2.2 Match day

2.2.1 Meal(s) before the match

> The goal of a meal before the match is primarily to replenish liver glycogen stores. The primary role of glycogen in the liver is to maintain constant blood glucose concentrations. Glucose is the main, and in normal circumstances the only, fuel used by the brain. The liver is often referred to as the glucoregulator or glucostat: the organ responsible for the regulation of the blood glucose concentration. An average liver weighs approximately 1.5 kg, and approximately 80 to 110 g of glycogen is stored in the liver of an adult human in the post-absorptive state. Glycogen is broken down in the liver to glucose and then released into the circulatory system. The liver has a much higher concentration of glycogen (per kilogram of tissue) than does muscle. Because of a much larger mass of muscle there is more glycogen stores in muscle (in absolute terms, 300 to 600 g in muscle versus 80 to 110 g in liver) but this does not take away that liver is very well suited to store glycogen. After an overnight fast, the liver glycogen content can be reduced to low levels (<20 g) because tissues such as the brain use glucose at a rate of about 6g/h in resting conditions. (Jeukendrup & Gleeson, 2018, https://bit.ly/2UENOq7).

Studies have demonstrated that athletes should have the last fairly large meal 3 to 5 hours before competition (Hargreaves, Hawley, & Jeukendrup, 2004). Even though this conclusion was based mostly on endurance studies, because of the role of glycogen during football, the same guidelines are used. In a football study, increased dribbling speed was observed when Briggs et al. (2017) studied the effects of (500 kcal versus 250 kcal, 60% carbohydrate) the size of the breakfast on performance in 7 English Premier League Academy football players. The players had their normal (relatively small) breakfast or a breakfast with added carbohydrate. The higher carbohydrate breakfast contained 77 g carbohydrate whereas the normal breakfast contained 39 grams (with similar amounts of protein and fat). They then played a simulated match with a number of skill tests. Although dribbling precision and success were unchanged, dribbling speed was improved with the added carbohydrate. Unsurprisingly, greater feelings of gut fullness were observed in B but no abdominal discomfort was reported.

Many other studies suggest that higher carbohydrate intakes before and during a match can delay fatigue (Holway & Spriet, 2011) and enhance the capacity for intermittent high-intensity exercise (Phillips, Sproule, & Turner, 2011; Russell, Benton, & Kingsley, 2012).

> Especially if the pre-exercise meal is breakfast, it is important to have a relatively high carbohydrate intake because after an overnight fast when the liver is almost depleted of glycogen. The advantages of a meal in the hours before exercise are related to the increased carbohydrate availability in both muscle and the liver. In the 3 to 5 hours before exercise, although the majority of carbohydrate may be stored in the liver, some carbohydrate is also still incorporated into muscle glycogen. Ingestion of a carbohydrate-rich meal (containing 140 to approximately 330 g of carbohydrate) 3 to 5 hours before exercise increases muscle glycogen levels and improves exercise performance (Hargreaves et al., 2004). Such a meal could include carbohydrate sources such as bread and jam or honey, cereals, porridge, bananas, canned fruit, and fruit juice. Following is an example of a daily diet containing 150 g of carbohydrate representing at least 80% of the energy intake:
>
> - Meal 1: one large bowl of porridge with skim milk, one banana, one glass (250 ml) of sweetened orange juice
> - Meal 2: four slices of bread with jam or honey, one can of a soft drink
> - Meal 3: 3 cups of rice made into a light stir fry with small amounts of lean ham or chicken, peas, corn, mushrooms and onion, and one glass (250 ml) of fruit juice. (Jeukendrup & Gleeson, 2018, https://bit.ly/2UENOq7).

The last larger meal should be 2.5-5 hours before a match. If only 2.5 hours is available the meal must be smaller; if 5 h is available the meal can be larger. Often the timing is dictated by logistics. In the hour before the game, there is a last opportunity to top up liver glycogen or to start fuelling for the game (for example the carbohydrate ingested 15 min before the game will be absorbed and become available during the game).

2.2.2 The hour before

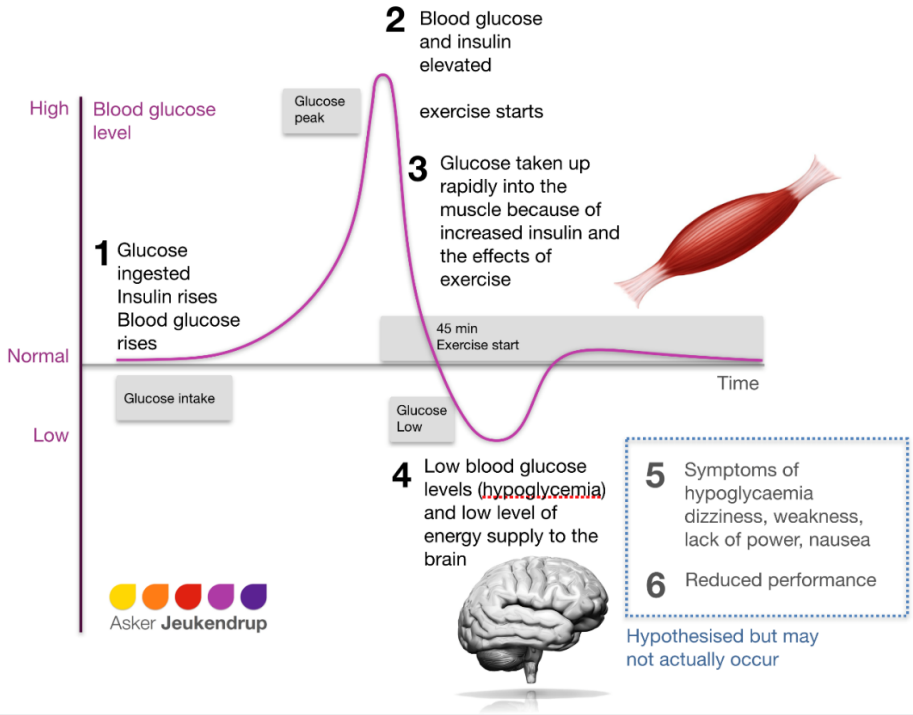
There has been a lot of debate about the ingestion of carbohydrate in the hour before exercise. Carbohydrate ingestion 30-60 min before a match results in a large rise in plasma glucose and insulin. With the onset of exercise, a rapid fall in blood glucose occurs, a phenomenon known as rebound or reactive hypoglycemia. Up to only a few years ago, athletes were often advised not to consume carbohydrate in the hour before exercise because this was thought to induce hypoglycemia and negatively affect performance. This view has gradually changed as will be discussed below. For a more detailed review of this topic the reader is referred to this review: (Jeukendrup & Killer, 2011). (Jeukendrup & Gleeson, 2018, https://bit.ly/2UENOq7).

Metabolic changes with pre-exercise carbohydrate ingestion

When carbohydrate is ingested in the hour before exercise, blood glucose as well as insulin concentrations will rise (Figure 3). This hyperinsulinemia stimulates glucose uptake. When exercise is initiated, contractile activity further stimulates muscle glucose uptake and the result is a rapid disappearance of glucose from the blood, causing a drop in the blood glucose concentration.

The exercise-induced increase in the normal liver glucose output is inhibited by carbohydrate ingestion (Marmy-Conus, Fabris, Proietto, & Hargreaves, 1996), despite ongoing absorption of the ingested carbohydrate. Enhanced uptake and oxidation of blood glucose by skeletal muscle may account for the increased carbohydrate oxidation after pre-exercise carbohydrate ingestion. In addition, in some studies, an increase in muscle glycogen degradation has been observed. (Jeukendrup & Gleeson, 2018, https://bit.ly/2UENOq7).

Figure 3: The concept of rebound hypoglycemia



Source: Jeukendrup, February 5, 2015, https://bit.ly/2QO2B2u

When carbohydrate is ingested in the hour before exercise blood glucose and insulin levels rise. When exercise is initiated, glucose uptake increases. Now, both insulin (at its peak) and exercise will stimulate glucose uptake, and as a consequence, a drop in blood glucose may be observed, and hypoglycemia may be the result. Hypoglycemia is associated with symptoms like dizziness, nausea, weakness, and shivering, none of which would be good for performance. However, research does not necessarily support this theoretical picture!

> The increase in plasma fatty acids with exercise is attenuated after pre-exercise carbohydrate ingestion because of insulin-mediated inhibition of lipolysis (Horowitz, Mora-Rodriguez, Byerley, & Coyle, 1997). Even small increases in plasma insulin (e.g., after fructose ingestion) can result in a marked reduction of lipolysis. Fat oxidation is reduced not only because of the lower plasma fatty availability (Horowitz et al., 1997) but also because of inhibition of fat oxidation in skeletal muscle. Artificially increased plasma fatty acid availability did not completely return fat oxidation to levels seen during exercise in the fasted state (Horowitz et al., 1997). Some evidence indicates that the hyperinsulinemia and hyperglycemia reduce the

uptake of FA into the mitochondria (Coyle, Jeukendrup, Wagenmakers, & Saris, 1997).

Factors that determine the glycemic response during exercise include

- the combined stimulatory effects of insulin and contractile activity on muscle glucose uptake,
- the balance of inhibitory and stimulatory effects of insulin and catecholamines on liver glucose output, and
- the magnitude of ongoing intestinal absorption of glucose from the ingested carbohydrate.

Because the metabolic effects of pre-exercise carbohydrate ingestion are a consequence of hyperglycemia and hyperinsulinemia, interest has developed in strategies that minimize the changes in plasma glucose and insulin before exercise. These strategies include the ingestion of fructose or carbohydrate types other than glucose that have a lower glycemic index, varying the carbohydrate load or the ingestion schedule, the addition of fat, and the inclusion of warm-up exercise in the pre-exercise period. In general, although these various interventions do modify the metabolic response to exercise, blunting the pre-exercise glycemic and insulinemic responses appear to offer no advantage for exercise performance.

The metabolic alterations associated with ingestion of carbohydrate in the 30 to 60 minutes before exercise have the potential to influence exercise performance. The increase in muscle glycogenolysis and suppression of fat metabolism could possibly result in earlier onset of fatigue during exercise as suggested in a study by Foster, Costill, and Fink (1979). Indeed, this early study reported a reduction in exercise performance. Since then, however, the overwhelming majority of more than 100 studies have shown either unchanged or even enhanced endurance exercise performance after ingestion of carbohydrate in the hour before exercise.

Interestingly in a series of studies (Jentjens & Jeukendrup, 2003; Moseley, Lancaster, & Jeukendrup, 2003) it was demonstrated that certain individuals may develop hypoglycemia when carbohydrate is ingested in the hour before exercise, although this was not a predictor of performance. Note that the causes of hypoglycemia in

this situation are different from what happens after prolonged exercise when endogenous carbohydrate stores become depleted. Here it is primarily the result of the combined effects of insulin and exercise. Liver glycogen concentrations may be high. After prolonged exercise the cause of hypoglycemia is the fact that liver glycogen is depleted, plasma insulin concentrations are low.

Hypoglycemia seemed to be more prevalent when the carbohydrate was ingested 75 minutes before exercise compared with 45 minutes, and when it was ingested 15 minutes before exercise few people developed hypoglycemia (Moseley et al., 2003). Other studies have demonstrated that hypoglycemia can be completely prevented when carbohydrate is taken 5 minutes before exercise or during a warm-up.

In conclusion, despite the well-documented metabolic effects of pre-exercise carbohydrate ingestion, little evidence appears to support the practice of avoiding carbohydrate ingestion in the hour before exercise, if sufficient carbohydrate is ingested. Some people, however, may be more prone to develop hypoglycemia; therefore, it is recommended to determine individual practice based on experience with various pre-exercise carbohydrate ingestion protocols. (Jeukendrup & Gleeson, 2018, https://bit.ly/2UENOq7).

Practical messages

- Make sure that liver glycogen is topped up before the game
- This can be done by ingesting 150-330 g of carbohydrate in the 3-4 h hours before
- Allow enough time for digestion and absorption, so a match can be started without feeling full
- In the hour before a match there is a last opportunity to replenish liver glycogen and to start the fuelling “during” exercise. Especially when carbohydrate is ingested in the minutes before a match, this will carbohydrate will become available during the match
- Establish a routine for the team that players can get used to (or establish a routine at individual level where possible)

2.2.3 Warm up and half time

Research activities typically note performance benefits in protocols simulating football matches when carbohydrate is consumed during exercise at rates of ~30–60 g/h (Baker, Nuccio, & Jeukendrup, 2014; Baker, Rollo, Stein, & Jeukendrup, 2015; Russell, Benton, & Kingsley, 2014). Effects on performance indicators may be greater with higher carbohydrate intakes (≥75 g) (Baker et al., 2014). However, it is also clear that football players often do no reach these intakes. For example, players in the English Premier League reported carbohydrate intakes of 32 g/h just before and during a match (Anderson, Naughton, et al., 2017). This may be attributed both to the match rules which limit intake to warm-up and half-time (see below), the fear or actual experience of gastrointestinal problems during high-intensity exercise or simply lack of awareness.

As mentioned above most published studies have reported improvements in soccer players' shooting, dribbling, and/or passing performance with ingestion of a 6-7.5% carbohydrate solution at an intake rate of 30-60 g/h. Currell et al [Currell, Conway, & Jeukendrup, 2009] found a significant improvement in dribbling and kicking accuracy with an intake of 55 g carbohydrate/h ingestion versus placebo. In the same study it was found that jumping to head a ball (which involves only a small cognitive component) was not influenced by carbohydrate feeding.

In general, there is a tendency for players' skill performance to decline during the latter stages of a game with placebo intake and carbohydrate ingestion can reduce this decline. For example, in a study using an intermittent running protocol there was a 14% reduction in passing performance from pre- to post-test with placebo ingestion and only a 3% reduction with 52 g carbohydrate/h (Ali & Williams, 2009).

At the moment there are few studies that have measured skill performance and measuring skill performance is notoriously difficult. Those measurements can have a large variation and are easily influenced by external variables. Therefore, they are more difficult to control. If a measurement has a lot of variation it is usually more difficult to detect the effect of an intervention (in this case carbohydrate feeding). I think that this is one of the main reasons why studies show variable results, with some shoring positive effects and some no effects of

> carbohydrate feeding. No studies to date have shown negative effects.
>
> Therefore, this is a strategy that should be explored more in soccer, especially at the highest level where small improvements in 11 players could make a difference. There are at least two good moments to ingest carbohydrate: just before the start of a game and at half-time. A target intake of 90 grams for a full game is a good start (45 g carbohydrate before and 45g at half-time) based on what we know from the few studies in the literature and from the work in endurance sports, but the reality is that there aren't enough studies to give very clear guidance on the optimal amount of carbohydrate. A very practical intake would be 2 times 25-30 grams (as this is the amount in a gel, a small energy bar or a banana). (Jeukendrup, May 27, 2015, https://bit.ly/2LcUdo1).

It has also become apparent that in addition to providing a substrate for the muscle and brain, carbohydrate consumed during exercise exerts central effects whereby receptors in the oral cavity detect carbohydrate ingestion and favourably alter the perception of effort (Carter, Jeukendrup, & Jones, 2004; Jeukendrup, April 16, 2013; Jeukendrup, July-August, 2013). This is different than providing fuel for the brain. In this case, there is a neural signal that immediately triggers certain areas of the brain.

> Several brain imaging technology (fMRI) studies have tracked changes in various areas of the brain with carbohydrate mouth sensing (Chambers, Bridges & Jones, 2009). In these studies, both sweet and non-sweet carbohydrates were shown to activate regions in the brain associated with reward and motor control. There is robust evidence that in situations when a high power output is required over durations of ~45-75 min, mouth rinsing or intake of very small amounts of carbohydrate play a non-metabolic role in enhancing performance by of 2-3%. (Jeukendrup & Gleeson, 2018, https://bit.ly/2UENOq7).

Although there is no football specific evidence, carbohydrate mouth rinsing has been shown to increase self-selected jogging speed with likely benefits in sprint performance during intermittent exercise (Rollo, Homewood, Williams, Carter, & Goosey-Tolfrey, 2015). In the future we may see studies that are more specific to football, but this approach is certainly promising if a practical solution can be found as a single rinse will have little effect and more rinses are likely required.

> Implications for football are still unclear, but practical solutions which enable the use of carbohydrate mouth rinses during match play (e.g. mouth guards which also serve as carbohydrate delivery systems) could potentially enhance performance in situations where carbohydrate consumption is limited by gastrointestinal concerns. A recent article in the New York Times addressed this as players at the football world cup were seen rinsing their mouths with (carbohydrate) solutions (Longman, 2018).
>
> Hydration can be another important factor during a match. Players are usually dehydrated to a smaller or larger degree after a football match (Nuccio, Barnes, Carter, & Baker, 2017) due to mismatch between sweat losses (governed by the intensity/duration of play and environmental conditions) and fluid intake (governed by match opportunities and individual hydration practices). In cool conditions, net fluid losses are typically within an acceptable range (1-2% BM) (Burke & Hawley, 1997), in which effects on running and cognitive performance (Nuccio et al., 2017) appear to be small and inconsistent. (Jeukendrup & Gleeson, 2018, https://bit.ly/2UENOq7).

For example, fluid ingestion had no effect on 15 m sprint performance during a Loughborough Intermittent Shuttle Test (LIST) protocol (Ali, Gardiner, Foskett, & Gant, 2011), although an earlier study by McGregor, Nicholas, Lakomy and Williams (1999) showed faster sprints with fluid ingestion during a 90 min LIST. Similarly, intermittent running capacity was not affected by mild dehydration in one study (Owen, Kregel, Wall, & Gisolfi, 1985), while another showed small improvements with drinking versus a water mouth rinse or no fluid (Edwards et al., 2007). Therefore, it is fair to conclude from the available evidence that current drinking practices are not a major concern for performance if they limit dehydration to moderate levels (up to 2.5% BM loss) in temperate conditions.

In hot conditions, however, greater fluid losses (e.g. match sweat rates of up to 3 L) could affect physiological responses and performance (Baker & Jeukendrup, 2014). How to deal with extreme environmental conditions is discussed elsewhere in the next module.

An elite football match played in a hot environment showed compromised performance of repeated sprint and jump activities, with pronounced reduction in high-intensity running toward the end of the match; this was attributed to training status and

hyperthermia/dehydration (Mohr & Krustrup, 2013; Mohr et al., 2010). It is therefore likely that enhanced drinking strategies can prevent some of the larger effects on performance effects in hot environments (Mohr & Krustrup, 2013; Mohr et al., 2010). It is important to note that inter-individual differences in fluid losses and needs occur, requiring an individualised approach to prevent excessive dehydration (Holway & Spriet, 2011).

A number of practical issues determine opportunities for hydration and carbohydrate intake within a match. The Fédération Internationale de Football Association (FIFA) rules dictate that drinks (and other products) can only be ingested during stoppages. Stoppages for drinks or other medical reasons are decided by the referee, although during extreme hot weather tournaments, FIFA may decide to have scheduled drinking breaks. Generally, however, there are few drinking opportunities during a match and these opportunities are usually not scheduled and may not be available to every player (e.g. a player may be on the opposite side of the pitch). Clearly this makes the opportunities before the match and during halfme more important than in many other team sports. Both hydration and carbohydrate intake may require special attention in matches where overtime (2 x 15 min) is played. All match nutrition strategies, including the use of supplements (see specific section) should be practiced in training and minor matches.

Ergogenic aids

Nutrition supplements are the next thing to consider for match day. There are probably two types of supplements that could be used. Ergogenic aids that would help to increase the amount of work that can be performed (i.e. running performance, reduction in fatigue/delayed fatigue) or supplements that improve skill and cognitive aspects of performance. It is tempting to believe that nutrition supplements that deliver such compounds can boost performance. This section goes beyond the carbohydrate and protein supplements that support the point already made above. This section explores the supplements that are promising and have an evidence base in sports like football.

Running performance

There are a number of supplements that could, at least in theory, improve running performance in football. These supplements will be discussed in more detail elsewhere in this course, but here we will focus on the practicalities for match day. Besides carbohydrate (which does not have to be ingested as a supplement), the supplement with most evidence for improved performance is caffeine. Of course, caffeine does not have to be ingested as a supplement either but in football it often is the most practical solution. If players wanted to get the effects from coffee, however, this is possible too. The first step would be to work out the

optimal dose for each individual, mostly by trial and error. Training can be used for this before trying caffeine in matches. On match day caffeine should be ingested 45-60 min before the start of the match, whether this is in the form of pills, capsules, sports nutrition products (most common form) or coffee. The target should be around 3 mg/kg but adjusted to the individual. If caffeine gum is used, this gum can be used during the warm up. Most gums require 3-5 min of chewing before all caffeine is released. Caffeine concentrations in blood will rise rapidly as a result of absorption in the oral cavity.

The other supplement that could be useful to take on match day, but is less practical is sodium bicarbonate. Studies have demonstrated improved buffering capacity with sodium bicarbonate and this could potentially improve repeated sprint performance. Specific studies in football are lacking at the moment but based on existing evidence in other activities, it is likely that this would exert small performance benefits. That is, if the ingested bicarbonate does not cause any side effects. The recommended dose is 300 mg per kg (0.3 g/kg) and this is a handful of salt that should be ingested in the 2 h before the match. This is where this supplement is not very practical. Some have ingested it dissolved in orange juice, others rely on capsules (the recommended method).

Another method to improve buffering capacity would be beta alanine. The mechanism is different, and therefore the effects of this method are likely additive to the effects of sodium bicarbonate. Bicarbonate increases the buffering capacity of the blood, drawing hydrogen ions out of the tissue; beta alanine will increase carnosine content, and this is an intracellular buffer. Carnosine content does not change overnight and a prolonged period of supplementation is needed to increase muscle carnosine concentrations. The recommended dose is 3-6 g/d for 3-4 weeks followed by a maintenance dose of >1.2 g per day. This means that it is a strategy suitable for the harder or more important part of the season (for example double weeks), but supplementation would need to be started 3-4 weeks earlier.

Because b-alanine may have side effects, especially at higher doses (tingling fingers and nose), it is recommended to practice and see if the potential performance effects outweigh the potential side effects.

The final supplements to consider are nitrates, which could be delivered in the form of foods (green leafy vegetables, beetroot) or in the form of concentrated beetroot juice (shots). The latter has been the most common and probably most practical form. Again, there is little research specifically to football, but there is some evidence with intermittent exercise. Performance effects may be small and may be even smaller in elite, very well trained players. Although studies suggest 3-6 day loading, 36 h nitrate loading may be more practical and acceptable amongst football players. The main limiting factor of this strategy will be taste and

palatability issues with current nitrate products that are commercially available (i.e. beetroot juice or shots). It is therefore highly recommended that players experiment with nitrate supplementation prior to implementation.

Finally, creatine is a supplement that has been very popular for many years in strength sports; it's heavily researched and has a good evidence base, especially for performance in repeated sprints. It is recommended to load with 4 x 5 g creatine/d for 5-7 d followed by a daily maintenance dose of 3-5 g/d. Because creatine supplementation will suppress endogenous production, and because it takes a relatively long time before creatine returns back to normal levels, it is recommended to "cycle" creatine supplementation to specific stages of the season. This should be carefully planned at the start of the season.

Skills performance

Caffeine and carbohydrate are the dietary constituents for which the greatest number of reports describing improved skills and cognitive aspects of sports performance have been published. However, more work is needed to determine the optimal dose and timing of caffeine and carbohydrate intake needed to elicit maximal and consistent benefits in motor skills and cognitive performance. In fact, dose-response studies are needed for all dietary constituents, as the paucity of such studies represents a significant gap in the literature.

Overall, the body of literature reviewed suggests that study participants with impaired cognitive function states (e.g., sleep deprivation, mental stress, or exercise-induced fatigue) are more likely to experience acute benefits from caffeine or carbohydrate ingestion. There is currently a lack of evidence to substantiate the use of any other dietary constituents to benefit sports-related motor skill or cognitive performance. Many claims and suggestions have been made, that link other supplements to improved skill maintenance: branched-chain amino acids, cocoa flavanols, Gingko biloba, ginseng, guarana, Rhodiola rosea, sage, L-theanine, theobromine, and tyrosine. However, at present these supplements cannot be recommended to enhance motor skills or cognition for sports performance.

Carbohydrate and caffeine are the only dietary constituents that have decent evidence for their efficacy as an ergogenic aid in sport-specific skill tests. For other dietary constituents, researchers usually use motor skills and cognitive tests designed for the general population, and such tests have questionable relevance to sports settings. It is crucial that future efficacy studies develop and employ valid, reliable, and sensitive batteries of motor skills and cognitive tests.

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