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FOOTBALL TASK FORCE

INJURY PREVENTION AND NUTRITION IN FOOTBALL

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KEY POINTS

- The incidence of outdoor football injuries is among the highest of all sports, particularly for adult male players.
- Almost one-third of all injuries in professional football are muscle injuries. A team of 25 players at elite level can expect about 18 muscle injuries each season with approximately two weeks missed for each injury.
- Body composition is important for elite football in order to prevent injuries. Abdominal fat (assessed by DXA or abdominal circumference) is considered a good predictor of muscular-skeletal injury.
- Although strong evidence is lacking, nutritional screening for injury prevention can include the monitoring of energy deficits, glycogen and protein recovery, nutritional quality, vitamin D levels, lipid profile, hydration status and alcohol avoidance.
- During injury, muscle protein synthesis (MPS) is reduced by inactivity, so muscle stimuli and additional protein are recommended during rehabilitation.
- The use of leucine, creatine, omega-3 fatty acids and some nutraceuticals may be beneficial to MPS during the recovery and rehabilitation process.

INTRODUCTION

Football challenges physical fitness by requiring a variety of skills at different intensities. Running, sprinting, jumping and kicking are important performance components, requiring maximal strength and anaerobic power of the neuromuscular system (van Beijsterveldt et al., 2013). These activities lead to a post-match fatigue that is linked to a combination of factors, including dehydration, glycogen depletion, muscle damage and mental fatigue. The magnitude of football match-induced fatigue is dependent on intrinsic and extrinsic factors. Extrinsic factors include the match result, quality of the opponent, match location and playing surface, whereas intrinsic factors include training status, age, gender and muscle fiber type. Both intrinsic and extrinsic factors have the potential to influence the time course of recovery, making it a complex issue (Nédélec et al., 2012).

The demands placed upon professional players are growing because of the increased fixture schedule, resulting in less recovery periods between training and competitive match play. This increases the risk of injury (Dellal et al., 2013). It has been suggested that recovery time between two matches, 72 to 96 h, appears sufficient to maintain the level of physical performance tested but is not long enough to maintain a low injury rate (Dupont et al., 2010). During periods when the schedule is particularly congested (i.e., two matches per week over several weeks), the recovery time allowed between two successive matches lasts 3–4 d, which may be insufficient to restore homeostasis within players. As a result, players may experience acute and chronic fatigue potentially leading to underperformance and/or injury (Nédélec et al., 2012). In elite European football, players play between 51-78 games a season, averaging 1.6 to 2 matches per week (excluding friendly games). For instance, 80% of FC Barcelona Professional squad averaged 65 official competitive games throughout seasons 2010-2013. Dupont et al. (2010) reported a 6.2-fold higher injury rate in players who played two matches per week compared with those who played only one match per week. During congested schedules, recovery strategies are commonly used in an attempt to regain performance faster and reduce the risk of injury (Nédélec et al., 2012).

Engaging with technical and coaching staff will allow the continued improvement of medical services for the players and a combined effort to prevent injuries to players (Hägglund et al., 2013). In our experience, there are two key messages to convey. The first is the direct relationship between number of matches played and the incidence of player injury. Second, an aggressive proactive recovery strategy will reduce the prevalence of injury. To this end, we have found nutrition to be among the fundamental recovery strategies in professional football.

EPIDEMIOLOGY OF FOOTBALL INJURIES

The incidence of outdoor football injuries is among the highest of all sports, particularly for adult male players. An elite football team with 25 players in the squad can expect about 18 injuries each season. Half of the injuries will be minor, causing absences of less than a week but as many as eight or nine will be severe injuries causing absences of more than four weeks. The incidence has been described to be around 24.6 and 34.8 per 1,000 match hours, and 5.8 to 7.6 per 1,000 training hours (Ekstrand et al., 2011a). Almost one-third of all injuries in professional football are muscle injuries. The majority (92%) of injuries affects the four major muscle groups of the lower limbs: hamstrings 37%, adductors 23%, quadriceps 19% and calf muscles

13%. A team of 25 players at elite level can expect about 15 muscle injuries each season with approximately two weeks missed for each injury. Interestingly, the incidence of match injuries has shown an increasing tendency over time in both first and second halves. Some authors have proposed that this is a consequence of insufficient recovery time between games resulting in chronic fatigue (Ekstrand et al., 2011a; 2011b). However, fatigue may also acutely manifest as the duration of a match increases. Thus, specific nutrition strategies to delay fatigue during games may also have an important role in injury prevention (Rollo, 2014).

PREVENTIVE MEASURES

As described previously, muscle injuries represent more than one-third of all injuries in football. Strategies for activities involving hydration, diet, sleep and cold water immersion have been reported to be effective, with regard to their ability to counteract the mechanisms associated with muscular fatigue (Nédélec et al., 2012). Recovery strategies aimed at reducing acute inflammation from muscle damage and speeding the rate of inflammation removal are prevalent in professional football settings. Sleep and other recovery methods are covered in detail in previous Sports Science Exchange articles (Halson, 2013a; Halson, 2013b). To this end, we will focus on preventive measures, monitoring and recovery of muscle fatigue from a nutritional perspective.

Skeletal muscle is an endocrine or paracrine organ. During contraction, muscle may release growth factors and anabolic factors as insulin-like growth factor-1 (IGF-I) and other mediators of the muscular cytokines or myokine type. Excessive muscle damage associated with overuse or injury results in the release of inflammatory cytokines that are believed to favour catabolism and anabolic resistance. Simultaneously, these factors influence muscle, bone and tendon as a normal response to the injury (Hamrick, 2012). The inflammatory responses are dependent on total muscle mass and can be influenced by nutrition. Therefore, the player's metabolic, biomedical/nutritional and body composition profile can influence the recovery of a muscle in response to an injury.

Biochemical Perspective

From a biochemical point of view, the study of nutritional status can be accomplished, in part, by monitoring certain biomarkers. The knowledge and tracking of individual player biomarkers allow the identification of chronic stress and, therefore, increased risk of injury. Physical performance associated with a single football game or an intense training session induces muscle damage and transient inflammation responses for as long as 72 hours post-exercise. Throughout the season, as workout sessions and training loads accumulate, we are able to detect an increase in biomarkers of muscle damage and inflammation such as CPK, LDH or IL-6 (Table 1). Sometimes these biomarkers are also associated with a decrease in anabolic parameters such as IGF-1 or free testosterone. Interestingly, due to the long competitive season, it remains unclear whether a period of 3-4 weeks' rest, prior to the preseason, is sufficient to fully recover these parameters. The high levels of injury in elite football players might indicate that thorough recovery is not actually achieved between playing seasons (Reinke et al., 2009).

Increased	Decreased
CPK	Hemoglobin
LDH	Ferritin
Cortisol	IGF-1
IL-6	Free testosterone
TBARS (Lipid oxidation)	Lymphocytes

Table 1. Examples of bio-indicators of nutritional status related to fatigue and injury (FCB unpublished data).

BODY COMPOSITION AND INJURY PREVENTION

Body composition must be assessed at the time of injury, specifically, total body mass, lean mass and fat mass. Changes in body composition during injury typically involve increased body fat and decreased lean mass from an early stage. These changes are not always reflected in body mass, as body mass may increase or decrease depending on the situation (Peterson et al., 2011).

Being overweight causes more mechanical stress in certain sports activities, increasing risk of injury. Interestingly, abdominal fat (assessed by DXA or abdominal circumference) has been reported as a better predictor of muscular-skeletal injury than body mass index (BMI); this correlation increases with age (Nye et al., 2014). It is important to note that although frequently used for the general population, players with low body fat and high muscle mass are classified "overweight." Thus, the use of BMI to monitor body composition is inappropriate for football.

Body composition is important for elite football. Players at professional clubs appear to be a homogenous group with little variation between individuals. Similar to our experience, the percentage body fat for professional football players has been reported to be 10.6+2.1% (Sutton et al., 2009). Body composition varies during preseason; a general decrease in abdominal fat mass and increased lean mass in the legs are generally observed. Conversely, during a long period of injury an overall decrease in lean mass is noted, with more marked changes in muscle atrophy and fat deposition in the injured region or segment (Reinke et al., 2009).

Recently, there has been interest in developing injury prevention models based on ratios of different tissues. Schinkel-Ivy et al. (2014) describes the ratio of components of lower extremity; showing the ratio between soft and hard tissues, defined as "Tissue mass ratio." The "Tissue mass ratio" differs according to sports and is believed to be optimized by adaptation to the type of stimulus or impact received. Thus, this ratio may be of consideration when planning nutritional interventions and in the prevention/monitoring of injury. Barbat-Artigas et al. (2012) reported that fat mass/bone mass ratio of a limb correlates inversely with the risk of injury, being lower in non-injured athletes in comparison to those who have suffered injury.

Other indices such as "muscle quality index" correlate the muscle area of a limb and the force or power output (Fragala et al., 2014). This index may be a useful evolutionary parameter when monitoring changes in muscle mass and function in limbs during a period of injury.

THE FOOTBALLER'S DIET: CONSIDERATIONS FOR INJURY PREVENTION

The energy cost of football is approximately 1,300-1,500 kcal for a 90-min game, depending upon playing position, tactics and body composition of the player. In our experience, the amount of energy required should be adjusted to reflect the lean body mass in kg of the individual player. Global positioning satellite technology can be used as a tool to approximate the energy cost of training sessions.

An insufficient energy intake does not cover energy required for match performance, training and daily living activities. It has been reported that energy intakes below 30-35 kcal/kg lean body mass (excluding exercise) accentuate fatigue, immune-suppression and the predisposition to injury (Loucks et al., 2011). Furthermore, low-energy diets in which calories are not consumed via a variety of foods typically have low nutritional quality. Insufficient energy intakes combined with poor dietary choices increase the risk of players being deficient in nutrients such as vitamins B or C; minerals like iron, calcium, magnesium, zinc and selenium. Interestingly, inadequate plasma vitamin D concentrations have been observed during the winter months in top-level players (<30ng/ml) (Morton et al., 2012). Low vitamin D may affect bone metabolism and has been associated with alterations in strength and muscle components (Morton et al., 2012). Therefore, vitamin D status may be a consideration in injury prevention. Unfavourable lipid profiles (pro-inflammatory) due to excesses in the diet of trans-fat, saturated fat and excessive omega 6 fat from vegetable oils should be avoided. Instead, players are encouraged to regularly eat foods such as oily fish for a source of omega-3 (Simopoulos, 2007).

Recommendations and guidelines for player hydration must be customized as far as possible by adjusting quantity and composition depending on changes in body mass. Analysis of sweat and electrolyte losses allows us to further individualize player recommendations. In general, we recommend that body mass losses be no greater than 2% of pre-exercise values. Regarding post-exercise hydration, recently authors reported alcohol intake after training/competition reduces rates of myofibrillar protein synthesis even if co-ingested with protein. The suppression of the anabolic response in skeletal muscle will impair recovery and adaptation to training (Parr et al., 2014). Therefore, inappropriate ingestion of alcohol will have implications for subsequent performance and thus risk of injury.

Dupont et al. (2010) reported that the injury rate increases according to hours of football exposure. However, the risk of injury is significantly increased when games overlap training with less than 72 h between them. In this circumstance (the recovery period is under 72 h) it is necessary to emphasize optimal nutritional recovery strategies. Specifically, the restoration of muscle glycogen after exercise can be achieved by ingesting approximately 60 g of carbohydrates per hour during the first 2-3 hours (Rollo, 2014). Protein intake is recommended immediately post exercise (0.3 g/kg BM, ~20-25 g), together with appropriate volumes of fluid to rehydrate (Laitano et al., 2014; Res, 2014). Some studies suggest the use of nutritional anti-inflammatory aids as flavonoids like quercetin or melatonin, "tart cherry juice" may also be of benefit when recovery time between matches is inadequate. However, evidence is limited and discussion of their application to football is beyond the scope of this review (Res, 2014; Howatson et al., 2010).

NUTRITIONAL INTERVENTIONS FOR THE INJURED PLAYER

During injury, one aspect of recovery that is often overlooked is nutrition. Besides the importance of maintaining body composition as described previously, nutritional interventions must be coordinated with the different phases of the recovery process to optimize the healing process. From this point of view, injury can be classified in two phases: immobilisation phase and functional recovery phase (rehabilitation and re-training). During these phases muscle wasting and atrophy are commonly observed. Therefore, the main objectives are reducing inflammation and increasing anabolic stimuli (Tipton, 2010). For those undergoing surgery a “preoperative” phase could also be considered. For example, it has been proposed that whey protein supplementation in the “preoperative” phase can reduce the acute inflammatory response post surgery (Perrone et al., 2011).

Muscle strength loss and atrophy markedly appear within 5 d of immobilization due to a rapid increase in muscle protein breakdown (MPB) followed by a decrease in muscle protein synthesis (MPS). Around 150 g of muscle mass is lost per day, equivalent to 1 kg/week, with type II muscle fibres being the most susceptible to atrophy (Wall & van Loon, 2013).

After 10 d muscle loss is mainly caused by MPS inhibition, basal and post-prandial, causing atrophy and functional loss. The decrease in MPS, even post-prandial and known as "anabolic resistance," is conditioned by inactivity and injury. Cytokines and catabolic factors, such as myostatins, block the processes in a similar response to aging-related sarcopenia (Wall et al., 2013). Thus, the effectiveness of protein ingestion is impaired and even in the presence of adequate levels of amino acids, protein synthesis is clearly inferior to the situation of no injury. The key issue seems to be muscle stimuli, since anabolic resistance will remain as long as muscle stimulation is lacking. Of note are methods such as percutaneous electro-stimulation and training the uninjured limb or other muscle groups that can exert some cross effect to diminish the anabolic resistance (Farthing et al., 2009).

From a nutrition perspective, the use of some supplements such as leucine may partially attenuate the decrease in MPS through the activation of mTOR (van Loon, 2012). Leucine is an essential amino acid found in greater amounts in proteins of high biological value (i.e., whey protein). The ingestion of 3 g of leucine, isolated or contained in protein, is capable of activating MPS enhancing muscle resistant to insulin (Katsanos et al., 2006). Food also offers a good source of leucine; for example, 3 g of leucine can be found in 25-30 g of whey protein, 140 g of chicken or 170 g of fish. The catabolite of leucine, HMB ingested at 3 g per day has also been reported to be an effective supplement in the activation of MPS, although further research is needed before its use can be recommended, especially in consideration for the injured player (Molfino et al., 2013). Finally, the ingestion of 4 g/day of omega 3 fatty acids may act synergistically with leucine, increasing protein synthesis (Smith et al., 2011a, Smith et al., 2011b).

ACUTE INJURY PHASE

The acute injury phase is characterized by inflammation and, depending on the injury, immobilisation, reduced weight bearing and rest. The daily energy intake needs to be adjusted to the current needs, which are generally lower than before the injury due to lower activity. It is important to note that some metabolic stress injuries require an increase in energy requirements such as bone fractures or walking with crutches. However, detailed discussion on how energy intake should be adjusted for specific injuries is beyond the scope of the current paper.

Protein intake up to 2 g/kg BM is recommended. Protein requirements can be achieved by either ingesting food or supplements containing protein of high biological value at regular intervals throughout the day (fractional dose of 25-30 g, Res, 2014). One strategy is to ingest whey protein between meals at mid-morning or mid-afternoon. Finally, protein intake prior to sleep is also recommended, in this instance casein is a good choice of protein (Churchward-Venne et al., 2012).

Fat intake recommendation should be focussed on omega-3 rich foods such as oily fish, dried nuts, olive oil, avocado, etc., and control where possible excess omega 6 fat diet, as well as other sources of saturated fat. As commented above, supplement with omega-3 in doses of 4 g/ day are also recommended for the injured player.

FUNCTIONAL RECOVERY PHASE

This phase is characterized by progressive hypertrophy and functional recovery. In long-term injuries this phase can be subdivided into regeneration, functional recovery and reconditioning.

REGENERATION PHASE

In this phase, the exercise workout is focused in non-injured muscle groups. General guidelines include adjusting calories to lean mass and controlling carbohydrate intake, choosing low glycemic index foods such as vegetables and legumes. Protein intake is prioritized after exercise (20-25 g/ serving). Interestingly, this phase may benefit from creatine supplementation. Creatine has been suggested to help with the recovery of muscle mass after immobilization when supplemented individuals are compared to non-supplemented individuals. An easy way to achieve this is to incorporate creatine into any protein drinks that a player is ingesting at the time (Op 't Eijnde et al., 2001).

FUNCTIONAL RECOVERY

This phase involves a progressive return to the pitch. The greater energy expenditure requires an increase in daily carbohydrate intake to about 3-5 g of carbohydrate/kg BM. Appropriately formulated carbohydrate sports beverages are typically ingested during and after exercise, to help meet player fuel and fluid requirements (Rollo, 2014). After exercise recommendations for protein are maintained.

RECONDITIONING OR ALTERNATIVE TRAINING PHASE

In this phase previous recommendations, in line with optimal nutrition practice for the player, should be adapted to ensure and support full recovery (advice on key macronutrients, carbohydrate, fluid and protein for football are discussed in Rollo, 2014; Laitano et al., 2014; Res, 2014, respectively).

SUMMARY AND CONCLUSIONS

The demands placed upon professional players are growing because of increased fixture schedules with less recovery periods between training and competitive match play, resulting in increased risk of injury. Recovery strategies are commonly used in an attempt to regain performance faster and reduce the risk of injury. Nutrition is among the key recovery strategies in professional football. The assessment of body composition is important for elite football players. Abdominal fat is a good predictor of musculoskeletal injury and can be used as a monitoring tool during recovery of musculoskeletal injury. Nutrition strategies for recovery should focus on adequate energy intake to meet the macro and micronutrient needs via foods or appropriate supplementation. During injury, muscle protein synthesis is reduced by inactivity. If possible, the muscle should be stimulated, in concert with the ingestion of suitable quantities of protein with high biological value.

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