



RECOVERY NUTRITION FOR FOOTBALL PLAYERS

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KEY POINTS

- Football induces accumulated fatigue during matches and training, mostly due to depletion of muscle glycogen stores, muscle damage, dehydration and central fatigue.
- The time needed to recover should be taken into consideration, with two matches per week requiring more aggressive recovery strategies than a single match per week.
- Nutrition can aid in recovery from fatigue by providing carbohydrate, fluid, protein and, possibly, bioactive food components.
- Alcohol consumption has been shown to impair muscle protein synthesis and functional recovery.
- The recovery strategies used should meet individual player requirements.

INTRODUCTION

Football matches reduce the players' exercise capacity (Mohr et al., 2005; Rampinini et al., 2011). Toward the end of 90-min matches, players generally sprint less and cover less distance (Mohr et al., 2003). After matches, sprint and jump capacity is compromised and muscle functionality is decreased. Recovery of exercise capacity after training and matches is important for optimal performance in football, especially with multiple matches in a week. The intermittent nature of exercise during matches is associated with rapid muscle glycogen breakdown during sprints (Reilly, 1997). Muscle glycogen is almost depleted after a football match (Saltin, 1973). However, muscle glycogen has been shown to be critically important for football performance (Saltin, 1973; Bangsbo et al., 1992). Clearly, restoration of carbohydrate stores is a primary focus of recovery after exercise and the type and amount of foods consumed plays a major role in this process. However, recovery of glycogen stores is only part of the total recovery process. Another focus of recovery strategies should be muscle adaptation and recovery of damaged muscle cells from impact that often occurs during football matches. In addition, restoration of fluid balance should be targeted (Maughan et al., 1997). New research suggests the potential use of specific foods to enhance recovery, nutrition has a profound influence on the recovery process. In contrast, alcohol has been shown to impair the recovery process. In this review, dietary strategies to optimize recovery from football matches and training will be discussed.

CARBOHYDRATE INTAKE FOR RECOVERY

Optimal match performance is largely dependent on muscle carbohydrate stores (glycogen). A football match has been shown to largely deplete muscle glycogen. In a classic study, Saltin (1973) showed that muscle glycogen concentrations were 96, 32 and 9 mmol/kg w.w muscle before, at halftime and after a 90-min match, respectively. Furthermore, it was shown here that a reduction in muscle glycogen content correlated with total distance covered and less sprints. If glycogen is increased through an increase in the amount of carbohydrate in the diet, players can run faster and farther

(Bangsbo et al., 1992). Clearly, replenishment of carbohydrates is a main focus of recovery and exercise capacity. Research has been performed on the type, amount and timing of carbohydrates and the addition of protein for optimal muscle glycogen recovery. The type of carbohydrate ingested can be categorised by glycemic index. Foods with a high glycemic index have been shown to increase muscle glycogen storage (Burke et al., 1993). However, researchers could not find a difference between high and low glycemic diets on sprint and endurance performance 24 h after 90 min of intermittent exercise (Erith et al., 2006). Glycogen resynthesis has been shown to be enhanced with the addition of protein when sufficient carbohydrate is not available (Zawadzki et al., 1992). However, this effect has not been replicated following a football-specific test. Krstrup et al. (2011) showed that even when players were given a carbohydrate-rich diet, it took up to 72 h before glycogen stores were fully replenished. In accordance, Jacobs et al. (1982) had shown incomplete recovery after 48 h with a daily carbohydrate intake of 8 g/kg body mass. In addition, Gunnarson et al. (2013) could not find enhanced glycogen recovery when a carbohydrate and whey protein supplement was added to the diet. In contrast to these football-specific studies, well-trained endurance athletes have been shown to be able to supercompensate muscle glycogen in just 24 to 36 h (Bussau et al., 2002). The cause of the discrepancy is unclear, but it may reflect an inhibition of glycogen resynthesis due to muscle damage due to the eccentric component during football matches in comparison to predominantly concentric exercise like cycling (Costill et al., 1990). The effect of type and amount of carbohydrate in recovery after football does not seem to be as clear as after classic endurance sports. Therefore, it is hard to formulate exact guidelines for optimal recovery given the incomplete 48-h recovery after football matches even in the face of a high carbohydrate intake. An extensive literature review on the ideal amount of carbohydrate for athletes was performed by Burke, (2001). They concluded that a diet containing 5-7 g of carbohydrate /kg BM is a prudent aim for general training needs and glycogen recovery (Rollo, 2014).

PROTEIN INTAKE FOR RECOVERY

Exercise will increase both muscle protein breakdown and muscle protein synthesis. However, in the absence of protein in the diet, net protein balance will remain negative. A negative protein balance will reduce muscle mass, which is key to football performance. Furthermore, eccentric contractions involved in football exercise and contact between players results in muscle damage. Healing of the musculature and any injury is likely to require additional protein (Medina et al., 2014). Therefore, protein is a key ingredient after matches and hard training sessions in order to achieve a positive net protein balance.

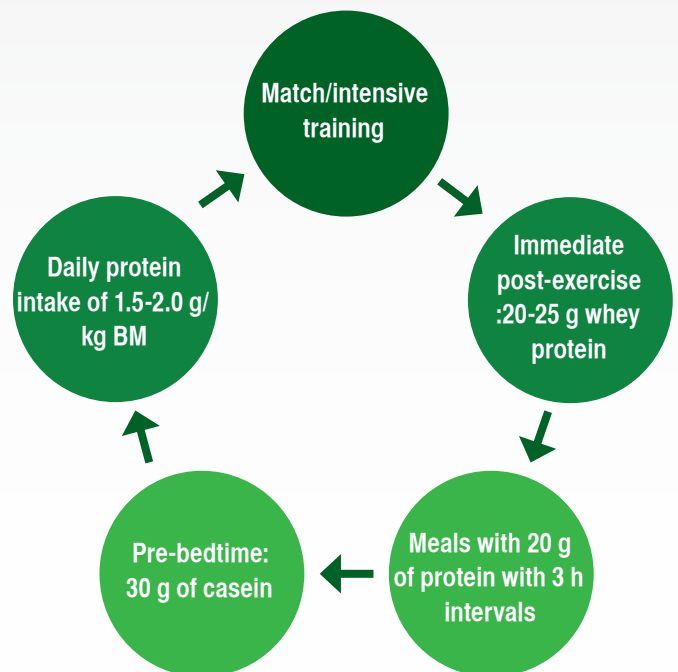
After resistance exercise, muscle protein synthesis in response to a meal has been shown to be elevated for up to 24 h (Burd et al., 2011). Still, protein intake should best be commenced directly after exercise for optimal recovery, especially if limited time is available until the next match or important practice. Muscle protein synthesis decreases over time if blood amino acids are continuously high. Thus, for optimal recovery, meals containing protein should be eaten about every 3 h, with a last meal containing protein just before bed (Res et al., 2012; Areta et al., 2013).

After exercise, the optimal dose of protein to maximally stimulate muscle protein synthesis appears to be 20-25 g, about 0.3 g/kg BM (Moore et al., 2009; Witard et al., 2014). Any protein eaten in excess of this amount cannot be stored and is used as fuel. Animal protein contains more of the amino acid leucine, which is believed to be a main trigger for increases in muscle protein synthesis (Garlick 2005). Whey protein can be quickly digested and absorbed and contains a high proportion of leucine (~10% w.w). Whey has also been shown to elicit superior muscle protein synthesis compared to soy or casein when taken in isocaloric amounts (Tang et al., 2009). Plant-based proteins contain less leucine compared to whey, so more plant-based protein is needed to maximize muscle protein synthesis. Whey protein is therefore considered the preferential protein to ingest directly after exercise.

After the initial protein intake directly post-exercise, players should continue maximizing their muscle protein synthesis. During the day, players should be encouraged to ingest protein from a variety of foods such as fish, meat, poultry and dairy, but also from vegetable sources like legumes, nuts, rice, corn or wheat. Casein has been shown to be beneficial for a pre-bedtime snack, as it is a slowly digesting protein that will be available during a longer portion of the night (Res et al., 2012). For example, cottage cheese, which is high in casein, would be an ideal snack for players before sleep.

Daily protein intake for athletes should be in the range of 1.3-1.8 g/kg BM (Phillips & Van Loon 2011). These recommendations are largely based on nitrogen balance studies and intakes to optimize protein synthesis. However, possibly due to other unknown mechanisms, in extreme situations, daily protein intake far above general recommendations has proven to be beneficial beyond enhancing muscle protein synthesis. In an offshore race, fatigue and memory

loss were attenuated after increased protein intake (Portier et al., 2008). Furthermore, when protein intake was elevated from 1.5 g/kg BM to 3 g/kg BM, tolerance to intensified training was increased (Witard et al., 2011) and immune function was better maintained, resulting in less upper respiratory tract infections (Witard et al., 2013). In addition, elevated daily protein intake in the range of 2.3 g/kg BM has been shown to better maintain muscle mass in the face of an energy deficit (Mettler et al., 2010). Thus, guidelines for daily protein intake for a 70 kg (154 lb) player are to consume about 120 g of protein divided over six meals, interspersed by about 3 h, with each meal containing approximately 20 g of protein (Figure 1). It is important to note that in cases of extreme physical demands or energy deficit, protein needs might be even higher.



FAT INTAKE FOR RECOVERY

Few studies have investigated the role of fat in recovery, let alone after football-specific exercise. In general, fat stores are not limiting during or after football exercise, so it is unlikely that restoration of fat stores has an acute effect on functional recovery. Nevertheless, there is data to show the potential implications that fat may have on recovery. For example, one study has shown an increase in muscle amino acid uptake of whole milk compared to skim milk intake after exercise (Elliot et al., 2006). Furthermore, fat intake should not be too restrictive, as low-fat diets (15% of total energy intake) have been reported to reduce the recovery rate of intramuscular triglyceride (IMTG) stores (Decombaz et al., 2001). Although the importance of IMTG to maximize football performance is unclear, they may serve an important role in the recovery between intermittent sprints. More research is needed to be able to make recommendations on fat intake after football exercise. In general, a high-fat diet will reduce the amount of carbohydrates and protein in the diet and is therefore not advised, but it is important to reiterate an extremely low-fat diet is not advocated either.

FLUID

The available evidence shows detrimental effects of mild dehydration on football performance (Edwards et al., 2007). However, there is little reason to believe performance decrements are different from other intermittent sports or endurance exercise. Fluid losses should be kept within 2% of body weight, with possibly a higher tolerance in a cooler environment (Sawka et al., 2007). Average sweat loss is around 2L for 90 min of football practice; however, individual sweat rates can range from 1.1L to 3.1L per 90 min (Shirreffs et al., 2006). Players should be aware of their sweat rate and drink accordingly to try to maintain within 2% body weight loss. Dehydration can be a cause of fatigue and the post-exercise routine should include a strategy to restore fluid balance. It has been shown that a minimum of 150% of fluid lost during exercise should be consumed to restore fluid balance and account for fluid loss via urine (Shirreffs & Maughan 1998). The dehydration levels typically seen after football matches (~ 2%) can be restored within about 6 h, but only if sufficient fluid and electrolytes are consumed. Electrolytes, especially sodium, should be consumed alongside the fluid in order to be able to retain the water. Sodium can be included in a recovery drink, but also in foods taken alongside the fluid. Sodium losses vary widely among individuals and can be substantial with losses reported up to 10g of sodium chloride during a 90-min football practice (Maughan et al., 2004). Electrolyte losses should be repleted after exercise in order to regain homeostasis.

The time required to rehydrate (~6 h) is much shorter than the time needed to replete muscle glycogen stores (~48-72 h), so that fluid deficit is generally not a limiting factor in recovery. It would be reasonable to suggest that optimal muscle protein and glycogen synthesis would benefit if the player was in a euhydrated state. Therefore, players should adopt an individualised rehydration strategy based on their individual sweat rate, for the first couple of hours after matches and practice. Fluid needs of football players are more extensively covered by Laitano et al. (2014).

NUTRIENTS TO INFLUENCE RECOVERY

In addition to providing macronutrients after exercise, promising data is emerging regarding other food components that may indirectly influence the recovery process. Vigorous (eccentric) exercise has been shown to increase muscle damage, inflammation, delayed onset muscle soreness and reduced muscle function. The response might be triggered by inflammatory cytokines (Davis et al., 2007). This is a healthy process to some extent, but it might overshoot and limit recovery. In that case, food components that modulate the inflammatory process might be helpful in the acute recovery process (Nedelec et al., 2013). Studies have shown some beneficial effects of omega-3 fatty acids (Tartibian et al., 2009), curcumin (Davis et al., 2007), tart cherry juice (Connolly et al., 2006; Howatson et al., 2010) and N-acetyl cysteine (Michailidis et al., 2013) in the recovery process due to their anti-inflammatory and/or antioxidant effects. Although these data show promising results, it should be noted that

not all results were obtained from human experiments, effects on functional outcomes are not always clear and long-term effects have not been evaluated. In any case, anti-inflammatory and anti-oxidant supplementation should be carefully dosed, as the inflammatory process and redox reactions trigger exercise adaptations. Thus, chronic high or mis-timed dosages of antioxidant supplementation may be detrimental to long-term training (Baar, 2014). Furthermore, it is important to note that training up-regulates antioxidant and anti-inflammatory defences (Gomez-Cabrera et al., 2008). Thus, the anti-inflammatory effects of food and supplementation are likely to be less in well-trained athletes. The use of functional foods or food ingredients to enhance recovery is an exciting new area of research, but clearly, more research should be done to be able to determine optimal timing, ingredients, dose and judging long-term effects.

In contrast to possible benefits of certain food components, other food components can have a negative impact on recovery. Anecdotally, some football players ingest large amounts of alcohol after matches. However, this habit can negatively influence the player's recovery via multiple mechanisms. Alcohol stimulates urinogenesis, thereby hindering post-exercise rehydration (Shirreffs & Maughan, 1997). In addition, a recent study by Parr et al. (2014) reported that alcohol consumption comparable to 12 standard units after concurrent training reduced muscle protein synthesis. Other effects of acute alcohol consumption are a decreased inflammatory response, altered cytokine production and increased free radical production (Szabo 1999). Thus, as a result of acute alcohol ingestion, recovery of muscle function is attenuated in the days after exercise (Barnes et al., 2010).

CONCLUSION

Football players should be made aware of the impact of nutrition on the recovery process after exercise. The main targets for recovery nutrition are refilling carbohydrate stores and maximizing the muscle protein synthesis by providing sufficient protein at appropriate intervals. Intake of fat and fluid is unlikely to be a limiting factor in the restoration of exercise capacity, but can play a permissive role. Bioactive food ingredients can have a modulating role in the inflammatory process, thereby speeding recovery. However, many questions remain. The use of "bio actives" should be carefully considered, with the possibility of doing more harm than good. Real food can be used to achieve recovery goals but players' diets are often supplemented with specific products due to ease and practicalities. Practical issues such as total recovery time until the next match, diet quality and individual energy intake "budget" should be considered when planning an individualised recovery strategy.

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