Module 1: Nutrition for Player's Well-Being

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Unit 1: Nutrition for Player's Health

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 module will discuss nutrition strategies aimed at improving player health (Unit 1) and player sleep (Unit 2). 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. This unit will discuss common methods used to "monitor" player's health over a season. Other factors associated with players' "well-being" such as the gastrointestinal tract, bone and oral health will also be discussed.

Immune Function

Participating in training and matches (either acutely or chronically) will influence a player's immune system and its functions (Bermon et al., 2017). Research has shown that completing intensified training (greater than usual) for 1 week or more may chronically depress several aspects of immune function (Gleeson, 2013). Although professional players are not clinically immune deficient, it is likely that consistent minor changes in multiple immune parameters may reduce the resistance to common minor illness. Players may be at particular risk when engaged in intensive pre-season training, periods of fixture congestion, or during major competitions (e.g. World Cup) (Nieman, 2000).

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, Orme, Anderson, Drust, & Morton, 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.

Bouts of intense exercise (approximately 1 hour in duration) have been shown to result in transient depression of immune function (leukocyte function). It has been suggested that such changes create an "open

window" of decreased protection against viral and bacterial infections (Walsh et al., 2011).

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 which have specialized roles depending on the infection they are fighting.

PLAYER'S HEALTH

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 is associated with a decrease in immune function which, in turn, increases the risk of infection (Cohen, Tyrrell, & Smith, 1991). Common causes of physical and psychological stress are displayed in Table 1.

Table 1: Sources of physical and psychological stresses over a 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	Contracts talks/disputes
Playing with injuries/infections	Loss of form
Inadequate sleep	Commercial/media attention
Rapid body mass loss	Family/personal conflicts

Source: Prepared by author

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". From experience, asking the players to routinely complete prolonged assessments does not work. It is advised that the nutritionist should work with the sports medicine department to devise 3-5 pertinent 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 nutritional status and sleep (Unit 2).

Research studies and some practitioners at football clubs 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) (Bosch, Ring, de Geus, Veerman, & Amerongen, 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 neutralizing 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, Cox, Valdimarsdottir, & Neale, 1987).

Research studies and some practitioners at football clubs use salivary IgA to monitor a player's immune status over the season. 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 period (Sari-Sarraf, Reilly, Doran, & Atkinson, 2007, 2008). The method and collection of saliva samples should be standardized. This is because the salivary IgA response to acute exercise is variable. Players are likely to have individual thresholds, and deviation from their "norm" may provide better indicators of compromised immune function (Moreira et al., 2014).

Nutrition

From a nutrition perspective, much of the core advice for supporting immune function has been discussed in previous "Sports Nutrition for Football" courses. This is because the capability of a player's immune system to protect against pathogens is dependent upon adequate availability of macronutrients [carbohydrate (glucose), protein (amino acids) and fatty acids] for energy and immune cell proliferation.

The player should be encouraged to eat a diet that meets energy needs, with a high intake of fresh fruit. Players should avoid significant hypohydration and a dry mouth during exercise. The player should also

be encouraged to meet all macronutrient and micronutrient requirements. Specific nutrition interventions are presented below but it is important to discuss nutrition in the context of other risk factors. 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 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	

Source: Prepared by Author

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. (Retrived from: https://www.who.int/about/who-we-are/constitution)

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. Therefore, the player should be advised to

follow the carbohydrate ingestion guidelines for training and matches outlined in previous courses.

Protein

There is no evidence that protein ingestion beyond the recommended daily intake of 1.6-2.2 g/kg BM/day will have any further benefits to the player's immune function. It is important to note that glutamine (an amino acid) is used as a fuel for the immune cells (Ardawi & Newsholme, 1983). However, despite the rationale for additional supplementation, there is no conclusive evidence to support the ingestion of additional glutamine for improved immune function (Keast, Arstein, Harper, Fry, & Morton, 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, Jenkins, Stevenson, & Coombes, 2006; Shing et al., 2007). However, it is important to note that not all studies report positive results or statistically significant findings (Buckley, Butler, Southcott, & Brinkworth, 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

Important minerals for immune function are zinc (Zn), magnesium (Mg) and iron (Fe). There is no evidence to suggest that supplementing non-deficient players will boost the immune system (Bermon et al., 2017). However, 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 to dissolve in the mouth may reduce the duration and severity of symptoms (Bermon et al., 2017).

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). Thus, vitamin D supplementation, especially during the winter months, should be considered for players (Close et al., 2013). Dietary supplementation guidelines outlined in previous courses should be followed. The recommended dosage of Vitamin D will be relative to the player's clinically diagnosed vitamin D status (He, Aw Yong, Walsh, & Gleeson, 2016). Current guidelines suggest the intake of Vitamin D3 should be 2000-4000 IU/day (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

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, and there is research suggesting that the intestinal microbiota can have a positive impact on the immune system, thereby reducing the risk of 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 gut will contain millions of microorganisms.

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, Pyne, Peake, & Cripps, 2009). Given the incidence and risk of URTIs in players, nutrition to improve this aspect of player's immunity should be considered.

DID YOU KNOW

The term "**pro**biotics" is given to specific foods or dietary supplements that contain live bacteria. The term "**pre**biotics" is given to foods that provide fuel for the bacteria already in the gut.

Probiotics

Probiotics ingestion is among the most popular nutrition strategies 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. Although a daily dose of ~10^{10} live bacteria is recommended, 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 are non-digestible polysaccharides that promote the growth and activity of the gut microbiota. In general, the ingestion of more than 2.5 grams per day is recommended to alter the quantity of microbiota (Roberts et al., 2016). 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).

It is important to note that whilst research outside of sports nutrition suggests prebiotics have strong effects on the gut microbiota and the metabolic by-products of bacterial fermentation, further research is required in football players. It will be important to investigate starch-specific microbial and immune effects, as well as the various dosages and durations of supplementation before practical recommendations can be prescribed with confidence. Nevertheless, the nutritionist can ensure players are ingesting "prebiotic" foods in their daily diet. Good examples include chickpeas, lentils, barley, bananas, oats, wheat, soybeans, asparagus, leek, chicory, garlic, artichoke and onion (Colbey et al., 2018).

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.

Players who experience significant gastrointestinal complaints during matches or training may improve gastrointestinal integrity by ingesting glutamine before exercise. It has been reported 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 a progressive step.

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), which are good dietary sources of the main nutrients supporting bone health listed above.

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, McLaughlin, Morgaine, & Drummond,

2011). Poor oral health may result in missed training days and ultimately may impact player performance (Gallagher, Ashley, Petrie, & Needleman, 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).

Summary

- Both physical and psychological stress has the potential to impede a player's immune function and increase the risk of infection.
- Players may be monitored for signs of stress, fatigue and recovery.
- The nutritionist should work with the medical team to implement strategies to reduce exposure to infection risks.
- The nutritionist should monitor players' training schedules, diet, frequency of illness and sleep (Unit 2), and if appropriate, modify nutrition strategies specifically for immune function support.

UNIT 2: NUTRITION FOR PLAYER'S 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 & 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 nutritional 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 utilize sleep as a recovery occasion.

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 characterized 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).

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 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.

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 (EOG), muscle activity (EMG) and cardiac activity (ECG) 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".

NUTRITION FOR SLEEP

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, Scammell, & Lu, 2005). The rationale for nutrition interventions is that certain nutrition strategies may act upon these neurotransmitters in the brain to influence sleep. For example, the player's diet may influence the rate of synthesis and function of neurotransmitters, such as serotonin (Silber & Schmitt, 2010). Only a small number of studies have investigated the impact of nutrition interventions on sleep, and they are summarized below.

DID YOU KNOW

The players body's contains chemical messengers are called neurotransmitters. The players 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, Lindseth, & Thompson, 2013; Lindseth & Murray, 2016). Diets higher in protein intake were associated with fewer wake episodes (Lindseth & Murray, 2016), and high fat diets were negatively

associated with total sleep time (Grandner, Kripke, Naidoo & Langer, 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 more than 1 hour before sleep and in accordance to the player's overall 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 & Wurtman, 1971). The uptake of large neural amino acids into skeletal muscle results in a relative increase in free tryptophan passing into the brain. This is because the free tryptophan has less competition to cross the blood brain barrier (Fernstrom & Wurtman, 1971). Based on this information, it is reassuring that the football nutrition guidelines on carbohydrate and protein presented in this certificate are also favourable for promoting player sleep.

Adding small quantities of tryptophan into the diet may improve both the sleep latency and sleep quality of the player. This can be achieved by ingesting approximately 300 g of lean turkey meat or approximately 200 g of pumpkin seeds (Halson, 2014).

DID YOU KNOW

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.

Foods that have high concentrations of melatonin may decrease sleep latency (Cheikh et al., 2018). For example, tart Montmorency cherries have been reported to contain high levels of melatonin. 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 may also have a role in player recovery (Module 2), it could be considered as a strategy for those players seeking to improve their sleep.

SLEEP AS A RECOVERY OCCASION

Optimizing 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 previous 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 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 sensitively of 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. 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 to sleep. The group of athletes routinely ingesting 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).

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, Brett, Cockburn, & Clifford, 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 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 player's sleep. Nevertheless, when introducing this strategy, the sports nutritionist may consider starting with smaller quantities and work towards 30-40g of casein protein over time.

DID YOU KNOW

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

In sports nutrition, one of the greatest challenges is to quantify the impact that nutrition has on performance or recovery (Module 4). A research method called the "intrinsically labelled protein technique" provides a means for the sports nutritionist to show "evidence" that players are "what they just ate", to highlight the importance of food (van Loon et al., 2009). To summarize, in this method 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 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 frequently 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 sensitize 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 maximize muscle recovery during sleep is lost (Snijders et al., 2019).

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 bright 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's time for sleep.

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, nutritionist and parents do not attempt to change this, but instead encourage the "sleep hygiene" steps listed above. Research suggests that sleep needs of adolescents do not differ from those of younger children (McLaughlin Crabtree & 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, teenagers are at the highest risk of poor sleep hygiene, i.e. 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.

CHALLENGES OF FOOTBALL

The schedule of professional football during a season is not inducive in promoting "good" player sleep. Players need to cope with several issues which challenge their ability to adhere to the "sleep hygiene" recommendations above. 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 traveling, if not staying at a hotel, the travel schedules may lead to an increase in sleep disruption, especially if traveling on a flight.

Regarding nutrition, previous courses have discussed the use of caffeine as a dietary ergogenic aid which may be used to support player performance. For evening matches, the ingestion of caffeine at the dosages recommended to aid performance are likely to 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 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 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 prioritized. 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.

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 optimizing 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.

- Dietary interventions may exert effects on neurotransmitters that are involved in the players' sleep-wake cycle.

- Diets high in:

  carbohydrate may result in shorter sleep latencies
  protein may result in improved sleep quality
  fat may negatively influence total sleep time

  though further research is required.

- Protein ingested prior to sleep (30-40 g of 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.

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.

REFERENCES

Abbott, W., Brett, A., Cockburn, E., & Clifford, T. (2018). Presleep Casein Protein Ingestion: Acceleration of Functional Recovery in Professional Soccer Players.

Ardawi, M. S., & E. A., Newsholme (1983). Glutamine metabolism in lymphocytes of the rat. *Biochem J*, *212*(3), 835-842.

Beelen, M., M. Tieland, A. P. Gijsen, H. Vandereyt, A. K. Kies, H. Kuipers . . . & van Loon, L. J. (2008). Coingestion of carbohydrate and protein hydrolysate stimulates muscle protein synthesis during exercise in young men, with no further increase during subsequent overnight recovery. *J Nutr*, *138*(11), 2198-2204.

Bermon, S., L. M. Castell, P. C. Calder, N. C. Bishop, E. Blomstrand, F. C. Mooren . . . & Nagatomi, R. (2017). Consensus Statement Immunonutrition and Exercise. *Exerc Immunol Rev*, *23*, 8-50.

Bosch, J. A., C. Ring, E. J. de Geus, E. C. Veerman & A. V. Amerongen (2002). Stress and secretory immunity. *Int Rev Neurobiol*, *52*, 213-253.

Brandtzaeg, P. (2003). Role of secretory antibodies in the defence against infections. *Int J Med Microbiol*, *293*(1), 3-15.

Bryant, S., K. McLaughlin, K. Morgaine & B. Drummond (2011). Elite athletes and oral health. *Int J Sports Med*, *32*(9), 720-724.

Buckley, J. D., R. N. Butler, E. Southcott & G. D. Brinkworth (2009). Bovine colostrum supplementation during running training increases intestinal permeability. *Nutrients*, *1*(2), 224-234.

Carskadon, M. A. (2011). Sleep in adolescents: the perfect storm. *Pediatr Clin North Am*, *58*(3), 637-647.

Cheikh, M., O. Hammouda, N. Gaamouri, T. Driss, K. Chamari, R. B. Cheikh . . . & Souissi, N. (2018). Melatonin ingestion after exhaustive late-evening exercise improves sleep quality and quantity, and short-term performances in teenage athletes. *Chronobiol Int*, *35*(9), 1281-1293.

Cirelli, C. & G. Tononi (2008). Is sleep essential? *PLoS Biol*, *6*(8), e216.

Close, G. L., J. Russell, J. N. Cobley, D. J. Owens, G. Wilson, W. Gregson . . . & Morton, J. P. (2013). Assessment of vitamin D concentration in non-supplemented professional athletes and healthy adults during the winter months in the UK: implications for skeletal muscle function. *J Sports Sci*, *31*(4), 344-353.

Clowes, J. A., R. A. Hannon, T. S. Yap, N. R. Hoyle, A. Blumsohn & R. Eastell (2002). Effect of feeding on bone turnover markers and its impact on biological variability of measurements. *Bone*, *30*(6), 886-890.

Cohen, S., D. A. Tyrrell & A. P. Smith (1991). Psychological stress and susceptibility to the common cold. *N Engl J Med*, *325*(9), 606-612.

Colbey, C., A. J. Cox, D. B. Pyne, P. Zhang, A. W. Cripps & N. P. West (2018). Upper Respiratory Symptoms, Gut Health and Mucosal Immunity in Athletes. *Sports Med*, *48*(Suppl 1), 65-77.

Dement, W. C. (2005). History of sleep medicine. *Neurol Clin*, *23*(4), 945-965, v.
Fernstrom, J. D. & R. J. Wurtman (1971). Brain serotonin content: increase following ingestion of carbohydrate diet. *Science*, *174*(4013), 1023-1025.
Gallagher, J., P. Ashley, A. Petrie & I. Needleman (2018). Oral health and performance impacts in elite and professional athletes. *Community Dent Oral Epidemiol*, *46*(6), 563-568.
Glaister, M., G. Howatson, C. S. Abraham, R. A. Lockey, J. E. Goodwin, P. Foley & G. McInnes (2008). Caffeine supplementation and multiple sprint running performance. *Med Sci Sports Exerc*, *40*(10), 1835-1840.
Gleeson, M. (2013). Nutritional support to maintain proper immune status during intense training. *Nestle Nutr Inst Workshop Ser*, *75*, 85-97.
Gleeson, M. (2016). Immunological aspects of sport nutrition. *Immunol Cell Biol*, *94*(2), 117-123.
Grandner, M. A., D. F. Kripke, N. Naidoo & R. D. Langer (2010). Relationships among dietary nutrients and subjective sleep, objective sleep, and napping in women. *Sleep Med*, *11*(2), 180-184.
Halson, S. L. (2014). Sleep in elite athletes and nutritional interventions to enhance sleep. *Sports Med*, *44*(Suppl 1), S13-23.
He, C. S., X. H. Aw Yong, N. P. Walsh & M. Gleeson (2016). Is there an optimal vitamin D status for immunity in athletes and military personnel? *Exerc Immunol Rev*, *22*, 42-64.
Howatson, G., P. G. Bell, J. Tallent, B. Middleton, M. P. McHugh & J. Ellis (2012). Effect of tart cherry juice (Prunus cerasus) on melatonin levels and enhanced sleep quality. *Eur J Nutr*, *51*(8), 909-916.
Jones, M. J., B. Dawson, P. R. Eastwood, S. L. Halson, J. Miller, K. Murray . . . & P. Peeling (2019). Influence of Electronic Devices on Sleep and Cognitive Performance During Athlete Training Camps. *J Strength Cond Res*,
Keast, D., D. Arstein, W. Harper, R. W. Fry & A. R. Morton (1995). Depression of plasma glutamine concentration after exercise stress and its possible influence on the immune system. *Med J Aust*, *162*(1), 15-18.
Lindseth, G., P. Lindseth & M. Thompson (2013). Nutritional effects on sleep. *West J Nurs Res*, *35*(4), 497-513.
Lindseth, G. & A. Murray (2016). Dietary Macronutrients and Sleep. *West J Nurs Res*, *38*(8), 938-958.
McLaughlin Crabtree, V. & N. A. Williams (2009). Normal sleep in children and adolescents. *Child Adolesc Psychiatr Clin N Am*, *18*(4), 799-811.
Mitchell, J. A., A. Chesi, O. Elci, S. E. McCormack, H. J. Kalkwarf, J. M. Lappe, . . . & Grant S. F. (2015). Genetics of Bone Mass in Childhood and Adolescence: Effects of Sex and Maturation Interactions. *J Bone Miner Res*, *30*(9), 1676-1683.
Moreira, A., A. L. Mortatti, A. F. Arruda, C. G. Freitas, M. de Arruda & M. S. Aoki (2014). Salivary IgA response and upper respiratory tract

infection symptoms during a 21-week competitive season in young soccer players. *J Strength Cond Res*, *28*(2), 467-473.
Morgans, R., P. Orme, L. Anderson, B. Drust & J. P. Morton (2014). An intensive Winter fixture schedule induces a transient fall in salivary IgA in English premier league soccer players. *Res Sports Med*, *22*(4), 346-354.
Nieman, D. C. (2000). Is infection risk linked to exercise workload? *Med Sci Sports Exerc*, *32*(7 Suppl), S406-411.
Owens, D. J., J. C. Tang, W. J. Bradley, A. S. Sparks, W. D. Fraser, J. P. Morton & G. L. Close (2017). Efficacy of High-Dose Vitamin D Supplements for Elite Athletes. *Med Sci Sports Exerc*, *49*(2), 349-356.
Palacios, C. (2006). The role of nutrients in bone health, from A to Z. *Crit Rev Food Sci Nutr*, *46*(8), 621-628.
Pugh, J. N., S. Sage, M. Hutson, D. A. Doran, S. C. Fleming, J. Highton . . . & Close G. L. (2017). Glutamine supplementation reduces markers of intestinal permeability during running in the heat in a dose-dependent manner. *Eur J Appl Physiol*, *117*(12), 2569-2577.
Res, P. T., B. Groen, B. Pennings, M. Beelen, G. A. Wallis, A. P. Gijsen . . . & van Loon, L. J. (2012). Protein ingestion before sleep improves postexercise overnight recovery. *Med Sci Sports Exerc*, *44*(8), 1560-1569.
Roberts, J. D., C. A. Suckling, G. Y. Peedle, J. A. Murphy, T. G. Dawkins & M. G. Roberts (2016). An Exploratory Investigation of Endotoxin Levels in Novice Long Distance Triathletes, and the Effects of a Multi-Strain Probiotic/Prebiotic, Antioxidant Intervention. *Nutrients*, *8*(11),
Saper, C. B., T. E. Scammell & J. Lu (2005). Hypothalamic regulation of sleep and circadian rhythms. *Nature*, *437*(7063), 1257-1263.
Sari-Sarraf, V., T. Reilly, D. Doran & G. Atkinson (2008). Effects of repeated bouts of soccer-specific intermittent exercise on salivary IgA. *Int J Sports Med*, *29*(5), 366-371.
Sari-Sarraf, V., T. Reilly, D. A. Doran & G. Atkinson (2007). The effects of single and repeated bouts of soccer-specific exercise on salivary IgA. *Arch Oral Biol*, *52*(6), 526-532.
Shing, C. M., D. G. Jenkins, L. Stevenson & J. S. Coombes (2006). The influence of bovine colostrum supplementation on exercise performance in highly trained cyclists. *Br J Sports Med*, *40*(9), 797-801.
Shing, C. M., J. Peake, K. Suzuki, M. Okutsu, R. Pereira, L. Stevenson, D. G. Jenkins & J. S. Coombes (2007). Effects of bovine colostrum supplementation on immune variables in highly trained cyclists. *J Appl Physiol (1985)*, *102*(3), 1113-1122.
Silber, B. Y. & J. A. Schmitt (2010). Effects of tryptophan loading on human cognition, mood, and sleep. *Neurosci Biobehav Rev*, *34*(3), 387-407.
Snijders, T., P. T. Res, J. S. Smeets, S. van Vliet, J. van Kranenburg, K. Maase . . . & van Loon L. J. (2015). Protein Ingestion before Sleep Increases Muscle Mass and Strength Gains during Prolonged Resistance-

Type Exercise Training in Healthy Young Men. *J Nutr*, *145*(6), 1178-1184.

Snijders, T., J. Trommelen, I. W. K. Kouw, A. M. Holwerda, L. B. Verdijk & van Loon, L. J. C. (2019). The Impact of Pre-sleep Protein Ingestion on the Skeletal Muscle Adaptive Response to Exercise in Humans: An Update. *Front Nutr*, *6*, 17.

Stone, A. A., D. S. Cox, H. Valdimarsdottir & J. M. Neale (1987). Secretory IgA as a measure of immunocompetence. *J Human Stress*, *13*(3), 136-140.

Trommelen, J., I. W. K. Kouw, A. M. Holwerda, T. Snijders, S. L. Halson, I. Rollo . . . & L. J. C. van Loon (2018). Presleep dietary protein-derived amino acids are incorporated in myofibrillar protein during postexercise overnight recovery. *Am J Physiol Endocrinol Metab*, *314*(5), E457-E467.

van Loon, L. J., Y. Boirie, A. P. Gijsen, J. Fauquant, A. L. de Roos, A. K. Kies . . . & Koopman, R. (2009). The production of intrinsically labeled milk protein provides a functional tool for human nutrition research. *J Dairy Sci*, *92*(10), 4812-4822.

Walsh, N. P., M. Gleeson, R. J. Shephard, M. Gleeson, J. A. Woods, N. C. Bishop . . . & Simon, P. (2011). Position statement. Part one: Immune function and exercise. *Exerc Immunol Rev*, *17*, 6-63.

West, N. P., D. B. Pyne, J. M. Peake & A. W. Cripps (2009). Probiotics, immunity and exercise: a review. *Exerc Immunol Rev*, *15*, 107-126.