# Module 4. Sports nutrition for football training and matches

## 4.1 Nutrition for football training

### Introduction

Football training is required at all levels of the sport. The type of football training can broadly be categorised into three categories: technical, tactical and physical. Where possible, the goals of training should be based on individual player development needs in context of the overall team objectives. In general, the aim of training is to prepare a player/the team for match competition. Individual players must train to achieve a level of performance which is superior when compared to their peers (be selected for the team) and rival players (win matches).

It is the accumulation of training hours that allows players to develop their skills and physical capabilities. The sports nutrition priorities are to keep players on the training pitch and maximise training adaptations. In the past, sports nutrition has been low on the list of priorities as coaches and the medical team prepare players for matches. However, in literal terms, we now have scientific evidence to support the fact that it is the sports nutritionist who may, in fact, have the biggest impact on "building" a successful team.

This is because all the tissues in a footballer's body (Module 3) are in a constant state of flux. Different tissues in the player's body turn over at different rates (figure 1). Tissues are continuously being broken down and rebuilt from the substrate provided via the diet. Thus, physically, the player that begins a season may be almost a completely different player by the end of the season. Therefore, practical nutrition strategies are required to optimise the remodelling of tissues to "build" capable, resilient footballers.

The aim of this Unit is to introduce the synergies between sports nutrition and football specific training. The objectives of sports nutrition during training will be discussed and practical strategies will be shared.

**Figure 1. Theoretical turnover of the players' different tissues/organs during a 38 week season**


Source: own elaboration.

## Football training

In professional football, players have been reported to complete approximately 3 training sessions a week during a 38-week season. This equates to approximately 120 team training sessions during the competitive season and does not include any self-led training exercise performance by the player (Gaudino et al., 2015).

The time spent engaged in training exceeds that of match play. Importantly for sports nutrition, this equates to a large proportion of the player's time being spent at the team training facility. The training facility provides opportunities to influence the players' daily diet through the meals provided, as well as introduce education and environmental nudges to impact players' eating behaviour. The degree to which training nutrition can be personalised to the player will depend in part on the quality and experience of the catering staff as well as resources (facilities, human and financial) available to the club (Football Nutrition Skills Course).

Although studies have researched the physical demands of football since the 1960s, the quantification of training loads completed by elite professional soccer players have only been examined over the last decade (Akenhead et al., 2016; Anderson et al., 2016; Malone et al., 2015). The energy expended during training will vary depending on the intensity and duration of exercise as well as the body composition of the player (Module 3). Training will also vary depending on the phase of the season and will be heavily influenced by the managerial regime.

**Did you know?**

Clubs often refer to the day of training based on the "proximity" of the game. For example, match day -2, match day -1, match day, match day +1.

It is common practice for professional clubs to monitor the external training load by global positioning satellite systems as well as heart rate and other measures such as player rating of perceived exertion (RPE) scores (Scott et al., 2013; Rampinini et al., 2015). The available evidence suggests that absolute training loads during training are lower than those experienced in match play. This is the case for parameters such as total distance covered, high speed running distance, sprint distance and average speed (table 1). Remember, the velocities associated with each movement are to act as a guide and ideally individual player thresholds should be determined. Training loads also depend on the time of the season, as during pre-season training intensities and durations are typically elevated. During the competitive season, daily training load for the weekly microcycle displays evidence of periodization. The pattern of the training load appears to be dependent on proximity to the game itself as well as the number of games scheduled in a week (Anderson et al., 2016; Morgans et al., 2014).

**Table 1. Typical differences in physical parameters during training and match play**

| Parameter | Training | Match |
|---|---|---|
| Total distance (km) | ~ <7 | ~10-13 |
| High Speed Running (m) | <300 | >900 |
| Sprint distance (m) | >150 | >200 |
| Average speed (m/min) | <80 | ~100-120 |

Source: own elaboration.

## Day to day nutrition

Nutrition for "training" should not be isolated to the "training" occasion. Players are now expected to compete all year round, especially when international tournaments follow domestic seasons and competitive pre-season tournaments are organised. Therefore, the principles of the training diet should ideally be adopted as part of the player's habitual dietary routine. However, experience tells us that implementing nutrition strategies with some players and clubs is not straightforward. Figure 2 summarises the benefits and barriers to good sports nutrition practices.

The appropriate solutions to overcome the barriers of implementing good sports nutrition will depend on the individual player and club. Nevertheless, the one universal tool for the adoption of good nutrition practice is education. If players and staff understand why a nutrition intervention is important, they are more likely to change their behaviour. The education of players and staff can be achieved in many ways. As an example, at FC Barcelona, we developed a sports nutrition guide. This was a working document that detailed the scientific rationale for all nutrition recommendations at the club. The objective of the nutrition guide was to promote a culture of good nutrition practice across all disciplines at the club. For a multidisciplinary approach to be effective, everyone in the team needs to work on the same basis. In this case, generating a nutrition guide or governing document allows a "go-to" resource for everyone to access.

It is important to note that a common challenge for sports nutrition practitioners embedded within football teams is to dedicate the time to collate the body of research. Furthermore, once the research is gathered, the final challenge is to translate the information into simple, relatable, informative materials to help guide and educate the player.

"Ongoing education is an integral part of the sports nutrition service at most top football clubs. Creating a culture to promote good nutrition is vital in this process. Aside from face-to-face contact with the sports nutritionist, other "touch-points" around the training ground are vital to up-skill the players and coaching staff, such as visual displays in the changing rooms, gym and restaurant" (Collins and Rollo, 2014, https://lc.cx/37AzwY).

Sending nutrition messages electronically to the players' telephones is also a common method to deliver advice as well as reinforce education efforts. The training environment should also be shaped to "nudge" players to make better informed decisions around their nutrition – this includes the "flow" of the restaurant and availability of labelled sports nutrition products (Collins and Rollo, 2014).

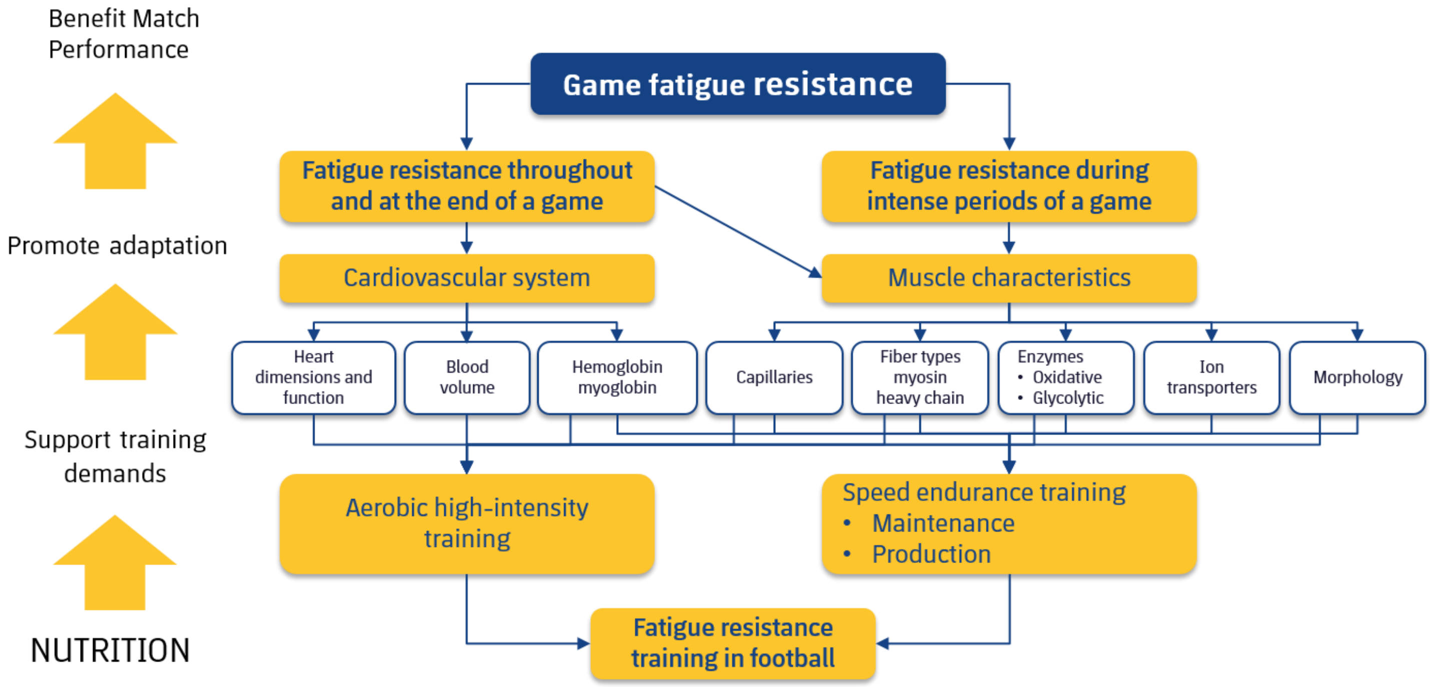
**Key point**

Placing posters at key sites in the training ground is a good way to convey education messages. However, if the same poster is used all year, its message and impact will be lost. It becomes "wallpaper". Change posters frequently to enforce messages relevant to that point of the season.

"Interventions with players need to be considered carefully, appreciating how best to interact and feedback to players. Regular contact with players allows interventions to be "drip-fed" with action points over a series of weeks to shape and reinforce behaviour. At times, the sports nutritionist will need to motivate and influence the player as part of an ongoing program of work" (Collins and Rollo, 2014, https://lc.cx/37AzwY).

If possible, having a designated office for nutrition allows privacy and space for individual work with players to refine their match day strategies. Also, the presence of a sports nutritionist in the changing rooms helps deliver and refine match day strategies (Unit 2).

**Figure 2. Summary of role of nutrition in supporting the training demands to impact match performance**




Source: own elaboration.

"Collaboration with other practitioners within the club will strengthen a sports nutrition strategy or intervention. For example, a fitness coach, physiotherapist or performance manager may coordinate a player's overall program so nutrition action points are often best delivered (and reinforced) by them" (Collins and Rollo, 2014, https://lc.cx/37AzwY).

"Most professional clubs will have an academy or youth development department. There has been much work to standardise the player development pathway. Fundamental to this is nutrition, which plays an ever-increasing role in the growth, maturation and performance of the young athlete (Baker et al., 2013; Jeukendrup & Cronin, 2011; Purcell et al., 2013)" (Collins and Rollo, 2014, https://lc.cx/37AzwY).

A syllabus of workshops can be scheduled regarding foods most relevant to the players and can be used to support training match day performance. With youth players, the parents or person preparing meals is the target audience for the presentation. However, with a low graduation of academy to senior players in many elite football clubs, nutrition can be a key factor in elite player development. Finally, understanding the manager's beliefs and guiding philosophy is paramount when working in a club. Thus, ideally the nutrition "plan" should be constructed in partnership with the coach (Collins and Rollo 2014).

## Benefits and common barriers to sports nutrition

### Benefits of good nutrition

- Enhanced recovery: optimal adaptations.
- Achieve and maintain required body composition.
- Player health: reduce risk of illness.
- Confidence in match day preparations.
- Attain and maintain a high-level performance.
- Enjoy food and social occasions.
- Learn about new foods and cultures.

### Barriers to good sports nutrition

- Poor knowledge of food and drink.
- Outdated knowledge in sports nutrition.
- Poor choices when shopping or dining out.
- Finance.
- Busy lifestyle.
- Poor availability.
- Frequent travel: domestic and international.
- Poor use of supplements and sports foods.

## Key objectives for sports nutrition during training

Four key objectives of nutrition for football training are player health, supporting training demands, training smarter and optimising performance.

### 1. Player health

The health of a player is a prerequisite for performance. Health can be defined as the ability to adapt and manage physical, mental and social challenges throughout life. Thus, maintaining the health of the player is a priority for sports nutrition during training.

The amount of training that a player completes will influence their risk of picking up infections, most likely by affecting immune function. Completing regular moderate intensity exercise will reduce the risk of infection compared with a sedentary lifestyle (Gleeson, 2015). However, very prolonged bouts of exercise, such as when training or match times exceeding 90 min, and periods of intensive training, such as pre-season, are associated with increased risk of infections (Gleeson, 2015). Finally, it is important to note that the inherent nature of football, i.e interacting with a large squad of players and frequent travel, increases the risk of illness.

Acute bouts of prolonged strenuous training may cause a transient depression of various aspects of the player's immune function. This lowered immune response can last for up to 24 hours after exercise (Gleeson, 2015).

"Several studies indicate that the incidence of upper respiratory tract illness symptoms increases in the days after prolonged strenuous endurance events (Gleeson et al., 2013; Walsh et al., 2011b) and it has been generally assumed that this reflects the temporary depression of immune function induced by prolonged exercise" (Gleeson, 2015, https://lc.cx/vCcrom).

**Did you know?**

> The immune response is how the players' body recognizes and defends itself against bacteria and viruses that are foreign and/or harmful.

"Periods of intensified training lasting a week or more, such as some pre-season training camps, have been shown to chronically depress several aspects of immune function" (Gleeson, 2015, https://lc.cx/vCcrom). Although elite football players are not clinically immune deficient, attention should be paid to the possibility that several small changes to immune function may reduce the resistance of the player to common minor illnesses particularly during periods of prolonged heavy training or fixture congestion (Gleeson, 2015).

The common illnesses in players are viral infections of the upper respiratory tract (i.e., the common cold and influenza), which are more prevalent in the winter months. Players can also develop similar symptoms (sore throat) due to an allergy or inflammation caused by inhaling cold or polluted air (Gleeson, 2015). Although these symptoms are considered trivial, they can cause the player to miss training, interrupt training and finally underperform or miss matches.

The sports nutritionist working at a club is unlikely to influence the training program (however, they should be in a position to advise if consulted). Nutritionists should be perceptive to the mood of the players and may use monitoring tools such as rating of perceived exertion, general mood, feelings of fatigue, muscle soreness and sleep to quantify the impact that training is having on player fatigue and immune function. To evaluate the relative risk of immune suppression of players the "red flags" for a nutritionist to watch out for when observing training include the following.

- Prolonged training sessions (>2 h).
- Excessive periods of intensified training or matches.
- Inadequate recovery between intense exercise.
- Monotonous training.
- Inadequate or interrupted sleep (often caused by travel or family commitments).
- Lack of appropriate nutrition interventions.
- Sharing drink bottles.

From a health perspective, it is important for players to ingest adequate dietary energy and essential micronutrients. This can generally be achieved by eating sufficient quantities of a variety of different foods (Macronutrients and Fluid for Football Course). This is particularly important during intense training and during periods of fixture congestion.

As a general recommendation, players can be advised to ingest several different fruits daily on at least 5 days of the week. This is because regular fruit intake is associated with reduced incidence of the common cold. In addition, the consumption of beverages should be encouraged during training to prevent significant hypohydration. Preventing significant hypohydration will reduce the stress hormone response during exercise and maintain saliva flow rate in the mouth. Saliva contains proteins with immune protection properties. Drinking fluid regularly can prevent the drop in saliva secretion typically observed during exercise.

Players should ensure adequate carbohydrate intake before and during prolonged and intense training. Specifically, topping up glycogen stores before exercise and ingesting carbohydrate at a rate of 30-60 g/h has been shown to lower the circulating stress hormone and improve the immune response. In addition, high carbohydrate intakes during repeated days of hard training or busy periods of the season may help preserve the "mood" of the player (Achten et al., 2004). To this end, it is recommended that players avoid rapid weight loss if engaging in intentional physique management programs (Module 3).

For elite footballers, the demands of both training (and match) play may also increase the requirements for some micronutrients to support metabolic processes within the body. These will be covered in detail in Nutrition Considerations in Football Course. Nonetheless, it is common for players to have suboptimal status of vitamin D and C, outlined below.

Vitamin D has important roles in up-regulating immunity and bone health. Vitamin D supplementation may be considered in those players who have limited exposure to natural sunlight, such as when training in the winter months or when routinely training indoors. In these situations, including a vitamin D3 (5,000 IU/day), in the player's overall energy intake may be beneficial for immune function.

It is important to note that "traditionally" high doses of vitamin C have been recommended to either boost immunity or combat common colds. The available evidence would suggest that high doses (≥1000 mg/day) are not justified. More prudent advice would be to ensure the ingestion of 200 mg/day through dietary sources. Vitamin C intake may not prevent common colds, but may reduce the duration of the symptoms. Fruits such as oranges, kiwi fruit, pineapple, strawberries and grapefruits are all good sources of vitamin C. The indiscriminate use of supplements is not recommended, and guidelines on dietary supplementation will be covered in Nutrition Considerations in Football Course.

**Key point**

Ingesting foods rich in vitamin C may not prevent common colds, but may reduce the duration of the symptoms.

### 2. Support training demands: energy balance

When training is modified to expend more or less energy, players should also modify their diet to increase or reduce energy intake. The ability to modify the diet according to training is important in the availability of energy as well as the management of the players' physique to achieve performance goals and avoid ill health (Loucks et al., 2011). The main factors governing the energy expended during exercise are the intensity and duration of training.

The quantification of the training loads completed by elite professional soccer players has been investigated (Anderson et al., 2017). The training load has been reported to be determined by the proximity of the training session to the game as well as the number of games scheduled in a week. As training load (energy expenditure) will fluctuate daily, it is intuitive from a nutrition perspective that energy intake should be adjusted to account for the goals of that particular day. For example, clubs may complete a "tactical" training session two days before the match. Tactical sessions are, in general, less intense and allow the team to practice formation tactics "shape" and set pieces (corners, etc.) An effective way to modify the daily energy intake is to adjust the daily intake of carbohydrate. In this circumstance, the "periodization" carbohydrate intake corresponds to the demands of exercise.

The energy requirements of elite soccer players during training (and matches) has been quantified over a 7-day in-season period (5 training days, 2 match days). Based on the individual data, elite players' daily energy expenditure ranged from 3047 to 4400 kcal per day. Lower energy expenditure and intakes were associated with training days. Interestingly, there was evidence that carbohydrate intake was periodized, such that absolute daily intake of carbohydrate intake and carbohydrate feeding surrounding exercise was greater on match days in comparison with training. Over the 7-day monitoring period there were no differences between average daily energy expenditure (3566 ± 585 kcal) and self-reported energy intake (3186 ± 367 kcal), suggesting that elite players are capable of ingesting sufficient quantities of food to match overall energy requirements. However, it is not clear whether these practices were player-led or a reflection of the nutrition guidance accessible to the player at professional clubs.

## Table 2. Suggested daily range of carbohydrate intake for football training

**Table 1** The training carbohydrate intake continuum

| Training scenario | Training objectives | Desired training adaptations | Typical daily external training load parameters (as quantified during pitch-based training according to GPS; HSR ≥19.8 km/hour) | Suggested daily CHO range | Comments |
|---|---|---|---|---|---|
| Preseason training | ► To improve players' physical/mental/tactical qualities<br>► To prepare players for a full playing season<br>► To avoid injury and illness | ► Increase aerobic and anaerobic fitnessIncrease lean mass/reduce fat mass<br>► Increase/maximise strength, speed, power for performance and injury prevention | Duration: 60–180 min<br>Total distance: 3–12 km<br>HSR: >400 m | 4–8 g/kg BM | Suggested range accommodates likely variations in loads (eg, potential twice per day sessions, recovery days) as well as individual training goals (eg, manipulation of body composition to accommodate weight loss and fat loss or weight gain and lean mass gain). For example, twice per day training structures would likely require higher CHO intakes (eg, 6–8 g/kg BM/day), whereas lower absolute intakes may be required where players are aiming for body fat loss or training intensity and duration is reduced (eg, 4–6 g/kg BM/day). |
| In-season training (one game per week) | ► To maintain physical qualities (and improve where possible/appropriate)<br>► To keep players injury and illness free<br>► To practise MD nutrition strategies | ► Maintain aerobic and anaerobic fitness<br>► At least maintain strength, power, speed<br>► Maintain lean BM<br>► Train the gut to tolerate CHO during football-specific training (occasional use) | Duration: 45–90 min<br>Total distance: 2–7 km<br>HSR: 0–400 m | 3–8 g/kg BM | Suggested range accommodates likely variations in loads across the microcycle (eg, low load days and MD-1 CHO loading protocols) as well as individual training goals (eg, manipulation of body composition). For example, MD-1 and MD +1 would require higher CHO intakes (eg, 6–8 g/kg BM/day), whereas lower absolute intakes may be required on other days of the week (eg, 3–6 g/kg BM/day) depending on training intensity, duration and player-specific goals. |
| In-season training (congested fixture periods) | ► To avoid injury and illness<br>► To accelerate recovery | ► Restore muscle function as quickly as possible<br>► Promote glycogen resynthesis<br>► Fluid replacement: rehydration<br>► Alleviate mental fatigue | Duration: <60 min<br>Total distance: <3 km<br>HSR: <50 m | 6–8 g/kg BM | Suggested range accommodates the requirement to replenish muscle glycogen stores in the 48–72 hours period between games. During this time, it is suggested that players consistently consume CHO within this range so as to promote glycogen availability. |
| Off-season training | ► To avoid detraining<br>► To ensure players come back ready for the demands of the preseason | ► Minimise the loss of aerobic and anaerobic capacity<br>► Minimise decrements in strength, power, speed<br>► Minimise decreases in lean mass and increases in fat mass | N/A | <4 g/kg BM | Suggested intake accommodates the cessation of normal training loads, to avoid gains in fat mass. Note, for players who may be undergoing higher training loads (eg, off-season training programmes) CHO intake should be increased accordingly. |

BM, body mass; CHO, carbohydrate; HSR, high speed running; MD, match day; N/A, not available.

Source: own elaboration based on Collins et al., 2021.

These recommendations should be refined with individual considerations of total energy needs, specific training needs and feedback from training/competition performance. The acute guidelines are designed to promote high carbohydrate availability to promote optimal performance in key training sessions and competition (Burke et al., 2011; Collins et al., 2014).

**Figure 3. Example of a training ground menu at FC Barcelona**

**DAILY TRAINING GROUND MENUS**

**High quality ingredients**
**Low fat recipes**
**Use seasonal ingredients**

Salad bar

1 soup option

≥ 2 options high in carbohydrates
*At least 1 gluten free option*

≥ 2 high protein low fat options
*Also 1 vegan protein option*
*Halal options*

≥ 1 recipe low or moderate in carbohydrates

≥ 2 cooked vegetable options

Healthy desserts made using fruit and yogurt
*Lactose and dairy free options*

White and wholemeal bread, and bread with seeds

Mineral water

**Depending on budget, menus can be adapted to add variety and specific recipes to cater for injured players, and different diets, religions and for those with allergies, for example.**

Source: own elaboration.

## 3. Train smarter

Traditional reasoning in football simply thought of sports nutrition as a tool to help players train harder. Nutrition strategies in this way were typically rolled out across the entire team, in a "one size fits all" approach. A modern approach in football, should consider sports nutrition as a way to train smarter. The nutrients the player ingests in their diet before and after exercise will impact the metabolic response during training and enhance the desired adaptations respectively. Players are still required to train hard, but nutrition can maximise those responses to training. The types of foods ingested, when they are eaten, and how much food is ingested can therefore have a big impact on the training response. Furthermore, instead of generic advice for all football players, certain sports nutrition strategies can be personalised to the individual player.

**Key point**

A modern approach in football should consider sports nutrition as a way to train smarter.

### Fluid

"Body fluid balance is primarily a function of a player's fluid intake (i.e., hydration practices) relativ to his or her fluid losses (i.e., sweat) during training (or matches). Electrolytes, particularly sodium, are also lost with sweat. Electrolyte replacement is linked to hydration because replacing sodium losses increases the retention of ingested fluid (Shirreffs & Sawka, 2011)" (Laitano et al., 2014, https://lc.cx/5r-D6e).

A previous misconception from coaches was that obtaining accurate fluid balance data during training would distract players. However, the increasing number of studies published about fluid and electrolyte balance in both professional male and female football players, and even in referees, would suggest this is not the case (Laitano et al., 2014).

“The method to monitor fluid balance includes the collection of a pre-match/practice urine sample (first morning void/mid flow) to determine urine specific gravity (USG) or urine osmolality followed by the recording of pre-exercise body mass. In studies where sweat electrolyte composition is determined, absorbent sweat patches are attached to various anatomical sites after the skin is thoroughly cleaned with deionized water and dried. Thereafter, bottles containing fluid (e.g., sports drink and/or plain water) identified with players’ names are weighed before the training or match. Players are instructed to drink only from their personal bottles, not to spit any of the fluid out, and not to rinse their faces with the water. They are also instructed to urinate in a container, if needed, during the practice/match-play so that this mass loss can be taken into account for sweating rate calculations. After the activity, sweat patches are removed and the body is towelled dry before post-match/practice body mass is recorded. Finally, bottles are re-weighed so the volume consumed during the training session or match can be calculated and considered for sweating rate calculations. This method is used to determine sweating rate, ad libitum fluid intake and percent change in body mass (i.e., fluid balance)” (Laitano et al., 2014, https://lc.cx/5r-D6e).

The key point of this method is that players will have significantly different sweat rates and electrolyte losses, even in response to the same training session. This method identifies those players with high sweat sodium losses who may need to pay attention to sodium replacement post exercise (Laitano et al., 2014).

“Rehydration is an important part of the post-exercise recovery process. If players have accrued a body mass deficit, they should aim to completely replace fluid and electrolyte losses prior to the start of the next training session (or match). If dehydration is severe (>5 % of body mass) or rapid rehydration is needed such as for preseason double training sessions (≤ 24 h before next practice or match) the recommendation is to drink ~1.5 L of fluid for each 1 kg of body mass deficit (Shirreffs & Sawka, 2011)” (Laitano et al., 2014, https://lc.cx/5r-D6e). This value can only be calculated by monitoring the player's body mass loss during training.

Other important watch outs for a nutritionist to observe during training are the frequency and duration of drink breaks, which should be modified depending on the intensity of the training session. The proximity of players to drink bottles is also important as, if they are not “near” their drink, the voluntary fluid intake will likely decrease. Drink bottles should not be shared, and ideally individually labelled bottles prepared. Finally, observing many football players, it is common for players to use drink bottles to pour on their heads to “cool down”, especially in hot conditions. On these occasions, simply make sure there are dedicated bottles for this purpose.

**Protein**

A common misconception in football is that increasing the protein intake in the diet will make the player "bulky" and "heavy". Instead, there is sufficient evidence to show that the ingestion of protein is important in remodelling skeletal muscle as well as all tissues in the body. Thus, the ingestion of sufficient quantities of protein is required for both endurance and strength adaptions required by the football player (Churchward-venne et al., 2020).

It is generally accepted that protein recommendations for athletes, including professional football players, are more complex than simply prescribing a total daily protein intake. Instead, multiple factors including the per meal/serving dose, source and timing of protein intake, as well as the co-ingestion of other nutrients, are known to influence recovery in professional football.

- **Timing**

Consume protein after training and matches to maximise protein synthesis and promote adaptation.

In general, consumption of protein following training has stimulatory effects on muscle protein synthesis and remodelling of muscle tissue. Ingesting protein increases the amino acid concentration in the blood, which then provides the substrate for anabolic processes that are activated by training (Phiilips, 2013).

An often forgotten occasion to enhance the adaptation to and recovery from exercise is sleep. Studies have shown that if 30-40 g casein or whey protein is ingested before sleep, the protein is digested and absorbed. The increased plasma amino acid availability results in increasing muscle protein synthesis rates. Therefore, ingesting dietary protein prior to sleep may represent an effective day-to-day strategy to maximize the skeletal muscles adaptive response to football training.

- **Quantity**

Players are recommended to consume protein throughout the day at regularly spaced intervals to maximize the anabolic response. As a guide, 20-25 g of protein should be ingested per meal. This can be personalized to the individual player by providing between 0.25-0.30 g protein per kg of the player's body mass each meal. Daily intake of protein in the range of 1.6 – 2.2 g/kg BM/day would be adequate for most players completing heavy training (Collins et al., 2021).

- **Type**

Whey protein, due to its leucine content, represents a good protein source to stimulate new muscle protein synthesis (Phillips, 2013). Following training, liquid forms of protein are generally used by footballers as it allows a rapid digestion rate and the co-ingestion of other key nutrients for recovery (carbohydrate, fluid). It should be noted that football training "primes" the muscle and so, although whey is commonly considered "the best" protein, other isolated proteins such as milk protein or soy offer similar benefits as long as appropriate quantities are ingested.

Ingesting 15 g of gelatin approximately 1 h before exercise may help the remodelling of tendons and ligaments. This is because gelatin is rich in specific amino acids (proline, lysine, hydroxylysine and hydroxyproline) required for connective tissues. However, as tendons and ligaments have limited blood flow, they get their nutrients through bulk fluid flow (Baar, 2015). This is why protein must be ingested prior to exercise, so the amino acids are available in the circulation to be "drawn into" the connect tissues as they are loaded and relaxed. Although, the evidence is currently limited, the ingestion of gelatin may be an effective strategy to consider for those players prone to or recovering from connective tissue injury.

**Carbohydrate**

Carbohydrate periodization refers to adjusting the daily intake of carbohydrate and carbohydrate intake during exercise to match the demands and objectives of training (table 2).

Studies have reported that periodically completing endurance training sessions with reduced carbohydrate availability ("training low") modulates the activation of acute cell signalling pathways (Impey et al., 2016). Although endurance type adaptations are enhanced, approximately a third of studies investigating this paradigm report no improvements in physical performance. Nevertheless, such strategies may be utilized for individual players either in rehabilitation or in physique management.

Manipulating the carbohydrate status of the player to promote components of training adaptation (train low), should be completed in conjunction with training sessions that ensure adequate carbohydrate (train high). This is because carbohydrate availability will promote physical performance, reduce injury risk and aid recovery (Burke et al., 2011).

It is important to note that "training low" and abstaining from carbohydrate ingestion during exercise is likely to result in a more substantial degree of immune suppression. Thus, as a guide "training low" should be limited to a few days of the week to reduce the risk of immune function being compromised. Furthermore, this approach is not encouraged during the season within weeks with multiple matches.

## 4. Optimise performance

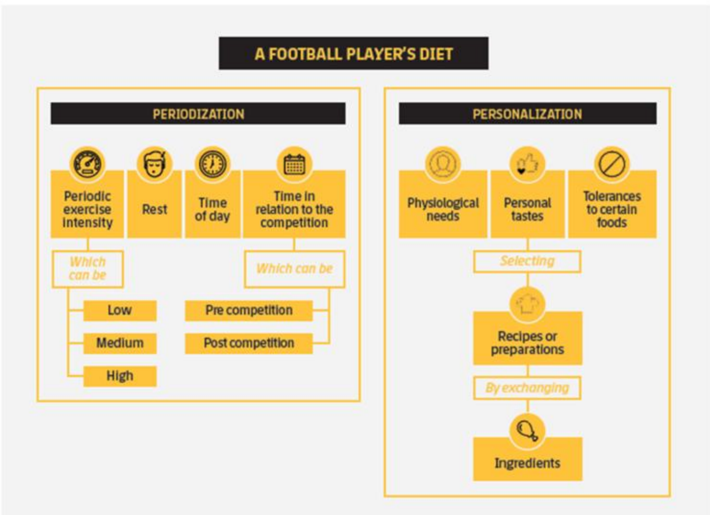
The principal aim of fitness training in football is to target the physiological mechanisms causing fatigue and thereby limiting physical football performance. A higher fatigue resistance will allow the players to utilize their technical and tactical capacity throughout a game and especially during the critical game periods (Mohr and Iaia, 2014).

Correspondingly, training is also the opportunity to practice match day nutrition strategies. The gastrointestinal tract is critical in delivering carbohydrate and fluid to the blood during football training and matches, and can therefore be a major determinant of performance (Jeukendrup, 2017).

Gastrointestinal problems are common in football players and may be alleviated by adapting the gastrointestinal tract during training to the specific conditions it will be exposed to during a match. There is a substantial body of evidence to support the fact that the gastrointestinal tract is highly adaptable (Costa et al., 2017). Therefore "training the gut" during training may improve stomach comfort and reduce symptoms of gastrointestinal tract distress during a match.

As a guide, ingesting carbohydrate before and during an intense training session to replicate match day strategies (Unit 2) may improve gastric emptying and carbohydrate absorption. These factors would be likely to reduce the chances and/or severity of gastrointestinal problems, improving the experience and subsequent performance of the player. Thus, as a rule, any nutrition strategy to be considered on match day should be practiced in training before adopting in competition (figure 2).

**Figure 4. Factors influencing sports nutrition strategies for training and matches**




Source: own elaboration.

**Summary**

- It is the accumulation of training hours that allows players to develop their skills and physical capabilities.
- Training intensities and durations are typically lower in comparison to a match.
- The primary objectives of sport nutrition for training is to maintain player availability and maximise adaptations.
- Energy intake and macronutrient composition of a player's diet should be modified to supporting training demands.
- Training is the opportunity to practice match day nutrition strategies before adopting in competition.

## 4.2 Match day nutrition

### Introduction

The team performance on "match day" is the focus for all players and staff. The primary objective on match day is to achieve a win over the opposing team. The success of the team depends on the mutual cooperation of individual players to score more goals than the opposition. On match day, there are many factors that may impact the "performance" of the individual player. However, out of all these factors, nutrition remains one variable over which the players may have direct control, and which can be easily influenced by the sports nutritionist.

Carbohydrate is the primary fuel for muscle during high-intensity activity (Module 2) and therefore the key macronutrient when preparing players for match play. From the perspective of the nutritionist working in football, planning a nutritional strategy for match day begins by first knowing the time and location of the match (Williams and Serratosa, 2006). Thereafter, the nutritionist may determine the time available for meals and recommend their composition considering the culinary preferences of the players. Second, the nutritionist may implement acute strategies before and during the match with the objective of optimising individual performances. Finally, after the match the objective is to speed the recovery (maximise adaptation) following exercise (Williams and Serratosa, 2006). The objective of this unit is to provide an overview of those studies that inform the nutrition practice of the player before, during and after the match, as well as to cover some of the practical issues in implementing these strategies.

### Did you know?

Many factors may influence a player's performance during a match, which they cannot control, including, but are not limited to, skill level of opponent, fitness of the opponent, tactics, formation, environmental conditions and official/refereeing decisions.

### Before the match

Preparation for the match begins the day before. On the day prior to a match (MD-1), training is usually light and CHO intake should be at least 6–8 g/kg body mass (BM) to elevate muscle and liver glycogen stores (Collins et al., 2021. To develop a successful nutritional strategy for players on match day, it is important to recognize that in many football clubs the pre-match meal is largely dictated by tradition and routine. For many players, a departure from their favourite pre-match meal is regarded as much a disadvantage as beginning a match with a physical injury (Williams and Serratosa, 2006).

A mistake would be for a sports nutritionist "new" to a team to enforce sweeping changes following their appointment. It is recommended to have patience and dedicate time to observing and "understanding" the current nutrition "regime" of the team. To this end, the recommended nutritional strategy should be developed in the context of what is custom practice within a football club, but also supported by sound scientific evidence. The standard recommendation is that players should eat an easy-to-digest high-carbohydrate meal no later than about 3 hours before a match. This recommendation has not changed since the publication of the Consensus Statement on Nutrition and Soccer over two decades ago (Ekblom and Williams, 1994; Collins et al., 2021).

The commonly practiced recommendation to eat an easy-to digest high-carbohydrate meal about 3 hours before exercise does not usually include details of the type of carbohydrate. Nevertheless, it is assumed that they are high glycaemic index (HGI) carbohydrates that are digested and absorbed more quickly than low-glycaemic (LGI) index carbohydrates.

Eating a HGI carbohydrate meal that provides 2.5 g/kg body mass (BM), 3 h before exercise, increases muscle glycogen levels by about 11–15 % (Wee et al., 2005). This relatively modest increase in muscle glycogen is a consequence of the early removal of systemic glucose by the liver and allowing 3 h may be insufficient for the complete digestion and absorption of the carbohydrate meal. In contrast, when an energy-matched LGI carbohydrate meal was consumed, there was no measurable increase in muscle glycogen levels. It is reasonable to assume that the slower digestion and absorption of the high-fibre carbohydrate meal results in a delayed delivery of glucose to the systemic circulation and hence skeletal muscles (Williams and Rollo, 2015).

Consuming an LGI carbohydrate pre-exercise meal results in a smaller rise in plasma insulin level than is the case following HGI carbohydrate meals. As a consequence, the inhibition of fatty acid mobilisation is reduced, the rate of fat metabolism during subsequent exercise is increased, and so muscle glycogen is oxidised more slowly. This more economic use of the limited glycogen stores is an advantage during prolonged submaximal exercise; however, brief periods of sprinting rely on a high rate of glycogenolysis and phosphocreatine degradation. Therefore, as mentioned in previous modules, even a higher rate of fat metabolism, following an LGI carbohydrate meal, will not provide ATP fast enough to support repeated high-intensity running (Williams and Rollo, 2015).

**Table 3.** Example of high and low glycaemic index meals

| Characteristics of the High and Low GI meals (for a 70kg subject) | | |
|---|---|---|
| **Meal** | **Description** | **Macronutrient content** |
| High-GI breakfast | 72 g Corn Flakes®, 300 ml skimmed milk, 93 g White bread, 12 g Flora spread, 23 g jam, 181 ml Lucozade Original® | 852 kcal<br>162g carbohydrate<br>12g fat<br>23g protein<br>**GI = 78*** |
| Low-GI breakfast | 100 g muesli (without raisins), 300 ml skimmed milk, 78 g Apple, 120g tinned peaches, 149g yogurt, 300ml Apple juice | 855 Kcal<br>162g carbohydrate<br>11g fat<br>27g protein<br>**GI = 44*** |
| *Calculated by teh method of Wolever (1986). Glycaemic index values from Foster-Powell *et al. (2002).* Registered trade marks: Corn Flakes® (Kellogg's Ltd, Manchester, UK); Lucozade Original® (GlaxoSmithKline, Brentford, UK) | | |

Source: own elaboration based on Foster et al., 2002

When considering objectives of the pre-match meal, it is important to make considerations beyond "topping up" muscle glycogen. The pre-match meal should also be formulated to optimize the "gut comfort" and feelings of satiety of the player. Overall, the objective is for the player to feel "ready" to play. For example, when considering the merits of HGI and LGI pre-exercise meals, it is important to remember that to achieve the same amount of carbohydrate and energy, the LGI meal will have a greater amount of food than in the HGI meal (Williams and Rollo, 2015). This is because LGI carbohydrates generally have higher fibre content and so more food has to be consumed to match the amount of carbohydrate in HGI foods. On the one hand, the higher fibre content of LGI carbohydrate foods may result in players feeling "fuller" earlier in comparison to ingesting HGI carbohydrate foods. Consequently, players may consume less carbohydrate than recommended when eating LGI foods which may be insufficient to increase their glycogen stores. On the other hand, feelings of "fullness" and satiety may improve the players' perception for "readiness" to play.

Interestingly, the few studies that compared the impact of HGI and LGI carbohydrate pre-exercise meals on performance during intermittent brief high-intensity exercise failed to show any performance differences (Bennett et al., 2012; Williams and Rollo, 2015). Therefore, the sports nutritionist should first evaluate the quantity and type of carbohydrate the player is choosing for their pre match meal, before adjusting gradually over time to meet guidelines.

Most players will have their routine pre-match meal. It is difficult for the player to break with tradition as typically it is a meal that they have been ingesting during their "rise" in the profession. This observation in itself highlights the importance that players place on food related to their performance. It is for this reason that changes to the pre-match meal and recommendations should be based individually and practiced in training first. Practicing the pre-match meal in training allows a "safe" environment, allows trial and error, which should ultimately lead to the player having confidence in their dietary choices. As players will complete approximately 50+ games a season that equates to 50+ pre-match meals. It is encouraged for the players to have options for pre-match meals to avoid monotony/flavour fatigue. Although, carbohydrate intake should be prioritized, meals should also include protein and there is no need for them to be devoid of nutrients.

**Figure 5. Example of a match menu at FC Barcelona**

## MATCH DAY MENUS

**High quality ingredients**
**High carbohydrate recipes**
**Moderate protein recipes**
**Low fat recipes**
**Low FODMAP recipes**
**Avoid new foods or recipes**

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Salad bar
*High nitrate foods*

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1 easy to digest soup option

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>2 options high in carbohydrates
*At least 1 gluten free option*

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≥ 1 recipe high in carbohydrates

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≥ 2 high protein low fat options
*Also 1 vegan protein option*
*Halal options*
*No seafood, raw fish and raw meat*

---

2 cooked vegetable options

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Low fibre foods

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Fruit and yogurts
*Lactose and dairy free options*
*≥ 1 special healthy dessert*

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White bread

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Mineral water

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Fruit smoothies

**Depending on budget, menus can be adapted to add variety and specific recipes. However, it should be considered that many players prefer stable menus without changes around the match period.**

Source: own elaboration.

**Did you know?**

The glycemic index ranks carbohydrate-based foods relative to how they affect the player's blood glucose concentrations. Low glycemic index carbohydrates are digested, absorbed and metabolized slowly, resulting in a lower and slower rise in blood glucose and insulin levels compared to high glycemic index carbohydrates.

Balsom and colleagues examined the influence of carbohydrate loading on the performances of six soccer players during a 90 minute four-a-side soccer match (Balsom et al., 1999; Williams and Rollo 2015). In this study, muscle glycogen levels were lowered 48 hours earlier when players completed a variable-speed shuttle running test. This protocol would be representative of playing a 90-minute match. Thereafter, the players changed the carbohydrate content of their diet to one with either 30 or 65 % of daily energy intake. Following the high-carbohydrate diet, muscle glycogen level was 28 % higher than after the low-carbohydrate diet. Importantly, the analysis of the movement patterns during the simulated four-a-side soccer match showed that after the high-carbohydrate diet, players performed 30 % more high-intensity running in comparison to the low-carbohydrate pre-match diet. There was no difference between the performances of technical skills during the four-a-side matches following the two dietary preparations (Williams and Rollo 2015).

## Caffeine

Dietary supplementation in football and its role on match day will be covered in Nutrition Considerations in Football Course. However, it is important to discuss the role of caffeine in pre-match nutrition due to its prevalence amongst players pre-match routine. Caffeine is found in a variety of drinks and foodstuffs (e.g., tea, coffee, cola, chocolate, etc.) and is perhaps the most widely studied and research-proven of all ergogenic aids. Indeed, caffeine has been consistently shown to improve both cognitive and physical performance across a range of endurance sports (Morton, 2014). However, numerous data suggest that caffeine also improves the physical and technical elements of performance that are inherent to football match play. For example, caffeine can enhance repeated sprint and jump performance (Gant et al., 2010), reactive agility (Duvnjak-Zaknich et al., 2011) and passing accuracy (Foskett et al., 2009) during intermittent-type exercise protocols. The ergogenic effects of caffeine are typically achieved with ingestion of 2-5 mg/kg BM (Burke et al., 2008). Given that plasma caffeine levels peak approximately 30-

60 minutes after ingestion (Graham and Spriet, 1995) it is recommended to consume caffeinated drinks, capsules or gels (depending on players' preferences) before the warm-up period prior to kick-off (Morton, 2014). These performance enhancing doses of caffeine remain high in the circulation for approximately 5 h after ingestion. Therefore, the nutritionist and player must weigh up the benefits of ingestion for evening kick-offs, or alternatively time the ingestion so that caffeine intake does not negatively impact sleep.

**During the match**

During the match, the priority is to maintain player performance for the duration of game. We have learnt in previous modules how football-specific exercise depletes the body's limited store of glycogen (carbohydrate). In addition, football causes a loss of body water (dehydration) as a consequence of thermoregulatory sweating. To this end, the available evidence suggests that carbohydrate and fluid delivery should be prioritized during a football match to provide an exogenous source of energy for the body, and prevent significant hypohydration.

**Did you know?**

A "placebo" treatment in sports nutrition studies provides an intervention (drink, bar, gel) to a participant, which lacks the "active" ingredient of being studied. The placebo should ideally be indistinguishable from the other trials so that the person feels as if they are getting the same intervention on each trial. For example, in many studies investigating sports drinks, the placebo beverage would contain the same level of electrolytes, fluid and be flavour matched, but contain no carbohydrate.

Studies have been conducted showing a close association with carbohydrate ingestion and player performance during "live" matches. For example, in a study by Kirkendall et al. (1988) the physical performances of 10 players were captured on video on two separate occasions, separated by one day. For each match, players drank either a carbohydrate solution or sweetened placebo before the game and the same volume at halftime. It was reported that the players who drank the carbohydrate solution ran approximately 40 % greater distance during the second half of the game, in comparison to when the placebo beverage was consumed (Kirkendall, 1998). Interestingly, a similar study in which players consumed 0.5 L of a 7 % glucose solution 10 min before a practice match and the same volume again at halftime, reported a 39 % greater muscle glycogen concentration at the end of exercise compared to players drinking a sweetened placebo (Leatt and Jacobs, 1989).

An important consideration when interpreting “performance” data during football matches is the high variability observed between games. For example, different tactical formations and levels of competition will have a great influence on the distance a player covers at high speed and sprint distances achieved (Gregson et al., 2013). Thus, although an interesting measure, assessing the impact that nutrition strategies have on match “performance” is challenging due to the complex interaction between physical and technical components. To this end, controlled experimental trials have offered excellent insights into the impact that carbohydrate ingestion during exercise has on multiple sprint performances and repeated skill execution (Rollo and Williams, 2023).

Using a test specially designed to mimic the physical demands of football (Loughborough Intermittent Shuttle Run Test: LIST), Nicholas et al. (1995) performed a series of studies to investigate the effect that drinking a carbohydrate-electrolyte solution has on performance (Nicholas et al., 1995; Nicholas et al., 2000). In the first study, players drank a 6.9 % carbohydrate-electrolyte solution or sweetened placebo immediately before (5 ml/kg BM) exercise and during the 3-min breaks (2 ml/kg BM) between each 15-min block of exercise. This regime provided carbohydrate at a rate of approximately 1 g/min or 60 g/h. Repeated sprint performance was no different between trials. However, similar to observations from field studies, players were able to sustain high-intensity running for 2 min 10 s (33 %) longer during the second part of the test when drinking the carbohydrate-electrolyte solution compared to the placebo (Nicholas et al., 1995).
In a follow-up study, players repeated six 15-min blocks of intermittent running up to 90 min, drinking the same volume and concentration (6.9 %) of carbohydrate-electrolyte solution or sweetened placebo. In this study, muscle biopsy analysis revealed a significant reduction in muscle glycogen concentrations in both type 1 and type 2 muscle fibre types. However, muscle glycogen concentrations were 22 % higher at the end of exercise when players ingested the carbohydrate solution in comparison to placebo (Nicholas et al., 1994). Thus, the preservation of muscle glycogen availability offers a viable mechanism to explain why players are able to offset fatigue and sustain high-intensity running in the second half of football matches (Rollo, 2014; Williams and Rollo, 2015).

It is important to note the vital role of skill execution in football performance (Rollo and Williams, 2023). Skilled movements are physically complex, but even more so when performed during match play because they involve an interaction between the physical and cognitive qualities necessary to achieve successful outcomes.

Using a modified version of the LIST, McGregor et al. (1999) reported fluid ingestion during exercise had a significant benefit to the maintenance of soccer-specific skill (dribble track test) compared to no fluid intake (McGregor et al., 1999). However, of relevance to this review, the ingestion of carbohydrate in addition to fluid has been reported to be superior to maintaining skill in comparison to the ingestion of fluid alone. Specifically, Ali and Williams (2009) developed a soccer passing and shooting performance test, which was performed before and immediately after the LIST (90 min). In this study, 16 male soccer players ingested either a 6.4 % carbohydrate-electrolyte solution or placebo solution, 5 ml/kg BM before and 2 ml/kg BM every 15 min during exercise (~60 g of carbohydrate per hour). Passing performance was well maintained in both trials. However, a reduction in the deterioration of shooting performance was associated with carbohydrate ingestion (Ali and Williams, 2009). At a similar time, Currell and colleagues developed a football test protocol, which allowed the assessment of football specific skill performance (Currell et al., 2009). Importantly, the execution of football skills was reported to show little day-to-day variation, with CVs of 1.2 %, 2.2 % and 2.8 % for agility, dribbling and kicking accuracy, respectively. In this study, the ingestion of a 7.5 % maltodextrin solution, 30 min before (6 ml/kg BM), at half-time (4 ml/kg BM) and routinely throughout exercise (1 ml/kg BM/12 min) was associated with a significant reduction in the deterioration of skill performance over 90 min of exercise, in comparison to the ingestion of a placebo solution. The ability to sustain skill execution during a football match has clear performance implications. For example, in Italy, teams with the smallest decrease in skill performance over a match were found to finish the season in a higher league position (Rampinini et al., 2009).

In an innovative study on the impact of carbohydrate ingestion on skill, tests were undertaken on players' dominant and non-dominant limbs. Using a soccer-specific protocol, higher passing scores were achieved by both dominant and non-dominant feet following the ingestion of carbohydrate (30 g, before and at half time, compared with placebo whilst drinking water *ad libitum*) (Rodriguez-Giustiniani et al., 2019). This effect was evident from 60 min onwards. Importantly, improved performance was attained without loss of passing speed, which was better maintained in the non-dominant foot with carbohydrate ingestion (Rodriguez-Giustiniani et al., 2019). This observation reinforces the approach that ingesting 30 g of carbohydrate before the match and at half time is a practical approach to support performance. Figure 6 shows some options which all provide approximately 30 g of carbohydrate (Harper et al., 2017).

**Figure 6. Food options for players to ingest before a match and at half time to provide approximately 30 g of carbohydrate**


Source: own elaboration.

Interestingly, carbohydrate ingestion has been reported to improve both sprint (15 m) and skill performance during the early stages (0-45 min) of simulated football protocols (Ali and Williams, 2009; Currell et al., 2009). When adequate recovery time is allowed for phosphocreatine replenishment, and sufficient glycogen remains in the muscle, a clear metabolic benefit of carbohydrate ingestion to support football performance is not immediately apparent. However, there is accumulating evidence that carbohydrate ingestion may have a “non-metabolic” central effect. Studies in running have reported a benefit on endurance performance by simply mouth rinsing and expectorating a carbohydrate solution (Rollo et al., 2011). The ergogenic effect may be mediated via the activation of brain pathways associated with reward and motivation, in response to carbohydrate recognition in the mouth (Rollo et al., 2020).

For example, the serial mouth-rinsing of a concentrated carbohydrate solution (10 %), without ingestion, has been reported to be 86 % likely of improving repeated 15-m sprint performance between 75 and 90 min of intermittent running in comparison with a taste-matched placebo (Rollo et al., 2015). However, not all studies have reported this (Dorling and Earnest 2013). Nevertheless, carbohydrate ingestion has also been reported to preserve the function of the central nervous system during prolonged exercise, which may have important implications for the successful execution of skills and decision making in football (Russell and Kingsley 2014; Rollo and Williams 2023).

“The available literature suggests that the ingestion of an appropriate carbohydrate-electrolyte solution during football-specific exercise will benefit performance. Players with compromised glycogen stores will be able to sustain their level of skill proficiency and repeated sprint performance, in comparison to no fluid or the ingestion of fluid alone. As discussed, fatigue during football and prolonged exercise is associated with the decrease in muscle glycogen. The ingestion of carbohydrate has been shown to attenuate the decline in blood glucose concentrations during prolonged exercise and maintain muscle glycogen availability over a football match (Coyle et al., 1986; Leatt and Jacobs, 1989). Thus, carbohydrate ingestion is advised for matches, where players aim to gain performance advantages” (Rollo, 2014, https://lc.cx/MK8-It).

Also carbohydrate ingestion should also be used during  intense training, where players aim to gain maximum benefits from the session whilst practising their match day nutrition strategy.

The opportunity to ingest carbohydrate during football matches is often limited to unscheduled stoppages in play (Rollo, 2014). It is vital that carbohydrate and fluid are readily available, and players are aware of the benefits of ingesting a carbohydrate so that these opportunities are not missed. Therefore, the role of the sports nutritionist is to prepare appropriate drinks and carbohydrate options and be ready to distribute them to players during any match stoppages.

Carbohydrate gels provide a convenient means of ingesting carbohydrate whilst “on the go” such as when running or quickly during unscheduled breaks in play. However, there are only a few studies on the benefits of ingesting carbohydrate gels during variable speed shuttle running. Of the two available studies, both report that ingesting carbohydrate gels improves endurance running capacity. One of the studies reported that when game players ingested either an isotonic carbohydrate gel or an artificially sweetened orange placebo while performing the LIST protocol, their endurance capacity was greater during the gel (6.1 min) than during the placebo (4.2 min) trial (Williams and Rollo, 2015). In the second study, on intermittent shuttle running, Phillips and colleagues compared the performances of game players when they ingested either a carbohydrate gel or non-carbohydrate gel before and at 15-min intervals while completing the LIST protocol. They reported that during the carbohydrate-gel trial, game players ran longer in Part B (4.6 min) than during placebo trial (3.8 min), but there were no differences in sprint speeds. Concerns about the potential delay in gastric emptying when ingesting carbohydrate gels before and during exercise are allayed by the performance benefits reported in the above studies (Williams and Rollo, 2015). Nonetheless, gels should be accompanied with drinking water.

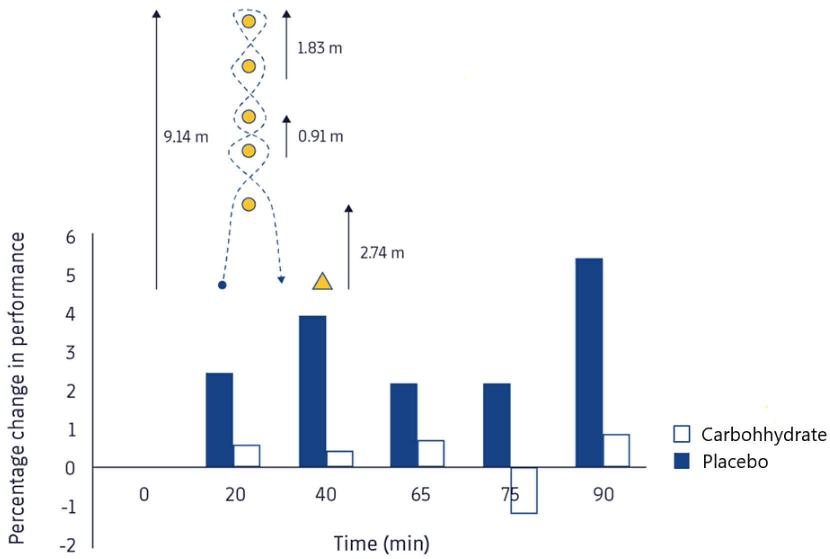
In respect of gels, carbohydrate can be provided to players in a variety of different forms (figure 6). “For example, carbohydrate is oxidised effectively, whether it is provided in solid, i.e., in bars, chews, semi-solid gels, or in a drink (Pfeiffer et al., 2010). Thus, strategies to provide approximately 30 g of carbohydrate before and at half time can be modified according to player preference, in context of other nutritional requirements such as the fluid needs of the player (Laitano et al., 2014). The main benefit of drinking well formulated carbohydrate-electrolyte beverages is that fuel and fluid needs are addressed simultaneously” (Rollo, 2014, https://lc.cx/MK8-It).

The fluid lost during a match will depend upon the sweat rates of the player. The sweat rates of players have been reported to vary greatly between players, and will be influenced by the environmental conditions, intensity of exercise, and acclimation status

(Duffield et al., 2012). During matches sweat rates have been reported to reach up to 2.5 L/h (Baker et al., 2016). In female players, sweat rates are generally lower because of lower body mass and absolute work rates (Da Silva et al. 2012; Kilding et al. 2009; Horowitz, 2014). Hypohydration as a consequence of sweating may impair football performance due to increased cardiovascular strain (Armstrong et al., 1985), impaired cognitive function (Ganio et al., 2011) increased perception of effort (McGregor et al., 1999), reduced physical function (Mohr et al., 2013) and reduced technical skills (McGregor et al., 1999). Therefore, for matches, players should aim to start the match fully hydrated. Urine indices such as urine-specific gravity can be useful indicators of hydration status. As a guide, a urine specific gravity of <1.020 suggests euhydration. During the match, although players will be more or less sensitive to varying levels of dehydration, it is recommended to drink sufficient fluids to prevent a deficit of >2 % of pre-exercise body mass (Sawka et al., 2007), whilst avoiding gains in body mass (hyperhydration) (McDermott et al., 2017; Montain et al., 2001), whilst also ensuring their carbohydrate needs are met (Williams et al., 2015).

In Macronutrients and Fluid for Football course, we will discuss fluid requirements and corresponding sports nutrition strategies in detail. The sweat response of FC Barcelona's men's first team during training in different environmental conditions and at different exercise intensities will be shared (Rollo et al., 2021).

**Figure 7. The percentage change in time taken to dribble a ball round a set of 5 cones and back over a distance of 9.14 m**




Source: own elaboration based on Currell et al., 2009.

**Did you know?**

The Loughborough Intermittent Shuttle Run Test (LIST) was developed in the year 2000 to study the physical demands of football under laboratory conditions. Participants run between cones spaced 20 m apart at variable speeds. Since its development, several modified versions of the LIST have been used to analyse aspects of football skill and self-selected running performance.

## Gastrointestinal comfort

Gastrointestinal comfort is a key consideration for match day sports nutrition. To examine whether gastric emptying is slowed during variable-speed running, Leiper and colleagues completed two studies in which game players ingested CHO-E solutions before and during exercise. In the first study, they monitored gastric emptying of a 6 % CHO-E solution before and after two 15-min periods of play during an indoor, competitive five-a-side soccer match (Leiper et al., 2001). The same gastric emptying and timing was repeated while the soccer players performed two 15-min periods of walking with the same 10-min rest between the two activity periods. Gastric emptying was slower during the first 15-min period than during the walking-only trial, but during the second 15 min of the soccer game there was no statistical difference in the emptying rate. In total, the volume of fluid emptied from the stomach was less than during the same period while walking.

In the second running study, gastric emptying of a 6.4% CHO-E solution and a CHO-free solution were monitored before and after two 15-min periods of the LIST and also after two 15-min periods of walking (Leiper et al., 2005). The exercise intensities during the two 15-min activity cycles of the LIST were higher and more closely controlled than those self-selected exercise intensities achieved during the five-a-side football match. Nevertheless, the results were quite similar in that gastric emptying was slower during the first 15 min of exercise both for the CHO-E and the placebo solutions than while walking for the same period. However, during the second 15 min, gastric emptying of both solutions was similar during both the running and the walking trials with a trend for slightly faster emptying rates. Whether or not this greater gastric emptying later in exercise suggests an acute adaptation to coping with large gastric volumes remains to be determined. Even with an intensity-induced reduction in gastric emptying, the available evidence suggests that team sport players are able to tolerate the ingestion of carbohydrate-electrolyte beverages. These carbohydrate-beverages are emptied rapidly from the stomach, providing fluid and fuel to the players' body (Williams and Rollo, 2015).

In studies which have provided more concentrated carbohydrate (12 %) beverages providing 30 g of carbohydrate before and at half time during modified LIST protocols, there has been no evidence of gastrointestinal complaint (Funnell et al., 2017; Harper et al., 2017; Rodriguez-Giustiniani et al., 2019). This would suggest that carbohydrate requirements can be achieved and are well tolerated when consumed at more ecologically valid times of ingestion.

**Did you know?**

A beverage containing carbohydrate and electrolytes is commonly known as a sports drink. Sports drinks are formulated (6 % carbohydrate) to provide the right quantity of carbohydrate, electrolytes (sodium) and fluid, to ensure that the ingested fluid is emptied rapidly from the stomach and absorbed into the body.

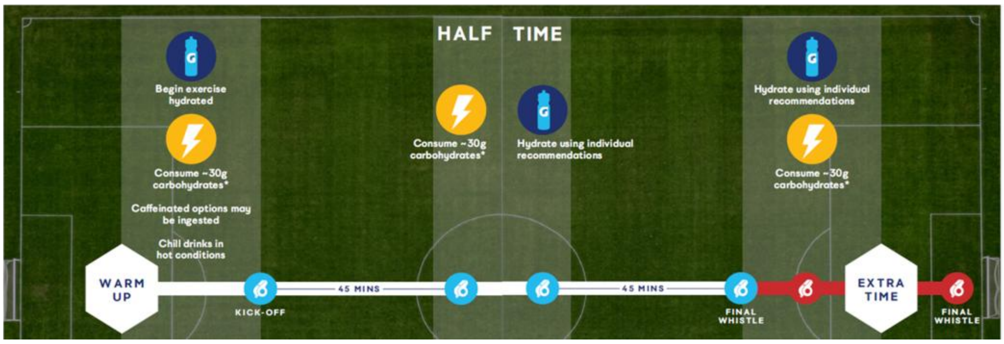
Sports drinks should not be confused with “energy drinks” which are typically formulated with a greater quantity of carbohydrate (15 %+). These concentration of carbohydrate slow gastric emptying and result in the net movement of water from the blood into the intestinal lumen. It is recommended not drink “energy drinks” during exercise.

**Extra time**

The ingestion of CHO-E solutions during prolonged, intermittent variable-speed running has been shown to improve endurance capacity. This is of relevance to those matches which the duration exceeds 90 min or enters extra-time. Indeed, it is now common for 5-10 additional minutes to be played, following completion of the 90. The physiological and performance effects of carbohydrate-electrolyte gels consumed before the extra-time period was investigated in English Premier League academy soccer player (Harper et al., 2016). In this study, the players performed 120 min of soccer-specific exercise on two occasions. Both times, players drank energy free water-electrolyte beverages before exercise, at half-time and at 90 minutes. Players then either ingested a carbohydrate-electrolyte gel (~50 g carbohydrate) or an energy-free placebo, 5 minutes before extra-time. The ingestion of carbohydrate raised blood glucose concentrations and improved dribbling precision during the extra-time period (Harper et al., 2016). However, the carbohydrate ingestion did not attenuate the gradual reduction in 30 m sprint performance observed during both trials over time (Harper et al., 2016).

**Figure 8. Maintain performance for 90 min and extra time**

Maintain your performance for 90 mins and extra time

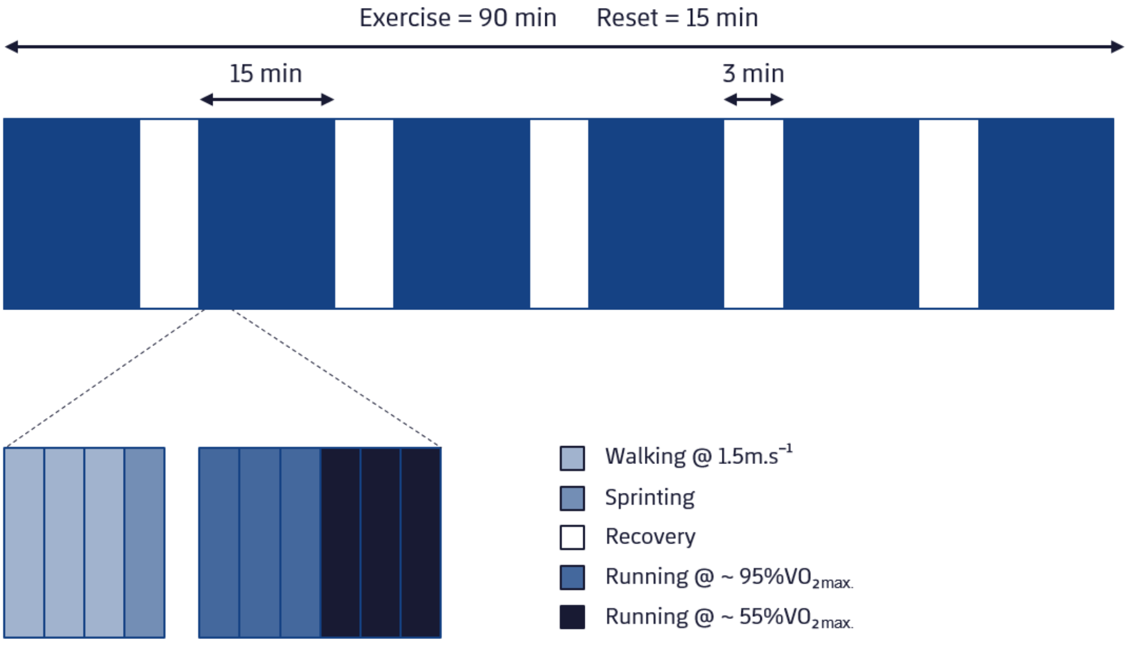



Source: own elaboration.

## Did you know?

As players ingest food or beverages, they first enter the stomach. Gastric emptying is the movement of food from the stomach to the intestine (duodenum).

## Figure 9. Schematic diagram of the movement pattern of the LIST




Source: own elaboration.

## After the match

Appropriate strategies to support a player's recovery after matches are fundamental to the team's overall ability to maintain their level of performance over the season. The aggressiveness of the recovery strategy will depend on when the player is next required to play, be it in training or competition, and becomes increasingly important in tournament situations (Rollo, 2014).

Following football matches, a complete depletion of muscle glycogen has been reported in a proportion of both slow and fast twitch muscle fibre (Krustrup et al., 2006). The resynthesis of glycogen in these fibres is most rapid in the hours immediately post exercise, in comparison to when carbohydrate is provided several hours later (Piehl, 1974). A general recommendation to achieve high rates of glycogen resynthesis is for players to ingest approximately 1 g of carbohydrate/kg BM immediately after exercise (Ivy et al., 1988). Nicholas et al. (1997) completed a study in which players performed the LIST to exhaustion on four occasions separated by one week. On one occasion, players ingested a diet rich in carbohydrate and repeated the shuttle-run protocol 22 h later. The high-carbohydrate recovery diet resulted in an increase in the players' normal daily energy intake from 2,600 kcal to 3,818 kcal. Absolute carbohydrate intake was increased from a daily average of 381 g to 705 g for the recovery period (5 g to 10 g of carbohydrate/kg BM respectively). On another occasion, the players performed the shuttle-run protocol again. However, players ingested a mixed diet during the 22 h recovery period. The mixed diet contained their normal amounts of carbohydrate (381 g), with protein and fat consumed to match the energy intake of the carbohydrate diet. When players ingested the mixed diet, they could not achieve the previous day's performance. However, the ingestion of the carbohydrate-rich diet was associated with an improved performance. Specifically, players were able to sustain high-intensity running for 3.3 min longer than that achieved on the previous day, which equated to an additional 7.4 min of running in comparison to the time achieved following the mixed diet (Nicholas et al., 1997).

Studies have suggested that the rate of muscle glycogen resynthesis may be slowed following a competitive football match. This is based on the observations that glycogen stores can remain lower than pre-match concentrations 48 h post-match, despite the ingestion of a high carbohydrate diet (Bangsbo et al., 2006; Krustrup et al., 2011). Football-specific activities, such as frequent change in direction and decelerations from sprints, have a high eccentric component. Eccentric contractions in combination with contact between players results in muscle damage, which in turn may impair glycogen synthesis (Krustrup et al., 2011). This phenomenon is not alleviated by a diet high in carbohydrate and whey protein (Gunnarsson et al., 2013). Of note, no super compensation of muscle glycogen concentrations have been reported 48 h after a football match, a typical response reported following prolonged running or cycling exercise.

To speed player recovery and reduce muscle soreness, many clubs utilise cryotherapy “ice baths”. However, due to the vasoconstrictive consequence of cryotherapy, concerns have risen as to whether glycogen resynthesis would be impaired due to reduced availability of substrate to the muscle. Reassuringly, 10 min of lower limb cold water immersion (8 °C), following exhaustive exercise, resulted in no impairment in glycogen restoration, in comparison to being seated at rest, when appropriate quantities of carbohydrate were ingested (Gregson et al., 2013).

During times of the season when players are exposed to more frequent matches, i.e., playing two to three matches a week, the importance of maintaining the players’ vigour and motivation to perform should not be underestimated. To this end, studies have reported that athletes’ “mood” state is better maintained by an increased daily intake of carbohydrate from 5.5 g to 8.5 g carbohydrate/kg BM/day during intensive periods of training (Achten et al., 2004).

**Did you know?**

An eccentric muscle contraction occurs when the player’s muscle is activated, and force is produced, but the muscle lengthens. This is common in football as the player decelerates following a sprint or when they need to change direction. Eccentric muscle contractions are associated with more muscle damage and increased feelings of soreness, typically 48 h after exercise.

It is important to note that the provision of protein should not be forgotten in the context of an optimal recovery strategy post football match (Collins et al. 2021). In the context of glycogen resynthesis, the co-ingestion of protein, with sub optimal carbohydrate intake can augment postprandial insulin secretion and accelerate muscle glycogen synthesis rates (van Loon, 2007). Although, additional protein ingestion will not increase muscle glycogen resynthesis when sufficient quantities of carbohydrate are available (Betts and Williams, 2010). Nevertheless, research suggests that the inclusion of protein (~0.25 g/ kg/ BM) in concert with an appropriate carbohydrate intake will aid the rebuilding of muscle tissue and support adaptation specific to football performance (Res, 2014). In addition, the ingestion of protein prior to sleep may be another opportunity to aid the player’s recovery following a match (Trommelen et al., 2016). The ingestion of 30-40g of protein before sleep has been reported to improve jump and reactive strength scores in professional football players at 12 and 36 hours following a match (Abbott et al., 2018).

After a match, as a general principle, players should be encouraged to replace any fluid and electrolyte deficit. In most situations, there is sufficient time to restore euhydration and electrolyte imbalances with normal eating/drinking practices, combined with carbohydrate and protein dietary objectives. Nevertheless, during pre-season or periods of fixture congestion, rapid and complete rehydration can be achieved by drinking 1.5 L of a sodium-containing fluid for each 1 kg of a player's body mass loss. Knowledge of sweat losses and electrolyte composition will also allow individualised rehydration strategies.

**Recommendations for match day nutrition**

1. On MD-1, MD and MD+1, carbohydrate intake should range between 6-8 g/kg body mass with the aim of elevating muscle glycogen stores.

2. Three to four hours before a match, players should ingest a "pre-match meal" that is high in carbohydrates (2-4 g/kg) to replenish liver glycogen stores.

4. Before (after the warm up) and during a match (half-time) an intake of 30 g carbohydrate should be targeted (figure 8).

5. It is recommended to start restoration of glycogen and protein synthesis as soon as possible after a match by providing 1 g of carbohydrate/ kg of the player's BM/h plus 0.3 g of high-quality protein/kg of the player's body mass.

6. When sweat losses are high, players should be encouraged to drink adequate volumes of fluid with electrolytes to aid the fluid retention.

7. It is recommended to practice all match day strategies in training first.

8. It is recommended to adjust all guidelines to the individual player needs and preferences.

**Managing match days**

The fixture schedule allows the nutritionist to plan for match days. Most preparation for matches should be completed in advance of the match day itself. For example, ordering of sports beverages (the correct quantity/flavour for each player), washing and preparation of bottles/shakers, sports nutrition and foods for before, during and after the match strategies should all be organised in advance. Home matches allow a degree of certainty around many factors, which need to be considered when planning match day nutrition. These include the location and format of the pre-match meal. For home matches, there are not usually issues in sourcing foods or drinks and hygiene standards are known.

It is important to cater for the whole squad. This begins with the pre-match meal and providing sufficient options in the menu to cater for all player preferences. One of the challenges for the nutritionist is to provide the appropriate quantity of food. Too little and players and staff will be unhappy. However, too much food leads to excess and wastage, which should be avoided. If the team has a chef, then meal offerings can be refined by trial and error (Football Nutrition Skills Course).

A checklist of items to consider when travelling for away matches is shared in figure 10. When travelling for away games, food safety is the biggest priority. For away games, it is recommended to call and if possible, meet the kitchen staff to ensure that they understand the catering requirements. Food health and safety standards should be met and inspection of the kitchens prior to the team's arrival is also recommended. The challenge is to maintain the quality of food when travelling away from home. If possible, some teams solve this by travelling with their own chef, who can cook and prepare meals on the team bus for example. If a chef cannot travel with the team, preparing (and storing appropriately) well formulated picnic food boxes for the players is also a good option. Finally, it is also important to check which foods can be transported internationally. For example, protein powders may need to be sourced at the country of destination. Therefore, knowledge of these issues in advance will allow time to find an appropriate alternative.

**Figure 10. Checklist of items to consider when organising the sports nutrition for away matches**

## ORGANIZATION OF AWAY GAMES

**Lining up the 11 key points**

Plan away game strategies well in advance

Find out which hotel will be used

Research the location and hotel
*(e.g typical/local foods and recipes)*

Prepare the appropriate menus
for training sessions and match day

Make contact with hotel chefs and send menus

Check in with chefs via video calls

Highlight food allergies – this is very important

Ask if the host stadium will provide you with
water, sport drinks and the post match food

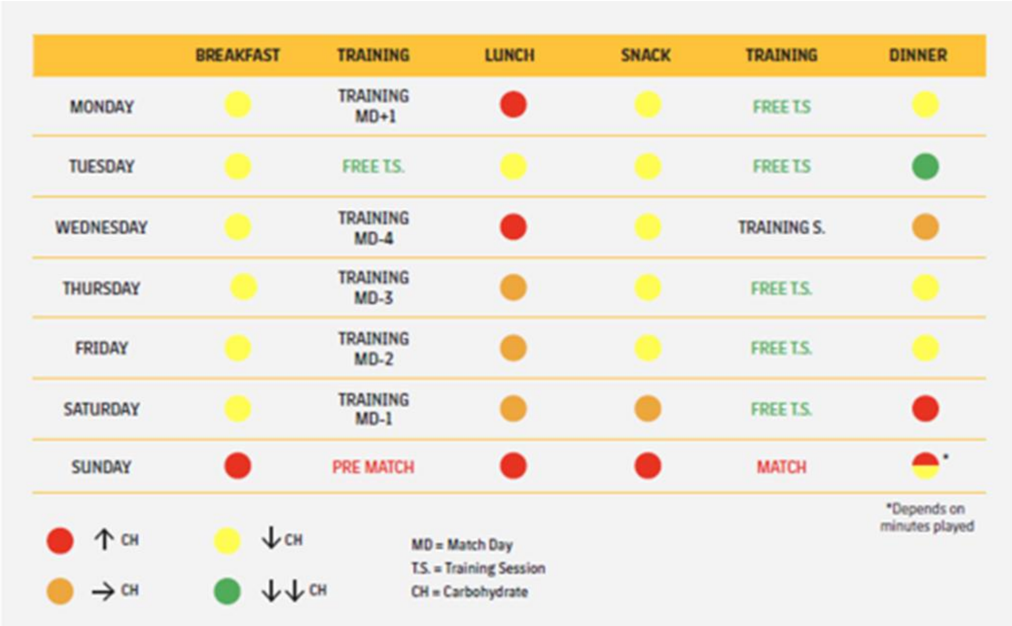
If travelling by plane, ask for the
in flight menu and adapt if required

Organise a good post match meal

Ensure you pack all required supplements
*e.g. recovery shakes, pre-match and half time supplements and any ergogenic aids*

Source: own elaboration.

**Figure 11. An example of how carbohydrate intake can be periodised depending on training and match requirements**




Source: own elaboration.

## Summary

- The match time and location are key information for the nutritionist.
- Carbohydrate is the primary fuel for muscle during high-intensity activities and it is therefore the key macronutrient when preparing players for match play.
- The ingestion of 2.5 g of carbohydrate per kg of the player's body mass is recommended in the "pre-match meal", no later than three hours prior to kick off, to "top up" stores of glycogen in the muscle and liver.
- The ingestion of 30 g of carbohydrate before the match and at half time combined with individually determined fluid intake is associated with improved running and skill performance during a match.
- After the match, the ingestion of carbohydrate, fluid and protein is required to speed the recovery of the player in preparation for the next match or training session.

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