep and it could be difficult for players to consume. Although studies have not been able to detect an acute effect of 30 g of casein on muscle protein synthesis, this could be due to the sensitivity of the method (i.e. it may be difficult to detect the impact of protein feedings over a 7-8 h fast (sleep)). It does not mean that 30 g of casein should be dismissed. In fact, the one study to investigate the "chronic" or long-term effects of pre-sleep protein ingestion on skeletal muscle adaptation used approximately 30 g of casein protein. In this study male athletes completed a 12-week resistance training program ingesting either 27.5 g of casein protein or a non-protein placebo (water) every day before going to sleep. The group of athletes that routinely ingested the additional casein protein had increased gains in skeletal muscle mass and strength over the 12 weeks in comparison to the placebo group (Snijders et al., 2015).

As these initial studies all used casein protein, sports nutrition strategies followed. The rationale for casein protein use was based on the digestion and absorption kinetics

following ingestion. Casein having a slower digestion profile in comparison to whey was believed to make it a superior choice for delivering amino acids during the 7 hours of sleep. However, casein or whey protein may be ingested pre-sleep as a recovery strategy. The ingestion of 45 g of whey or casein protein, both increased mitochondrial and myofibrillar protein synthesis rates during overnight recovery from endurance exercise compared to a non-caloric placebo (Trommelen et al., 2023).

To investigate the pre-sleep protein recommendations in football, a study asked ten professional players from an English Premier League team to consume 40 g of casein or 40 g of carbohydrates 30 min pre-sleep following an evening match (kick off 19:00) (Abbott et al., 2018). The ingestion of casein protein was associated with improved markers and perception of muscle soreness, and corresponded with improved physical performance (countermovement jump height, reactive strength index) in the three days following the match (Abbott et al., 2018). Therefore, providing 30-40 g of casein 30 min before sleep, in addition to the carbohydrate and protein recovery strategies immediately post exercise, would be advised for football players to promote adaptation and functional recovery. This feeding regime would be advised during periods of intense training (pre-season) and may be particularly relevant following an evening kick off. Finally, to date, there is no evidence that protein feeding before bed disrupts or interferes with a player's sleep. Nevertheless, when introducing this strategy, the sports nutritionist may consider starting with smaller quantities (15 g) and work towards 30-40g of casein protein over time.

Did you know?

Foods rich in casein protein include milk, yoghurt and cottage cheese. Casein or whey protein powder may also be added to foods such as yoghurt or milk to increase protein content.

In sports nutrition, one of the greatest challenges is to quantify the impact that sports nutrition has on performance or recovery (Module 4). A research method called the “intrinsically labelled protein technique” has been effectively used in sleep studies. Interestingly, this method provides the scientific evidence that players are “what they just ate” (van Loon et al., 2009). In this method labelled amino acids, which can be traced, are infused into dairy cows. The amino acids become incorporated into the cow’s tissues and subsequently incorporated into the cow’s milk. When the cow is milked, the traceable amino acids are intrinsically contained in the milk proteins (casein and whey). These proteins are then isolated and fed to participants in studies to investigate digestion and absorption kinetics, and the subsequent incorporation into skeletal muscle (van Loon et al., 2009).

This technique has been successfully used to investigate protein feeding prior to sleep (Snijders et al., 2019). Intrinsically labelled protein has allowed researchers to

demonstrate that 76 % of the amino acids ingested before sleep are incorporated into myofibrillar protein when individuals exercise (resistance training) earlier that evening (Trommelen et al., 2018). Thus, playing football in the evening may sensitise the muscle, priming it for the uptake of amino acids to aid recovery. Failing to provide protein prior to sleep means that the opportunity to maximise muscle recovery during sleep is lost (Snijders et al., 2019).

The teenage player

It is important to note that teenagers experience changes in their sleep schedules. During adolescence, the internal body clock may shift causing individuals to fall asleep and wake up later. It is advised that the sports medicine staff, sports nutritionist and parents do not attempt to change this, but instead encourage the "sleep hygiene" steps listed in this unit. Research suggests that sleep needs of adolescents do not differ from those of younger children (McLaughlin Crabtree and Williams, 2009), in that generally, studies suggest that adolescents may require a minimum of 9 hours of sleep per night.

Did you know?

Despite being the population requiring the most sleep, teenage players are at the highest risk of poor sleep hygiene, i.e. watching television, using computers or phones late at night. Furthermore, sleep disturbances in players are most likely to occur prior to important matches/competitions. Educating the player on the importance of sleep at an early age should assist in establishing good sleep hygiene habits and equip the player for pre-match preparations as they progress into their senior career.

Modern challenges to sleep

The schedule of professional football during a season is not conducive in promoting "good" player sleep. Players need to cope with several issues which challenge their ability to adhere to "sleep hygiene" recommendations. For example, the kick-off times for professional football matches vary significantly. Teams may be required to play early (12:00, 13:00, 14:30) and late kick offs (19:00, 20:00) to accommodate the scheduling for television. It is possible that if a team has 2-3 matches in a single week, the kick-off time could be different for each match, making a routine bedtime impossible. When travelling, if not staying at a hotel, the travel schedules may lead to an increase in sleep disruption, especially if travelling on a flight.

Finally, social media and computer games are a distraction for youth and professional players alike. Although removing the use of electronic devices in the evening has been reported not to improve sleep quantity or cognitive performance, this was only assessed during a short-duration (4-7 nights) training camp (Jones et al., 2019). It is intuitive that habitual use of telephones or playing video games prior to bed would increase sleep

latency. Educating the player to either turn their phone off 1 hour before bed or to leave their phone in a separate room when going to bed are two simple strategies to reduce screen time prior to sleep.

Summary

- Sleep is important for optimising the health and performance of football players at all levels of the game.
- The nutritionist may use tools such as sleep diaries or actigraphy to monitor or assess players' sleep.
- Players are recommended to achieve 7 hours of sleep a night, though individual needs should be understood.
- Dietary interventions may exert effects on neurotransmitters that are involved in the players' sleep-wake cycle.
- Protein ingestion prior to sleep (30-40 g of whey or casein) is effectively digested/absorbed and used in the recovery of skeletal muscle.
- Nutrition interventions to promote sleep should be used alongside best practice guidelines of sleep hygiene.

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