3.1 Nutrition in Competition

The goal of athletes during competition is to be able to perform at their maximum potential. There are several factors that can diminish their capacity to perform; without a doubt, nutrition is one of them.

Nutrition in competition is based on trying to develop a nutritional plan that can reduce or delay the onset of those factors that cause fatigue or diminish performance. Of course, this competitive nutrition strategy should be as individualized as possible, be tested beforehand, and take into account the practical aspects that will allow for it to be carried forward, all without causing gastrointestinal discomfort that may adversely affect the athlete's performance.

Ideally, the nutrition plan for competition should be organized taking into account the nutritional strategies that will be applied before, during and after the event.

3.1.1 Pre-Competition

A variety of factors related to nutrition can make athletes fail to make the most of their chances during competition. Among these, we have (Burke, 2006):

- Depletion of muscle glycogen stores.
- Hypoglycemia.
- Dehydration.
- Gastrointestinal discomfort.
- Hyponatremia.
- Mechanisms of central fatigue related to neurotransmitters.

It is important to bear in mind that the risk of developing an issue during competition, as well as the severity thereof, will be influenced by other factors, such as the duration and intensity of the effort, the environmental conditions during competition, training status, individual characteristics, and the success of the nutritional plan before and during the competition.

The nutritional intervention we plan for competition should begin by identifying the limiting factors of performance, especially which of them are likely to be favorably affected by an adequate nutritional plan. While it is much easier to recognize these factors in simpler activities, such as running or cycling, it may not be so when it comes to more complex efforts, such as team sports. Once these factors have been identified, the

next step would be to establish the nutritional goals that will modulate them favorably. Finally, a nutritional plan or series of strategies needs to be developed to meet the goals.

Pre-competition nutrition strategies may include a wide variety of interventions that can be implemented the week before the competition, or just hours before. Beyond the timeframe they cover, they should always be directed to positively impact on the physiological challenges imposed by each sports discipline. Depending on the characteristics of the sports event, these strategies may aim to minimize fluid deficit, ensure the availability of energy substrates, or prevent gastrointestinal distress (Burke, 2006).

Ideally, a nutrition plan for competition should be based on a combination of strategies covering pre-, intra- and post-competition. But in practice, on several occasions, the athlete is not able to take advantage of all the periods or opportunities available for a nutritional intervention. When an opportunity is lost or underutilized, more emphasis should be placed on strategies at other times in an attempt to compensate.

The main goal of a pre-competition diet is to optimize muscular and hepatic glycogen stores, since the depletion of CHO from the body's reserves is one of the main causes of fatigue during exercise, not only for resistance, but also for intermittent sports, as well as for other high-intensity efforts. In addition, since glucose is the main fuel for the central nervous system, the availability of CHO could also affect sports dependent complex motor skills or coordinations.

Other dietary goals at this stage are: to ensure an optimum state of hydration and prevent hunger during competition, especially during long-lasting competition, but at the same time to avoid gastrointestinal discomfort that can impair performance.

The *general recommendations* usually given with respect to what foods to consume during this period are: that they should have a high content of CHO, a moderate amount of proteins, and be low in fats and fibers to facilitate gastric emptying; they should provide a sufficient amount of liquid; and finally, the food should be familiar and appetizing to the athlete (American College of Sports Medicine, 2000).

The size and timing of intake are inversely related, meaning, the closer to the beginning of the competition, the lower the amount of food that should be eaten. Most studies that showed a positive effect on performance have used CHO amounts of between 200 and 300 g, consumed 3 to 4 hours before competition (American College of Sports

Medicine, 2000). If we wanted to make this recommendation considering the athlete's body size, we might suggest an intake of 4 to 5 g CHO/kg (1.82 to 2.27 g CHO/lb) about 4 hours before the competition, whereas this amount should decrease by 1-2 g CHO/kg (0.45 to 0.9 g CHO/lb) when eating 1 hour before the competition.

3.1.2. Intra-Competition

During exercise or competition, athletes can benefit from fluid and food intake. The benefits can be expressed as improved performance and/or reduced physiological stress on an athlete's cardiovascular, central nervous and muscular systems.

Despite the existing scientific evidence to support the general theory for encouraging athletes to consume water and CHO during exercise, it is sometimes difficult to convert these recommendations into practical tips that athletes can follow in real competitive situations.

The main nutrients to be consumed during exercise or competition are CHO, fluids, and sodium. The consumption of other substances, such as glycerol, fats, proteins and neurotransmitter precursor amino acids (AA) is not recommended during exercise (Coyle, 2004).

CHO are the most important nutrients in an athlete's diet because they are the **main energy substrate** in intense exercise, and because fatigue, during intense and prolonged exertion, is usually due to depletion of muscular and hepatic glycogen, since the body's reserves of CHO are limited. Consuming CHO during exercise allows the athlete to maintain blood glucose levels, a substrate that becomes predominant in the later stages of long-term competition. Therefore, CHO consumption during prolonged exercise may delay the onset of fatigue.

Consuming CHO during exercise is even more important in certain circumstances, such as when the athlete was unable to incorporate CHO, when it was not possible to eat prior to competition, or when undergoing a hypocaloric diet plan for weight loss (American College of Sports Medicine, 2000).

Most carbohydrates (glucose, sucrose, maltose, maltodextrins, amylopectin) are oxidized to relatively high levels while other carbohydrates (such as fructose, galactose, trehalose) are oxidized to slightly lower levels (Leijssen et al. 1995). Carbohydrates consumed during exercise are oxidized in small amounts during the first hour of exercise (~ 20 g) and then reach a level of up to ~ 60 g/h. Even the intake of large

amounts of carbohydrates does not reach high levels of oxidation (Jeukendrup & Jentjens 2000; Jeukendrup 2004).

In general, and for exercise lasting two to three hours, a carbohydrate intake of 60 g/hr is recommended before reaching fatigue or depletion of the body's carbohydrate stores. Ingestion of more than 60 g/h will not have an additive effect and may even cause gastrointestinal distress, while for exercise lasting between one and two hours, a carbohydrate intake of 30 g/h may be more appropriate (Jeukendrup & McLaughlin 2011).

Consuming CHO during events that last about one hour has been a controversial issue for a long time; however, current recommendations support the benefit of this practice, especially for athletes who exercise in the morning (American College of Sports Medicine, 2000).

CHO intake during exercise can have a positive effect on performance. However, for this to happen, it is necessary to consume the optimum dose; too much or the wrong type can cause several issues that will worsen performance, while too little will have no real effect on performance. Table 1 summarizes the recommendations on the optimal amounts and types of CHO to be consumed according to the type of exercises.

Table 1 Recommendations on the Amount and Type of Carbohydrates Needed for Optimal Performance in Different Types of Exercises

Event	Recommended Amount of CHO for Optimum Performance	Type of CHO
Maximum exercise, duration < 45'. Speed cycling. Most swimming tests. Most athletic races, including 10 km (6.21 miles).	They are not necessary	
Maximum exercise, lasting 45' to 60'. Cycling: 1 km (0.62 miles) individual time trial (ITT). Basketball game. Soccer: one half.	Less than 30 g/hour	Glucose, sucrose, maltose, maltodextrins, amylopectin, fructose, galactose, isomaltulose, trehalose, amylose.
Team Sports, lasting ~ 90'. Football match, Rugby match, etc.	Up to 50 g/hour	Glucose, sucrose, maltose, maltodextrins, amylopectin, fructose, galactose, isomaltulose, trehalose, amylose.
Submaximal exercise, duration greater than 2 hours. Recreational tennis match. Recreational cycling. Hiking.	Up to 60 g/hour	Glucose, sucrose, maltose, maltodextrins, amylopectin, fructose, galactose, isomaltulose, trehalose, amylose.
Maximum and almost maximum exercise, duration greater than 2 hours. Marathon. Cycling: individual pursuit. Competitive tennis match. 50-km (31-mile) ski race.	50-70 g/hour	Glucose, sucrose, maltose, maltodextrins, amylopectin.
Ironman Triathlon, Tour de France	60-90 g/hour	Most likely only achieved with the intake of different types of CHO: glucose, fructose, sucrose, maltodextrins, amylopectin, etc.

Source: Taken from Jeukendrup, 2007.

In the sports world, athletes consume carbohydrates during exercise using a variety of foods and beverages, and a variety of eating schedules. Carbohydrates effectively oxidize, if offered in solid form such as energy bars, chewing gum, semi-solid gels, or in beverages (Pfeiffer et al., 2010). Therefore, strategies to provide approximately 30-60-90 g of carbohydrates/h (depending on the duration of the exercise) can be

modified according to the preference of the player and based on other nutritional requirements such as the player's need for liquid. Sports drinks (commercial beverages containing between 4-8% carbohydrates – 4-8 g carbohydrates/100 ml, electrolytes and pleasant flavors) are particularly important since they allow the athlete to replace his carbohydrate and liquids needs simultaneously. For sports lasting over 60 minutes in which fatigue may occur, athletes are encouraged to create customized nutritional plans to match their needs to their preferences (Burke et al., 2011).

A common recommendation is that, when possible, athletes should consume a sufficient amount of fluids to balance the rate at which they sweat (Coyle, 2004). This is based on the fact that dehydration reduces the dissipation of body heat, usually resulting in an increase in body temperature. In addition, dehydration may induce increased cardiovascular stress during exercise, evidenced by a decrease in stroke volume, which may adversely affect performance in endurance exercises. When it is not possible or practical to ingest sufficient amounts of liquids, athletes may tolerate dehydration levels equivalent to 2-3% of their body weight without it significantly affecting their performance or their health, especially in cold to moderate environmental conditions. However, when stressing under very hot environmental conditions (> 30°C/86°F), even dehydration levels as low as 2% decrease performance and predispose the athlete to suffer some complications such as heat stroke.

The suggestion of ingesting sodium during exercise is based on the fact that sodium chloride is the main salt element lost through sweat and that sodium is the body's main electrolyte. While sodium losses through sweat can vary greatly among individuals, athletes have been recommended to consume sodium-containing liquids during exercises that last longer than 2 hours or are performed under environmental conditions that stimulate very profuse sweat losses.

Finally, each sport or activity offers particular opportunities for liquids and carbohydrates to be consumed throughout the session, either by stopping at relief stalls, using supplies provided by the athlete himself, or during official breaks during the game, such as time-outs or half-time rests. The athlete, coach, and medical team should remind athletes to implement nutrition strategies during these times.

3.1.3 Post-Competition

Post-exercise recovery is a complex process that requires body deposits to be reloaded with energy substrates, for damaged muscle tissue to be repaired and thus begin training adaptations (Ivy, 2004). To achieve this, it is necessary for the organism to move from a predominantly catabolic state to a predominantly anabolic state. Therefore, not only is it necessary to consume appropriate nutrients, but these should also be provided in sufficient quantities and at the right time.

Recovery of muscle glycogen stores is a key component of the recovery process. This process is slow, requiring a number of factors to be taken into account, especially when there is little time between training sessions or competitions. When the time between sessions or events is very limited (hours or less) it makes sense to turn every minute into efficient recovery time and therefore, it is not necessary to consume carbohydrates immediately after exercise and the athlete can afford to follow his desired meal schedules as long as they meet the goals of total carbohydrate intake per day. Under these circumstances, muscle glycogen can be restored to resting levels 24 hours after exercise (Parkin et al., 1997), although it is also true that glycogen stores can increase rapidly if they are consumed during the first two hours post-exercise (Ivy, 2001). In addition, there is some evidence that carbohydrate-rich foods and beverages with a high or moderate GI may be more favorable for glycogen stores than those with lower GI (Jentjens & Jeukendrup 2003). We will focus the discussion of diet within the recovery period on this basis.

Interestingly, recent studies suggest that the level of muscle glycogen resynthesis may be slower after high-intensity and intermittent exercises, such as a soccer match. Glycogen stores tended to be lower after competition than during meetings up to 48 hours prior to the match, despite the ingestion of a high carbohydrate diet. (Bangsbo et al., 2006; Krustrup et al., 2011).

However, another point to bear in mind during this stage is that most athletes do not ingest enough fluids during exercise to compensate for sweat loss, and usually end with some degree of dehydration (American College of Sports Medicine, 2000). That is why another key dietary point at this stage is the replacement of fluids and electrolytes to recover optimal euhydration.

Finally, the third element to consider in the recovery of athletes is the provision of protein after exercise. Perhaps this is one of the areas most neglected by athletes, especially when it comes to endurance. Specific soccer activities, as well as frequent changes of direction and sprint

decelerations, have a high eccentric component and eccentric contractions, in combination with contact between players, all of which causes muscle damage and interferes with glycogen synthesis (Krustrup et al., 2011). This phenomenon is not relieved by a diet high in carbohydrates and milk protein (Gunnarsson et al., 2013), although certain amino acids have a powerful effect on insulin secretion, which stimulates glycogen re-synthesis (van Loon et al., 2000). This is why the effects of adding proteins to amino acids and carbohydrate solutions are being researched.

Recovery objectives include paying attention to the immune system, muscle groups, and the reparation of injuries. It may therefore be useful to eat nutrient-rich carbohydrates and drinks during the recovery period to provide a range of valuable nutrients (Betts & Williams 2010).

In an attempt to accelerate the player's recovery and reduce muscle pain, cryotherapy or ice baths have become a common strategy adopted in many sports. Due to the vasoconstrictive effects of cryotherapy, concerns have risen as to whether glycogen re-synthesis would be impaired due to reduced availability of substrate as a result of reduced blood flow to the muscle. However, one study researched the effect of immersing the lower limbs in cold water (8°C) for 10 min following exhaustive exercise, and found no alteration in glycogen restoration, compared to being at rest, when appropriate quantities of carbohydrate were ingested (Gregson et al., 2013).

Protein during Recovery

Exercise increases both muscle protein breakdown and muscle protein synthesis. Therefore, in the absence of protein in the diet, net protein balance will remain negative. That is why protein is a key ingredient after matches and training sessions, in order to achieve a positive net protein balance. In addition to the general effects of exercise, most "stop and go" sports involve many decelerations (eccentric contractions) and contact among athletes, which can lead to muscle damage. Protein intake is, therefore, advised to aid in repairing muscle tissue and other potential injuries (Res 2014).

After endurance exercise, muscle protein synthesis in response to a meal has been shown to be elevated for up to 24 h (Burd et al., 2011). However, it is better to start protein intake immediately after exercise for optimal recovery, especially if limited time is available until the next match or important event. Muscle protein synthesis decreases over time if blood amino acids remain high. Therefore, for optimal recovery, meals containing protein should be eaten approximately every 3 hours, with the

consumption of a final snack containing protein just before going to bed (Res et al, 2012; Areta et al. 2013).

After exercise, intake of different amounts of food can deliver a similar amount of the total amino acids required. However, the speed at which the amino acids are delivered and the profile of branched-chain amino acid (BCAA) and leucine, in particular, will vary (Burke et al., 2012). The optimal dose of protein to maximally stimulate muscle protein synthesis seems to be around 20-25 g, or about 0.3 g/kg (0.14 g/lb) BM (Moore et al, 2009;. Witard et al, 2014.). Animal protein contains more of the amino acid leucine, which is believed to be a main trigger for increases in muscle protein synthesis (van Loon, 2012). Meanwhile, whey protein can be quickly digested and absorbed and contains a high proportion of leucine. For example, 20 g of whey protein contain approximately 2.5 g of leucine. Whey has also been shown to be superior in terms muscle protein synthesis compared to soy or casein, when taken in isocaloric amounts (Tang et al., 2009). Plant-based proteins contain less leucine in comparison to whey, which is why it may have to be ingested in larger amounts to maximize muscle protein synthesis. Whey protein (or good sources thereof) is therefore considered to be the best protein to consume directly after exercise.

After the initial intake of post-exercise protein, players should continue to increase muscle protein synthesis. During the day, players should be encouraged to eat protein from a variety of foods such as fish, meat, poultry and dairy, but also of from plants such as legumes, nuts, rice, corn or wheat. Casein is beneficial as a pre-bedtime snack, as it is a slowly digested protein that will be available during a longer portion of the night (Res et al., 2012).

Daily protein intake for athletes has been advised to be in the range of 1.3-1.8 g/kg BM (0.59 - 0.82 g/lb) (Phillips & Van Loon 2011).

Although these studies advocate the benefits of very high protein intakes, the current recommendation for daily protein intake for a 70 kg (11.02 stone) player is to consume about 120 grams of protein divided over 6 meals, interspersed by about 3 h, where each of these foods contains about 20 g of proteins (Van Loon and Phillips 2011). However, it is important to note that in cases of extreme physical demand or energy deficit, protein needs may be greater.

3.1.4 Training Cycles

Periodization of training involves varying the components of the training load (mainly volume and intensity) throughout the year to achieve maximum performance. While there are numerous models of periodization, which divide the sports season into different cycles, the three cycles most commonly used by coaches and athletes are:

- Preparatory Period (or Pre-Season). The most common goals for athletes at this stage are to develop cardiovascular endurance, general strength, technique and tactics, and flexibility, among others. In some cases, they may seek changes in body composition.
- Competitive Period. The most common goals at this stage are often power, specific strength and tactics, among others.
- Transition Period (or Off Season). During this stage, athletes often perform unstructured exercise or do other sports to maintain their fitness level, carry out rehabilitation processes and modification of body composition.

In general, any periodization plan should also consider other factors that could affect training and recovery. Undoubtedly, nutrition stands out among these, although on numerous occasions it is not taken into account or intended for the long term (e.g., within the annual training plan). Ideally, athletes would also carry out a nutritional periodization plan (NP), to support changes in training load, and thus be in optimal conditions to perform high-quality workouts and recover faster.

Before making a recommendation on nutrient requirements and optimal timing during each training cycle, it is very important to have a clear idea of the goals pursued and the training load to be faced. This includes information on frequency of training, focus of the sessions, duration and intensity, etc.

Daily macronutrient needs for athletes usually cover a fairly wide range; on the one hand, due to the differences between different sports, and even within the same sport (meaning among different specialties or different positions); and on the other, due to each athlete's individuality and the different objectives for each training cycle. Either way, it is important to note that these ranges only provide a starting point, meaning that they are the basis from which the nutritional plan should adapt to the training program.