Module 2. Nutrition and ergogenic aids

2.1 Introduction

Maria Antonia Lizarraga, Patricia Garrido, Mireia Porta, and Gil Rodas

1. Importance of nutrition in team sports
2. Objectives of nutrition in team sports
3. Body Composition
4. Energy Expenditure
5. Periodized Nutrition. Energy and Carbohydrate Adjustment
6. Time Adjustment: timing
7. Nutrition Strategies during recovery
8. References

1. Importance of nutrition in team sports

The importance of nutrition in sports as well as the population's interest in it have increased in the last years. Today, it is considered that food provide much more than energy. It also has a direct impact on health, performance, rest, state of mind, injury prevention, etc.

Nutrition is one more aspect to work on in a team depending on the importance the team gives to it, especially its coach. If she/he considers it a key aspect, she/he will communicate that to the players and the rest of the professionals involved. At the same time, this will be expressed through actions and by controlling the hydration, the weight, and the body composition or the nutrition education for the best recovery possible.

In the long term, a team which considers nutrition to be a controlled and an important aspect communicates a discipline and a beneficial routine that will later be automatically internalized by the new players of the team.

The concepts of "going on a diet" and of "restriction" are currently perceived as useful and positive in the athlete's training. The aim of nutrition focused on training and competition is that the player, individually, knows how to eat, drink, and rest at any time.

The key objective of the "athlete's diet" some years ago was to provide extra energy by means of carbohydrates. This is, by eating pasta, rice, cereals, etc. Although, nowadays, this food continues being important, the personalisation and periodization are now the new objectives for the performance since the improvement of the performance is only achieved through adaptation. (Heaton, Davis, Rawson, Nuccio, Witard, Stein, 2017).

Periodization means making changes in the diet depending on the intensity of the training sessions or games to achieve a better adaptation. (Jeukendrup,2017).

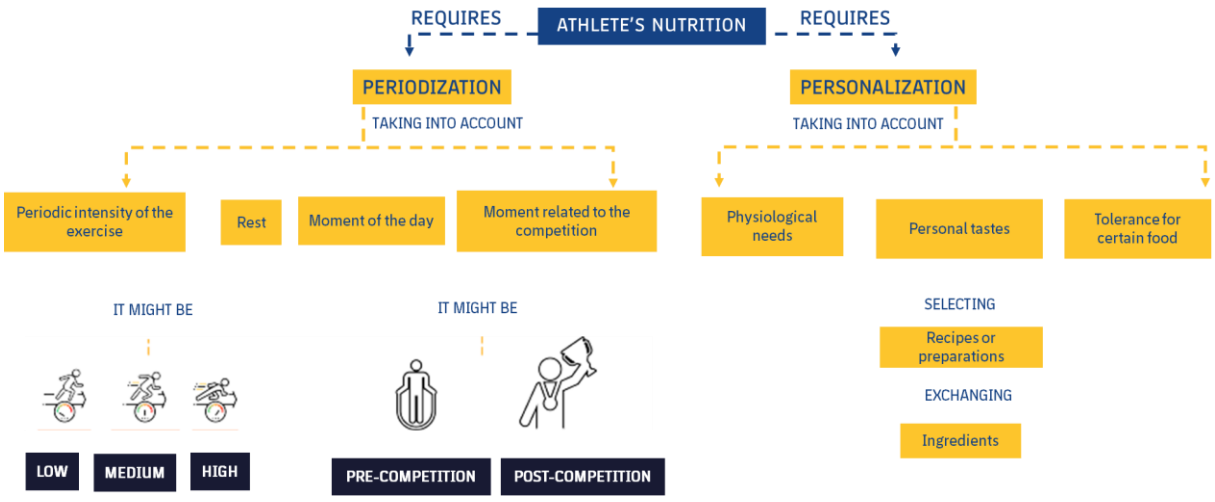
Not only is what to eat important but also when to eat. The concept of timing is really important. What is eaten and drunk before, during, and after the training should be designed according to the objectives of each of these moments.

Adaptation is a dynamic process of balance between both physical and mental demands in training sessions and games. It must be compensated with the recovery capacity based on the nutrition and rest guidelines, the stress management capacity, etc.

Personalisation is based on the knowledge of each player's individual needs at a metabolic level, a level of physical composition and even of supplementation based on the specific objectives as regards their characteristics, position in the team, etc.

In the not-too-distant future, nutrigenetics, metabolomics, metagenomics and other omics included in sportomics will lead to a better knowledge and a tailor-made design of the player's needs.

Figure 1: Periodization and Personalisation Scheme



Source: Adapted from (Ref Grafis) (YEAR)www.ub.edu/grna

2. Objectives of nutrition in team sports

Team sports have in common the performance of intermittent high-intensity efforts but with a huge variability between the needs of the different sports or even in the same sport according to the period of the season, the position, the athlete's type of game, etc.

There are some common guidelines for sports nutrition in team sports:

1. Getting a proper body composition.

2. Adapting food to training sessions: periodising depending on the higher or lower demand.

3. Planning a nutrition and hydration strategy for the competition.

4. Using the ergogenic aid and the most suitable supplements (Mujika and Burke, 2011).

The nutrition recommendations for team sports must have objectives for the group that should later be adapted to the individual characteristics of each player depending on their peculiarities, type of game, body composition objectives, etc.

General Objectives:

1. Covering the energy adapted to the needs and adjusting the quantity of high-carbohydrate food according to the days with more or less activity, games, etc.

2. Providing high-quality proteins fractionated throughout the day so as it leads to muscle adaptation and repair after the effort.

3. Choosing healthy food with high nutritional value that provide significant quantities of vitamins and minerals and help modulate the inflammation, maintain immunity, etc.

4. Importance of timing: knowing what to eat according to the moment with different objectives (before, during, and after).

5. Hydration and Supplementation: this topic will be deeply developed in the following unit.

Other Nutritional Aspects to be considered

- Knowing the way each player eats: who prepares the meal, cultural aspects, religion, family environment, types of meals when eating out (favourite restaurants and food that determine the quality of the diet).
- Knowing if any player is going on a special diet, taking supplements on their own or being advised by another professional.
- Thinking of and planning a nutrition plan for trips and movements.
- Nutrition education through talks, by delivering informative material, etc.
- Assessing the player's profile and their environment to know their higher or lower amenability and adherence to possible changes that may arise.

In the team, some players might be more or less interested in nutrition and that is transmitted and spread among the new additions and also to the younger teams. Especially when there is any model or referent of well-qualified player who takes care of their food and will be imitated. It is about a matter of attitude and interest towards nutrition as an extra tool to achieve their objectives.

A key strategy to change the behaviour is that the player understands what they want to achieve and why they need to make that change since this is not always considered a key factor for their performance. Cases in which there is a loss of performance or even an injury could be considered good opportunities to raise interest.

The player on its own should be a nutrition expert and know which is the optimal 0% fat weight for them, hydration strategies, pre- and post-game food, the most suitable supplements to have the best performance and be good at all levels. The nutrition professionals as well as the team physician, the physical trainer, the physical therapist and the professional environment have to provide the information and tools to achieve it. However, it is very important that the own player knows that it is their decision and that throughout their career, they would have to choose each day what to eat, drink or when to rest.

The aim of these units is to summarise some of the key nutrition aspects and strategies to consider in team sports and to try to communicate them in a practical way that can be useful for the professional and, at the same time, the professional can pass it on to the player.

3. Body Composition

The relationship among an adequate body composition, health, and sport performance is clearly evident. In team sports, it is important to maintain a specific somatotype or anthropometric profile that leads to the optimal development of each of the sports. Thus, its assessment and control are key. On the other hand, it is important that the team of professionals know the team's objectives and the individual ones and pass it on to the players in order to obtain a proper nutrition education and thus, optimise the athlete's health and performance. We refer to optimal percentages not to specific figures.

In team sports, there are a suitable somatotype and a percentage of fat depending on age that varies according to the position in the team or the type of player (Oliveira, Ferreira, Caetano, Granja, Pinto, Mendes, et al., 2017).

It is common to experience changes throughout the season in team sports, and, for instance, the percentage of fat increases during the rest period. These values are normally corrected throughout the preseason and the muscle component tends to be increased after one or two daily training sessions.

There are many reasons why there might be an excessive increase of weight and body fat out of the season or when the athlete is not able to compete or is injured. It is important to have nutrition strategies for these cases so as players can choose what to eat at home, restaurants, trips, etc.

It is a good idea that the athlete knows the changes and thinks of the preseason as the most appropriate time to improve since once the competition starts it will be more difficult. An excess in the training load and a bad adaptation to it during the competition can lead to a decrease in the muscle component associated with other overload signs and bad recovery. On the contrary, the well-established strength training and the protein intake in bolus of 25-30g in post-stress help to gain muscle mass and are, sometimes, used to optimise the body composition during moments of control. On the other hand, a percentage of fat lower than the optimal values will not always be a benefit. The prolonged search for reducing the percentage of fat would make the athlete to undergo a long period of low energy availability that would increase the risk of injury.

In order to monitor these changes, registering the body weight is considered to be a simple and non-invasive method to evaluate the player's energy balance. However, it does not specify when the changes occur. This first measurement can be later completed with a more detailed analysis.

The aim of analysing in detail the changes in the body composition throughout the time is to enable the evaluation of the joint effect of the training loads, nutrition, rest, the player's physical development and their correct adaptation to the demands. It is important to bear in mind that a player's body composition is determined, but not exclusively, by genetics. There are other factors that can have an influence on that such as the type or intensity of the training, the food, the rest, different hormonal aspects, and even the gut microbiota.

In the professional leagues of different team sports, the body composition tends to be measured at the beginning of the preseason and it is then monitored during the whole season, normally every one or two months. The evaluation methods and frequency of the body composition will vary according to the resources and preferences of the club.

There are different methods to evaluate the body composition. Based on our knowledge, the following three are the main ones for athletes involved in team sports:

Anthropometry: the measurement of fat folds is the most used method to evaluate body composition. This method uses callipers to measure fat skinfolds in specific parts of the body. This measurement is carried out in the 8 points described in the protocol of the International Society for the Advancement of Kinathropometry (ISAK): biceps, triceps, iliac crest, supraspinale skinfold, abdominal fold, front thigh and calf. After measuring this, the results are expressed as the addition of the skinfold thicknesses of the places measured or the evaluation of certain fold changes individually.

The skinfolds that better correlate with body density and which can show changes in the short and middle term are: tricipital, abdominal, suprailiac and above the thigh.

The abdominal skinfold is related to short-term changes depending on the diet while the changes in the limbs can be related to the higher or lower intensity of the effort and the muscle component. In addition, if the midarm and midleg circumferences are registered, it is possible to calculate the muscle or corrected circumferences of them and take into consideration the changes in this component. This enables the evaluation of changes in both the percentage of fat and muscle throughout the season. The limitation of this method is that qualified personnel is required.

Bioimpedance (BE): This non-invasive technique determines the body composition through a bioelectrical method that measures resistance to electric current flows. This resistance is determined by the quantity of tissue which is a good or bad conductor. Water and tissues with high water content such as the muscle will act as good conductors while fat will act in the opposite way. This method allows to know the total of water, fat, and the quantity of lean mass that in some cases can be reflected in a segmental way. The result of this method has a direct relationship with the results of the DXA (see the following point). The advantages of this method are the possibility of being self-directed by the person who performs the test, the determination speed (from one to two minutes), and the speed at which the results are obtained. Some of the bioimpedance limitations are that the results are subject to gender, age, height, and the ethnic group. Besides, it tends to underestimate fat mass in normal weight people and overestimate it in overweight people compared to the DXA (Aragon, A., et al 2017).

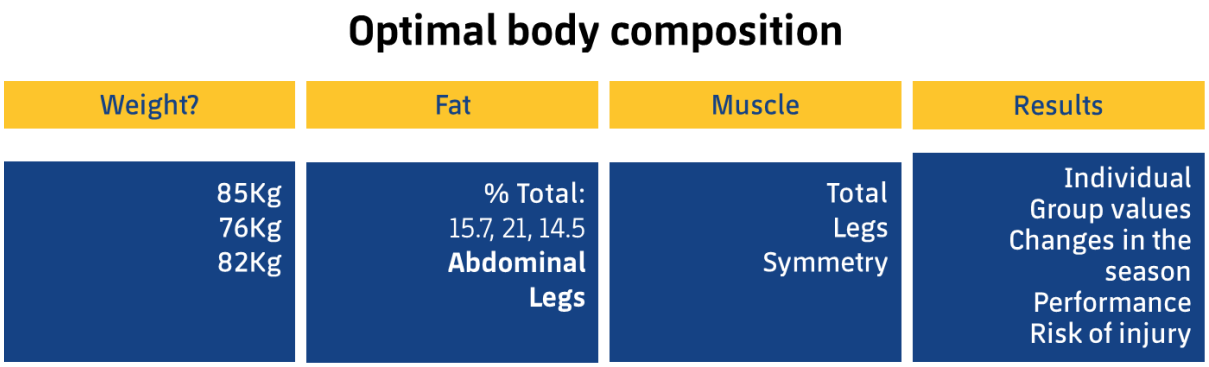
Dual –energy X ray absorptiometry (DXA): indirect technique that measures the different attenuation of the photons emitted in relation to the body composition and the thickness of the tissue penetrated. The DXA studies this by means of a three-compartment model: fat, bone, and lean mass. The body composition is calculated through a body scanning and the application of attenuation coefficients.

This technology has currently become a very common method used by some team sport elites and it offers a relatively precise estimation of the lean mass, bone density, and fat mass proportion and their analysis at the level of segments such as trunk and limbs, etc.

The DXA is normally carried out 3 or 4 times throughout the season to evaluate changes. For example, in the preseason, one month after it, and 2 more times. However, in case of special needs such as weight control or injured players, it can be more frequently performed due to its low dose of radiation.

One drawback is that it is a really expensive method and not all teams can afford it. Thus, there are few reference values to compare (Kelly, Wilson, Heymsfield, 2009).

Figure 2: Interesting aspects of body composition to be considered for team sports



Source: Lizarraga, 2018.

Generally, a common objective of team sports is to adjust, throughout the season, the fat percentages as well as to gain muscle mass whenever is the right moment to do it. As we have already seen, the preseason is a very favourable moment to do it. Throughout the season, there are other factors that influence its achievement. For instance, if the player is playing in the starting line-up and the number of minutes played in the season. These factors optimise the state of those who compete in comparison with those who were not called.

The normal control of body weight can be considered a way to evaluate the balance between what is eaten and what is burnt. It is important to consider it together with feedback on how tired they feel, their appetite, their difficulty to fall asleep, etc. All of them can be signs of maladaptation.

Weight is not all. Although it is a useful indicator of the player's state, it should not be taken as something that causes anxiety or stress and that could lead to a conduct disorder.

In cases in which weight control represents an excessive concern for male and especially female players, it is advised not to control it. In addition, we should pay special attention to punishments for not losing weight since it is a way to know the situation in depth.

It is good that the staff (physician, coach, physical trainer, etc.) are motivated by the players' good health condition and that they consider the weight as a parameter to be controlled in a rational way with clear objectives and a common message. Derogatory and dangerous remarks should be avoided at all times. Having the right weight and a good nutrition is a favourable positive and desired aspect that motivates the player when thinking about their professional career and even after finishing it.

It can be a group objective to have a specific percentage of fat and each player should aim at it, but it is also important to individualise the objectives and know what that means for each of the athletes and to what extent they work to achieve them. For instance, in a

team, a value of 12% of fat can be easily got by some players without a lot of effort. However, for other players with higher values, reaching a 13 or 14% can be consider a great achievement and they should be congratulated on it. The optimal individual value is what each player should aim at.

In order to evaluate significant changes, the players' weight can be registered regularly at the same time of the day, normally when they arrive at the training session or when they are under a normal hydration. This control enables the detection of important changes but with the flexibility of considering the physiological oscillations, especially in women athletes.

The strategy of weighing the player before and after the training session and evaluating the ingested liquid and the urine output can be a useful tool to understand how the hydration will be afterwards. In case of a marked weight change (both gained or lost weight), it is important to estimate the possible causes and to motivate the player to find out an explanation.

The player who will stop for a couple of weeks or months due to an extended injury, will require motivation as regards the changes in the body composition and will need to make special nutrition adjustments. The aim is to control, whenever possible, the increase of abdominal fat and modulate the loss of muscle mass associated with the immobilization and the lack of exercise. In these cases, it is important to educate the player so as they replace the energy-dense food they used to eat before with more anti-inflammatory and protective ones which have lower caloric content. For example: reducing cereals or replacing pasta with a colourful vegetable salad with some pasta as a side dish. We cannot forget that the high-quality protein which maintains the muscle should be included and fractionated in all foods.

The daily protein distribution in bolus or portions of about 25 - 30g each, 5-6 times a day enables the optimisation of the muscle response to exercise. The anabolic or increasing effect of the muscle mass is more noticeable if one of these protein intakes is carried out after training.

The above-mentioned 25-30g can be easily obtained with an intake of 120-150g of meat or fish or with a protein shake which tends to be easier to get in the immediate post-effort

4. Energy Expenditure

When athletes train or compete, energy expenditure increases significantly in terms of absolute value with important differences between days of game or intense training and those of rest or lower intensity. It is interesting to know an estimation average of these needs and evaluate whether they are met or not. Moreover, in situations in which fatigue markers, weight loss, immune and hormonal disorders, among others can be identified and taken as a sign of inadequate energy availability.

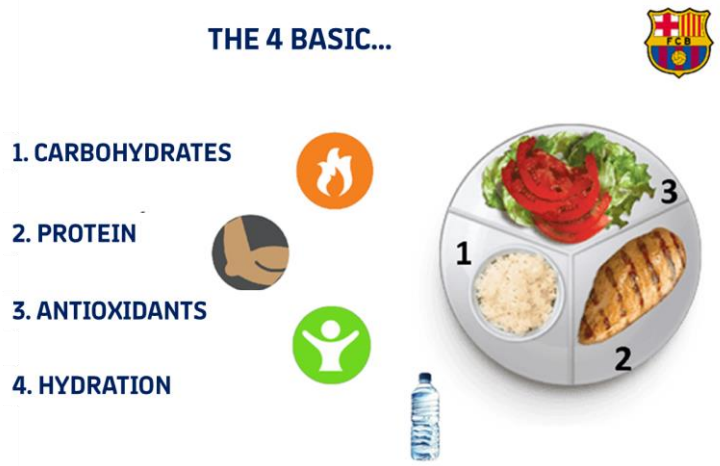
The literature establishes that when the energy availability is low, this is, when the daily energy intake is lower than 30 kcal/kg of lean mass (fat free) without considering the physical exercise, problems such as tiredness, fatigue, lower sport performance or even immunosuppression might appear.

It is important to detect the population segments which are at risk due to a continuous insufficient energy intake. This can be the case in growing young athletes or in female sports athletes since it is more difficult to maintain the weight and the body composition. Sometimes, female players go on strict diets and set some restrictions that can pose the risk of eating disorders or hormonal disorders or even the complete triad which includes a decline in bone mass and loss of menstruation.

5. Periodised Nutrition. Energy and Carbohydrate Adjustment

A special model of dish is used that includes the three main groups of food the athlete needs: energy, protein or structural and protective food. Their proportions are modified so as different kinds of dishes can be designed. These designs can include a model for low-intensity training days or for players who control their weight, another model which can be appropriate for normal training days and a third one for high-intensity training or load days adaptable for the day previous to the game: day -1, day of the game with its peculiarities, and recovery day (day +1).

Figure 3: Example of dish models



Source: prepared by the authors.

From these values, the periodised nutrition supposes an adaptation to days of rest, of moderate intensity or high intensity/game and a performance of different adjustments. In team sports such as football, these adjustments might suppose, for instance, burning 2500 kcal/day in a day of rest, 3000 kcal in a low-intensity or recovery day, and 3500 kcal

in the day of the game taking into account that the energy expenditure per game, in the case of football, is of about 900 - 1000 kcal. (Jeukendrup, 2017).

Figure 4: Periodized nutrition in a week of just one game

EXAMPLE OF PERIODISED NUTRITION IN FOOTBALL					
	BREAKFAST	MID-MORNING	LUNCH	AFTERNOON SNACK	DINNER
MONDAY MD+2		TRAINING SESSION			
TUESDAY NO TRAINING SESSION		FREE DAY			
WEDNESDAY MD-3		TRAINING LOAD			
THURSDAY MD-2		TRAINING SESSION			
FRIDAY MD-1		TRAINING SESSION			
SATURDAY MD				**GAME**	
SUNDAY MD+1		TRAINING RECOVERY			

Source: prepared by the authors.

As shown in the Figure with different colours, a periodised training load and weekly nutrition can be carried out with days of higher energy demand (orange and red colours) and lower-intensity days (green colour).

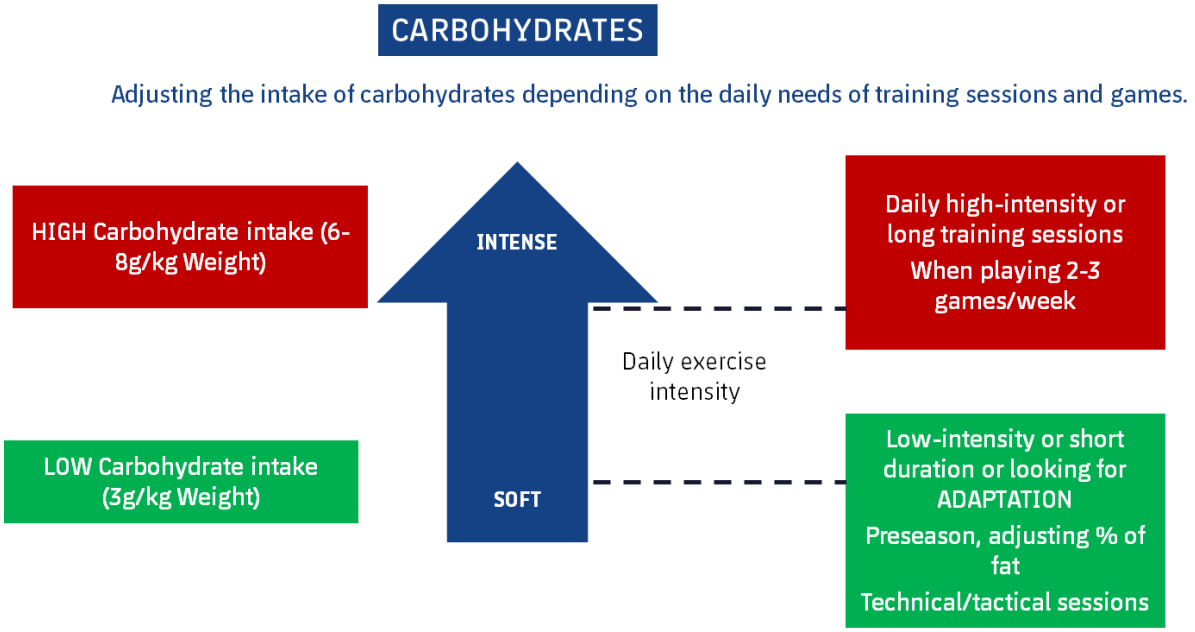
The objectives in each case can be different. From a general perspective, they can be established as:

Previous days and Post-game Objectives: -2 -1 Restock the muscle glycogen stores.

Game day Objective: complete extra energy, hydrate, good sensations, digestibility.

24-48Hs post-game: rehydrate optimal recovery of energy used, recover muscle damage, modular inflammation, etc. (Heaton, Davis, Rawson, Nuccio, Witard, Stein, et al., 2017).

Figure 5: Periodised Nutrition or Adjustment of carbohydrates for higher-intensity sessions or game days



Source: Rollo Lizarraga, Porta 2017

As we have already mentioned, the energy of a day of rest can quantitatively vary with respect to a game or intense training session in about 1000 kcal. However, it is necessary to communicate the players the concept of high- quality nutrition, even in diets for the control of energy in order to motivate them and make them have a nutrition:

1. Which is varied, colourful and anti-inflammatory. Rich in vegetables and healthy fat.
2. With adequate protein content distributed throughout the day.
3. With a carbohydrate intake adjusted to the effort duration and intensity. These intakes can be side dishes or fruit, cereal, rice snacks, etc.

The athlete does not understand the % of calories of the diet or the gr/Kg of weight of carbohydrates or proteins. That is why the message about what to eat should be clear and simple, using units of measurement which are easy to identify such as big, medium or small or even by using pictures to evaluate them.

The concept of the size of the dish and the distribution of food which is modified according to the needs, increasing or decreasing the portion of pasta, rice or potatoes and the other way round, salad, vegetables, etc., leads to the design of different options for different situations.

Even though the concept of periodised nutrition in other sports is clear and the athlete trains and eats differently depending on the moment, in team sports, this concept has been recently presented. The periodisation in team sports is interesting since it is a way

to make the player conscious that in the same way they adjust the training load and intensity for an optimal adaptation, it is also necessary to adjust nutrition and increase or decrease the amount of certain key food when maintaining and recovering the energy reserve. Thus, for instance, the quantity of carbohydrates may vary in absolute value between days, and two portions of pasta or rice, a bowl of pieces of fruit, half a litre of sport drink and a recovery shake with cereals might be added to a basic diet before going to bed.

Periodising carbohydrates leads to a consumption of 4g/g of the body weight during training days, but up to 7g/g of the weight in days of games. This means that a player of about 80kg may start consuming about 250 g extra per day of energy food such as rice, pasta, fruit, cereals or sport drinks with a difference of about 1000 kcal between some days and others (Anderson, Orme, Naughton, Close, Milsom, Rydings, et al., 2017)

6. Time Adjustment or Timing

The moment of eating is also very important. The concept of timing or time adjustment must be known by the athlete so as they can identify in which situations it is necessary to make even a little effort to eat and, thus, optimise the recovery.

The correct pre-eating timing aims at completing the digestion before the effort and at preparing the athlete, hydrating them and providing the glucose for the mind before starting. During the effort small quantities of fruit, gels, bars might be eaten and drinks might be taken in accordance with the tolerance, regulation, etc. Once the effort is over, the objective is to adjust the food and drink in order to have an optimal recovery.

There is a pregame timing that implies the respect of previous digestion times and the adaptation of food quantities and types to the time needed to digest them. There is an inverse timing in which the player starts their recovery with liquids and small quantities of food to be completed in the following hours.

Figure 6: Scheme about what and when to eat before a training session/game

Source: Prepared by the authors based on Lizarraga, 2018.

The adequate recovery timing is similar to an effect called "open window" in muscles that considers the two hours after the effort of vital importance to provide the athlete with the proper drinks, food and even supplements (Ranchordas, Dawson, Russell, 2017).

Figure 7: Scheme about what to eat after a training session/game

Source: prepared by the authors based on Lizarraga, 2018.

These are frequent causes of cumulative fatigue: dehydration, the bad restocking of glycogen stores after the effort, the metabolic acidosis or the central fatigue due to decreases in blood glucose levels, among others (Mujika and Burke, 2011).

7. Nutrition Strategies during recovery

It is vital to know when it might be important to eat and what to eat. Food today is more than just calories. Apart from modulating energy, they help modulate, for instance, the hormonal and inflammatory response during the post-effort hours. The recovery food of the first two hours after the effort has as an objective to stop the levels of cortisol and inflammatory mediators as well as to promote the rapid recovery of the muscle glycogen. To do so, it is necessary to have proper quantities of nutrients which are well-proportioned.

A carbonara pasta dish, a low-fat pizza, sushi, or a recovery shake can be considered good options to recover and get a proportion of 4:1 or 3:1 of carbohydrate and protein providing a minimum of 15-25g of protein.

The optimal recovery is one of the main objectives when training sessions or games overlap. It is difficult to get it when there are fewer than 3 days between them, sometimes associated with trips and the combination of nutrition and rest is the key to get it (Dupont, Nedelec, McCall, McCormack, Berthoin, Wisløff, 2010).

Support strategies such as protein shakes or combinations with carbohydrates after the effort and before going to bed together with sleeping the right number of hours can help to minimize the effects of the cumulative fatigue (Heaton, Davis, Rawson, Nuccio, Witard, Stein, et al., 2017).

2.2 Hydration and performance

Methods for evaluating dehydration and hydration strategies before, during and after training

Every day, during exertion, athletes lose lots of a water through sweat, urine, and breathing. However, they can take it in through foods and liquids in their diet. Dehydration by more than 2% of body mass can result in diminished performance. Each athlete has a different rate of dehydration, and so it is important to measure and monitor fluid balance.

To measure their rate of dehydration, the difference between a player's weight before and after exertion must be calculated, adding fluid intake and subtracting urine. The total is divided by minutes of exertion and multiplied by 60 to calculate their volume of sweat/hour.

This rate varies according to environmental conditions, the intensity of the training session or match, etc.

Formula:

$$\frac{\text{(Weight before exercise – weight after exercise) + (Volume of fluid ingested – volume urinated)}}{\text{Minutes of physical effort x 60 minutes}} = \text{Volume of sweat/hour}$$

It should also be kept in mind that minerals, such as sodium and chloride, are also lost through sweat, and that individual differences in this regard exist between players. So some players will need an extra intake of electrolytes after they finish activity in order to avoid cramps, etc.

Physical activity is often begun in a state of dehydration. This diminishes athletic performance and reasoning. That is why hydration before competition or training is as important as hydration during or afterwards. Players should know how to maintain their level of hydration and how to modify their fluid intake in accordance with the demands of exercise or environmental conditions.

The ingestion of fluid during training sessions and matches can help maintain plasma volume and prevent the adverse effects of dehydration on performance and health. When there is little time between matches, rapid and effective rehydration is crucial for optimizing recovery. But it is also important to engage in daily strategies that improve hydration and build up a tolerance for liquids before and after exertion:

- **Prior to exercise:** 5-7 ml of fluid for every kg of body mass is recommended for the 2 hours before exercise is performed. The ingestion of liquids during meals, combined with small quantities of sodium, will help to stimulate thirst and retain water.

- **During exercise:** In order to avoid dehydration, it is important to follow suitable rehydration guidelines during training sessions and matches. To do this, athletes must be weighed regularly before and after training sessions and personalized guidelines must be designed that combine, for example, water with sports drinks. This will be particularly effective if exercise continues for more than 30 minutes in a warm environment. Unrestrained and excessive water consumption should be avoided during exertion over an extended period, as this can lead to hyponatremia (low concentrations of plasma sodium) caused by large volumes of sweat being replaced only with water. Hydration guidelines must be followed every day. Athletes should avoid consuming large quantities all at once to prevent the negative impact of excessive volume, such as the urge to urinate immediately, since this generates voluntary dehydration.

- When choosing sports drinks, it is important to see which drink is best adapted to the needs of the athlete. Nowadays, mineral salt content and carbohydrate content can be adjusted to 2, 5, or 12 percent, in accordance with athletes' needs. As we shall see, hydration through liquids also provides athletes with an opportunity to take in carbohydrates in accordance with their tolerance and needs. Drinks should be specifically tailored to the team sport to be played, and they should also be tested before being used during competition, to ensure that athletes do not suffer from intestinal problems. Sports drinks tend to contain sodium as well as water and carbohydrates in order to improve the absorption and retention of the water consumed.

- **After exertion,** it is important to rehydrate as soon as possible and to consume, in the two hours immediately following, at least 150% of what has been lost, through sports drinks, water, and food. In cases of severe dehydration, a combination of water, salt, and carbohydrates rehydrates more efficiently than water alone.

Ergogenic aids in team sports

Ergogenic aids include any substance that improves athletic performance, whether psychologically, materially, pharmacologically, or nutritionally. Nutritional aids includes both foods and functional foods, such as nutritional supplements whose purpose is to improve athletes' performance or to optimize their health. These supplements are often utilized by players during the season with the aim of improving performance and optimizing recovery. One example of their extensive use is that 43% to 93% of soccer players use supplements, claims made in various studies. During the 2002 and 2006 FIFA World Cups, rates of supplement use of between 40% and 50% were recorded. In the face of these numbers, it is important to remember that it is rarely necessary to use supplements if athletes' diets are healthy, varied, and balanced. Even so, there are

exceptions in which supplements can help with performance or recovery, but they must always be taken to complement a healthy diet, not as a substitute for it. In this context, a supplement is something that is designed to be edible and contains a dietetic component which is meant to provide additional nutritional value. The dietary ingredient can be a combination of the following substances:

- A vitamin.
- A mineral.
- A herb or other botanical components.
- Amino acids.
- Dietary ingredients are also utilized to increase an individual's total intake, through concentrates, metabolites, ingredients or extracts.

Sports nutrition products (such as drinks intended for athletes, protein drinks, or recovery drinks) are not considered supplements. Unfortunately, the athletic supplement industry is not well-regulated, and this implies a set of risks that must be avoided. Quality is an essential factor, and decisions about which supplements to use should be based on a rigorous cost/benefit analysis. Although there are thousands of supplements on the market, only a few are backed by scientific endorsement and evidence. These supplements or functional foods are classified according to their level of scientific evidence into the following groups:

Grade A evidence

Data from multiple randomized clinical studies or meta-analyses.

Figure 8: Supplementation with Grade A Evidence

Source: prepared by the authors.

Grade B Evidence

Data from a single randomized clinical study or from large non-randomized studies.

Figure 9: Supplements with Grade B Evidence

Source: prepared by the authors.

Grade C Evidence

Consensus of expert opinion and/or small studies.

It is important to keep in mind that, as professionals, we must preferentially recommend those supplements that are in groups A or B.

Grade D Evidence

Banned or at a high risk of contamination by substances that might lead to a positive doping test. Should not to be used by athletes.

The recommending evidence must always be grades A or B in order to avoid false positives or inefficiency and to increase the demonstrated beneficial effects of supplements belonging to groups A and B.

2.2.1 The most commonly utilized nutritional supplements and functional foods

In this chapter we will take a detailed look at the most important supplements and corresponding scientific evidence. Next, some will be categorized according to their medical use (for the improvement of performance or of recovery):

Table 2: Most important supplements according to their medical use

Medical use, according to analytical results	Iron
	Multivitamin/Vitamin C
	Vitamin D
Improved performance	Caffeine
	Creatine
	B-Alanine
	Nitrates
Recovery	Tart cherry juice

Source: prepared by the authors.

This chapter will focus on those supplements that are used most frequently and have as their objective both the improvement of performance and the optimization of recovery. It is worth emphasizing that supplements should be used in specific situations in accordance with the protocols validated for their use. Supplements should be used after having been individualized, supervised and monitored by professionals working in the field. Although there is generalized evidence relating to these products, studies are needed to further refine individualized protocols, including for timing. Programs to ensure quality at every level are needed. These programs help to assure that supplements are safe and do not contain banned substances.

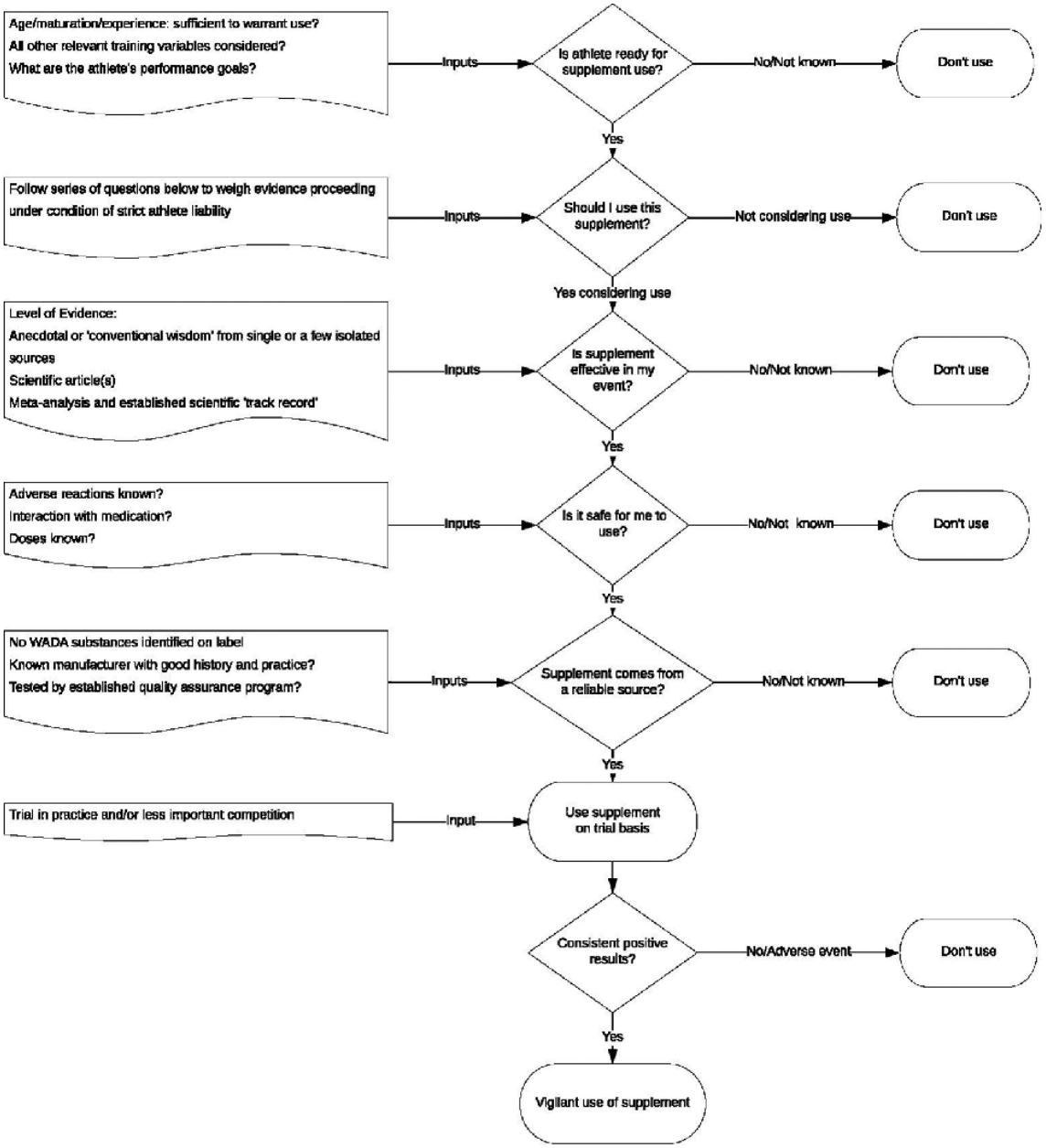
Supplement safety: quality assurance programs

There are significant risks associated with the use of unregulated dietetic supplements. These include:

- The absence of the active components named.
- The presence of harmful or toxic substances.
- The presence of drugs that should be prescribed and are potentially dangerous.

After the decision to use supplements has been made, it is very important to ensure that the supplement in question is among those supplements allowed by the World Anti-Doping Agency (WADA). In particular, we must also ensure that all supplements are free of banned substances. There are many examples of athletes who tested positive on an anti-doping test as a result of their use of a nutritional supplement and experienced difficulties due to their use of these supplements. Thus, it is important to consider the risks and benefits before making a decision.

Figure 10: Flow chart to guide informed decision making and reducing risk of antidoping rule violation during nutritional supplement use.



Source: Maughan et al., 2018, p. 450.

There are quality assurance programs that test products for banned substances. These programs analyze samples of supplements currently on the market and compare them using guides to substances banned by the WADA. However, these programs are still not reliable, since, in general, they do check whether the active components are present. Athletes, and those responsible for their supplementation, see these programs as a guarantee of the integrity of the products that they analyze. However, it is important to keep in mind that only a small number of supplements have been analyzed and that these analyses are limited in terms of minimum detectable amounts. Thus, although these programs make assurances that they are reliable, they do not offer an absolute guarantee of quality.

The supplements most commonly used by athletes are multivitamin complexes and mineral supplements, followed by other micronutrients, including vitamin C, vitamin D, magnesium and iron.

The supplements described in this chapter are those that are supported by a moderate-to-high amount of evidence and are important to various sports.

Performance-enhancing supplements

- **Caffeine**

Caffeine is a compound that is found in many drinks and food products (for example, in tea, coffee, cola, chocolate, etc.). It is possibly the most widely studied compound that is an ergogenic aid used to enhance performance. It has been consistently demonstrated that caffeine improves both cognitive performance as well as performance during various physical activities such as running, bicycling, swimming, and rowing (Burke 2008). Various studies have also concluded that it also improves the physical and technical aspects of athletic performance that are inherent to many athletic competitions.

For example, caffeine can improve the ability to perform sprints and jumps, as well as improving performance in high-intensity intermittent sports (Grant et al., 2010). The ergogenic effects of caffeine are obtained with an intake of 2-6 mg/kg of body mass index (Burke 2013). Caffeine's peak plasmatic concentration tends to occur 45-60 minutes after its ingestion. It is recommended that it is consumed via drinks that contain caffeine, capsules, or gels (depending on the athlete's preferences) during warm-ups prior to the start of activity. Although the precise mechanisms of caffeine's ergogenic contribution must still be verified, the majority of researches agree on caffeine's ability to affect the central nervous system. Caffeine moves through the blood-brain barrier easily and acts as an antagonist for adenosine, preventing its action. Caffeine can thereby increase concentrations of certain neurotransmitters such as dopamine, which elevates motivation levels and heightens physical ability. Recently, it has been shown that it can have an ergogenic effect in high-intensity intermittent sports through a mechanism related to muscle excitation. In fact, it has been demonstrated that caffeine

supplementation causes an improvement in physical capability, since it reduces the accumulation of potassium in muscle during intense exercise (Mohr et al., 2011, 1372-1379).

Multiple studies have recreated competition scenarios and observed the effects of caffeine supplementation. Some of these have reported improved recovery and performance in comparison with players who were not supplemented with caffeine. In soccer, there are also studies that show a greater capacity for sprinting and jumping and improved perception on the part of players, since caffeine seems to reduce feelings of fatigue during training or matches. Unlike competition days, on which athletes consume caffeine products, on training days, they can obtain the same beneficial ergogenic effects if they consume caffeine by drinking tea or coffee at breakfast, prior to their training session.

Although there is ample evidence on caffeine supplementation in sports, it is recommended that athletes first trial supplementation during training. This is because caffeine may have adverse effects that limits its use in some sports or in sensitive individuals. These include: insomnia, headaches, intestinal irritation and bleeding and the stimulation of diuresis. Also, not all individuals obtain benefits after being supplemented with caffeine, and increasing the size of the dose (especially above 6 mg/kg BMI) can have negative consequences such as an increased heart rate, greater irritability, trembling, confusion, decreased concentration, shortness of breath, etc. Many of these side effects have a negative impact on athletic performance. Equally, consuming elevated doses of caffeine the night before a competition can also be problematic because sleep quality will be compromised (Morton, http://www.gssiweb.org/sports-science-exchange/article/sse-130-supplements-for-consideration-in-football, 2014).

Practical recommendations for caffeine supplementation

1. Carry out tests during training to ascertain the correct dose.
2. Set a goal of reaching 3mg/kg (within a range of 2-5mg/kg).
3. Take caffeine 45-50 minutes before a match.
4. If utilizing chewing gum for caffeine intake, take it just prior to or during warm-ups.
5. The form in which caffeine is taken will depend on athletes' tastes and preferences.

➢ **Creatine**

Like caffeine, creatine is one of the most frequently studied supplements, with a significant body of evidence available. Creatine is a guanidine compound that is synthesized in the liver and kidneys, derived from amino acids arginine and glycine. From a dietetic perspective, the richest sources of creatine are fish and red meat. For example,

1 kg of steak contains over 5 g of creatine (Maughan et al., 2011). The largest reserve of creatine in the body is in the musculoskeletal system, where between approximately 60%-70% of creatine is stored in a phosphorylated form known as phosphocreatine (PCr). Creatine supplementation has traditionally been associated with strength and power in athletes (such as, for example, the strength required by weightlifters or athletes who perform sprints) because of the role that PCr plays in the hydrolization and regeneration of ATP during the initial seconds of a high-intensity activity. In any case, in the context of high-intensity intermittent sports, creatine supplementation is especially important because PCr stores are markedly reduced during team sports such as soccer. As a consequence, creatine supplementation improves the repeated execution of sprints of both short and long duration and also improves the performance of intermittent exercises over an extended period of time. This improvement may be due to an increase in the reserves of phosphocreatine in recovery periods between sprints. Several sources (Casey, 1996) show an improvement in sprinting when creatine has been supplemented, as compared to athletes who have not been supplemented. Players can also take creatine with the objective of increasing muscle mass, strength, and power, as well as to improve their sprints.

Harris and his colleagues provided the initial evidence that creatine supplementation (utilizing a supplementation protocol of 20g per day for 5 days) increased (by magnitudes of 20%) both total quantities of creatine as well as PCr stores in the musculoskeletal system (Harris et al., 1992). The guidelines for taking creatine have been standardized to a protocol for use (which usually implies 4 doses of 5 grams a day for 5-7 days) followed by a daily maintenance phase involving a dose of between 3 and 5 grams (Human et al., 1996). However, given that athlete adherence to this protocol may be limited, it should be kept in mind that the intake of smaller doses over longer periods of time may, in the end, increase creatine in muscles, even to values similar to those observed after implementing more traditional supplementation protocols. After supplementation has been completed, muscle creatine stores tend to return to initial basal levels in 5 to 8 weeks. In order to maximize creatine stores, it is recommended that it also taken after physical activity in combination with carbohydrates or proteins, since an increase in insulin is also known to increase the production of creatine. At a practical level, this means ensuring that creatine is taken before and after periods of training together with other sports nutrition products that may contain carbohydrates and/or protein, or with a meal (breakfast, lunch, or dinner). Supplementation prior to exercise can also improve the resynthesis of muscle glycogen after exercise. Taking into account that it is difficult to replenish muscle glycogen deposits after physical exercise even with the proper contribution of carbohydrates, a strategy that includes creatine can be important during periods that feature numerous training sessions of matches, one after the other. (Morton, http://www.gssiweb.org/sports-science-exchange/article/sse-130-supplements-for-consideration-in-football, 2014).

It is important to take into account that not all athletes will have the same response to creatine supplementation, not only in terms of increased levels of muscle creatine but also in terms of improved athletic performance. In fact, the extent of the increases in muscle creatine (when a specific dose is administered) have an elevated rate of variation that depends on the initial quantity of muscle creatine present prior to supplementation. The latter is determined by dietary intake.

Improvements due to creatine in sports of intermittent duration are also greater in those athletes that have a higher starting level of creatine or PCr. A substantial supplementation of creatine can produce an increase in weight of between 1-1.15 kg. This effect occurs more frequently in men than in women (Mihic et al., 2000). This increase in weight is not associated with fat but may be due to increased concentrations of intracellular water. This is why not every player is interested in this type of supplementation: they may feel heavier and less fast. In particular, it will not be beneficial to athletes who require velocity and agility. This supplementation also has a negative effect on the liver and kidneys, although studies indicate that there is no relationship between creatine supplementation over long periods of time and liver or kidney damage in healthy individuals. In general, the current evidence suggests that creatine supplementation has positive effects in short-duration high-intensity sports and in those with intermittent periods of activity. Creatine has crucial effects on the musculoskeletal system: it acts as an energetic sponge, as an energy carrier, and as a regulator for the ATP/ADP ratio.

After supplementation, it takes weeks for creatine levels to return to their original values, and, during this period, the benefits it provides can still be enjoyed. It is prudent to supplement during specific moments of the season (for example, in the pre-season, or when there are many matches scheduled one after the other, etc.) or in order to achieve objectives during training sessions (improving muscle mass, strength, etc.).

Recommended practices for creatine supplementation

1. Develop individual strategies.

2. Monitor changes in height and weight.

3. Supplementation can be of short duration (5 days x 20g/day) or be gradual in nature (3g daily for 30 days).

➢ **β-alanine**

In skeletal muscle cells, b-alanine combines with L-histidine to form b-alanine-L-histidine, better known as carnosine. Carnosine is associated with high-intensity exercises, since it can act as an intracellular sponge for hydrogen ions. In soccer, for example, repeated sprints can cause muscle pH to decline to levels that may impede the formation of ATP via glycolitic metabolism. For this reason, it is common for soccer players to consume b-alanine supplements daily in order to increase their stores of carnosine and

improve their performance in high-intensity sports. In fact, it has been demonstrated that daily supplementation ofb-alanine raises concentrations of carnosine in the musculoskeletal system by approximately 50% in type 1 and type 2 muscle fibers (Harris & Sale 2012). Recent studies (Hobson et al., 2012) have also demonstrated that supplementation of b-alanine leads to ergogenic effects in sports with periods of high intensity that last between 1-6 minutes, such as track and field, rowing, swimming, etc.

Unfortunately, there is a lack of precise research that evaluates the effects of b-alanine supplementation in high-intensity sports such as soccer. It is possible that, in the studies in which performance improves, this may be due to a longer period of supplementation and, thus, to an increase in b-alanine stores in muscles.

Negative effects of supplementation with b-alanine include the reddening and tightening of the skin and paresthesia, which occur when a one-time dose of over 10 mg per kilo of weight is administered. To diminish these negative effects, various formulations have been developed that allow for the intake of up to 800 mg at a time without bringing on these symptoms (Decombaz et al., 2012). Although the optimal protocol for use is still unknown, a relationship has been demonstrated between the total quantity of b-alanine consumed (in a range of 1.6 - 6.4 grams per day) and both relative and absolute increases of muscle carnosine. (Stellingwerff et al., 2012). To this end, it has been observed that four weeks of supplementation with 3.2 g of b-alanine per day leads to an increase in stores of muscle carnosine twice as large as with supplementation of 1.6 grams per day. It has also been observed that a supplementation of 3.2 g of b-alanine per day leads to more than double the muscle carnosine as compared with a supplementation of 1.6 grams per day. At the same time, it has been observed that a supplementation of 1.6 grams per day may lead to larger increases after four weeks of supplementation (Stellingwerff et al., 2012). Recently, it has been observed that after daily supplementation with 3.2 g of b-alanine for a period of six weeks, a daily dose of 1.2 grams per day is required to maintain an increased level of muscle carnosine that is 30% to 50% greater than the level that is typical without supplementation (Stegen et al., 2014). After supplementation, a return to initial levels occurs at 10-20 weeks (Baguet et al., 2009). On the basis of the above, it is recommended that, when necessary, levels of carnosine be rapidly increased. Supplementation with high doses (for example, 3.6 grams daily for three or four weeks) can be a good start, followed by a daily maintenance dose of over 1.2 g. Paresthesia symptoms can be minimized with formulas that are eliminated from the body more slowly and by spreading doses throughout the day. Finally, it has also been established that increases in carnosine achieved through supplementation of b-alanine are more pronounced in athletes that are in training than in individuals who are not in training (Morton, http://www.gssiweb.org/sports-science-exchange/article/sse-130-supplements-for-consideration-in-football, 2014).

Recommended practices for beta-alanine supplementation

1. Use slow-release b-alanine formulas to avoid side effects

2. Take between 3-6g daily for three to four weeks and, afterwards, take 1.2 g of b-alanine as a maintenance dose.

➢ **Nitrates**

Dietary supplementation with inorganic nitrates is being increasingly studied due to the effects that nitric oxide has on various physiological functions. In fact, it has been documented that nitric oxide plays a role in regulating blood flow and replenishing muscle glucose, and also has an effect on the contraction of skeletal muscle (Jones 2014; Jones 2016). The traditional pathway of nitric oxide production involves the oxidation of L-arginine by nitric oxide synthase. In any case, it is known that inorganic nitrates that are ingested can also be metabolized into nitrates and then into nitric oxide, complementing those nitrates that are produced by the oxidation of L-arginine (Hord et al., 2011). The identification of this biochemical pathway has led to numerous studies on the ingestion of inorganic nitrates and physical performance. Nitrates are mainly found in leafy green vegetables such as spinach, chard, lettuce and beets, although their nitrate content can vary widely depending on the soil or the time of year. As a reference for the ingestion of a stable quantity of nitrate, many researchers use a standard dose of beet juice (keeping in mind that half a liter is equivalent to approximately 5 mmol of nitrate) in order to increase the availability of nitrate and nitrite. Utilized either regularly (half a liter of beet juice daily for 3-15 days) or on specific occasions (2.5 h prior to training), beet juice has been demonstrated to lower blood pressure, reduce oxygen consumption, and to heighten capacity during high-intensity exercises of short duration, such as in cycling and competitive running events (Bailey et al., 2009). It has also been observed that race times for distances of between 4 and 16.1 km (between 5 and 30 minutes of exercise, approximately) are also reduced. These positive effects are not observed in elite endurance athletes, which may be due to a combination of physiological differences between elite athletes and those with lesser ability, which make elite athletes less sensitive to increases in nitric oxide (Jones 2014, S35-45).

The mechanism that provides the basis for reduced oxygen requirements and improvements in performance is thought to be related to improvements in muscular efficiency and energy metabolism (Jones 2014, S35-45).

The optimal doses for facilitating nitrates' ergogenic effects are not yet clear, for example, it is not known if one-time, concentrated doses or regular doses are more beneficial. Protocols for use are therefore required. In any case, when the protocol for occasional use is followed, no variation in physical endurance has been observed for nitrates doses between 8.4 and 16.8 mmol consumed 2.5 hours prior to physical exercise, although both of these quantities are more effective than a dose of 4.2 mmol (Wylie et al., 2013). It was also observed that the reduction in oxygen consumption became more noticeable as the

dose increased (Wylie et al., 2013). This information suggests that the inability to detect the physiological effects of nitrates in episodic supplementation scenarios may be overcome by using greater doses prior to physical activity or through the use of longer duration protocols (Morton, http://www.gssiweb.org/sports-science-exchange/article/sse-130-supplements-for-consideration-in-football, 2014).

Although initial studies were carried out on continual, high-intensity physical activity, recent studies have examined the benefits of beet juice in high-intensity intermittent sports. Through the use of higher intensity supplementation protocols (approximately 30 mmol over a period of 36 hours), improvements have been seen in intermittent sports that feature repeated sprints during competition (Wylie et al., 2013).

From a practical perspective, it is more likely that it would be easier for athletes to supplement themselves with larger quantities of nitrates over the course of 36 hours than with more moderate quantities over the course of 3-6 days.

It is very important that athletes experiment with nitrates supplementation before competing (perhaps it is more important that they do so with this type of supplementation than with those mentioned earlier). In order to enhance the beneficial effects of supplementation with beet juice, it is recommended that athletes do not use antibacterial mouthwash or chew gum, as these products inhibit the conversion of nitrate into nitrite.

Practical recommendations for supplementation with beet juice

1. In the two days prior to a match, take a tablet of beet juice concentrate in the morning and another at night.
2. Take two sips of beet juice 1 to 4 hours before the beginning of physical activity.
3. Avoid mouthwash and gum.
4. Always experiment with this supplementation during training, prior to competing.

2.2.2 Supplements for performance enhancement

Tart cherry juice

Both tart and sweet cherry juice contain high levels of antioxidants, including melatonin, carotenoids, hydroxycinnamates, and several flavonoids such as anthocyanins and quercetin (McCune et al., 2011). Although the mechanisms involved are not known, there are reports that both sweet cherries and the Montmorency variety reduce inflammation (Kelley et al., 2006), oxidative stress and muscle pain, and improve muscle recovery.

In sports such as soccer, muscle stress is high, which results in muscle damage. This damage is followed by a second phase of inflammation, which is part of the recovery process. During this phase, the muscle is inflamed and its function diminished. It is believed that cherry juice acts mainly during this second phase, reducing inflammation

and damage and maintaining muscle function. In general, current evidence indicates that there are ergogenic benefits to consuming cherry juice both before and after playing sports.

Practical recommendations for supplementation with cherry juice

During a very intense season with 2-3 matches a week, take a concentrate equivalent to 100 tart cherries in liquid or capsule form per day.

References

Anderson, L. Orme, P. Naughton, R.J. Close, G. Milsom, J. Rydings, D. et al. (2017) Energy intake and expenditure of professional soccer players of the English Premier league: Evidence of carbohydrate periodization. International Journal of Sport Nutrition and Exercise Metabolism.

Aragon, A. A. et al. (2017) 'International society of sports nutrition position stand : diets and body composition'. Journal of the International Society of Sports Nutrition, pp. 1–19. doi: 10.1186/s12970-017-0174-y.

Baguet, A., Reyngoudt, H., Pottier, A., Everaert, I., Callens, S., Achten, E. y Derave, W. (2009). Carnosine loading and washout in human skeletal muscles. Journal of Applied Physiology, 106(3), 837-842.

Bailey, S., Winyard, P., Vanhatalo, A., Bkackwell, J., Dimenna, F., Wilkerson, D., Tarr, J., Benkamin, N. y Jones, A. (2009). Dietary nitrate supplementation reduces de 02 cost of low-intensity exercise and enhances tolerance to high-intensity exercise in humans. Journal of Applied Physiology, 107(4), 1144-1155.

Burke, L., Desbrow, B. Y Spriet, L. (2013) Caffeine and Sports Performance.

Burke, L.M. (2008). Caffeine and sports performance. Applied Physiology, Nutrition, and Metabolism, 33(6), 1319-1334.

Casey, A., D. Constantin- Teodosiu, S. Howell, E. Hultman & P.L. Greenhaff (1996). Creatine ingestion favorably affects performance and muscle metabolism during maximal exercise in humans. American Journal of Physiology, 271(1), E31-37.

Decombaz, J., Beaumont, M., Vuichoud, J., Bouisset, F. Y Stellingwerff, T. (2012). Effect of slow-release beta-alanine tablets on absorption kinetics and paresthesia. Amino Acids, 43(1), 67-76.

Dupont, G. Nedelec, M. McCall, A. McCormack, D. Berthoin, S. Wisløff, U. (2010) Effect of 2 soccer matches in a week on physical performance and injury rate. The American Journal

of Sports Medicine. Vol. 38. Nº 9 [pp. 1752– 1758]. Taken from: http://www.ncbi.nlm.nih.gov/pubmed/20400751Heaton

Gant, N., Ali, A. y Foskett, A. (2010). The influence of caffeine and carbohydrate coingestion on simulated soccer performance. International Journal of Sport Nutrition and Exercise Metabolism, 20(3), 191-197.

Harris, R. y Sale, C. (2012). Beta-alanine supplementation in high intensity exercise. Medicine and Sport Science, 59, 1-17.

Harris, R., Soderlund, K. y Hultmman, E. (1992). Elevation of creatine in resting and exercides muscle of normal subjects by creatine supplementation. Clinical science, 83(3), 367-374.

Heaton, L.E. Davis, J.K. Rawson, E. Nuccio, R.P. Witard, O.C. Stein, K.W. et al. (2017) Selected In-Season Nutritional Strategies to Enhance Recovery for Team Sport Athletes: A Practical Overview. Sports Medicine.

Hobson, R., Saunders, B., Ball, G., Harris, R. y Sale, C. (2012). Effects of beta-alanine supplementation on exercise performance: a meta-analyisis. Amino Acids, 43(1), 25-37.

Hord, N., Ghannam, J., Garg, H., Berens, P. y Bryan, N. (2011). Nitrate and nitrite content of human, formula, bovine, and soy milks: implications for dietary nitrite and nitrate recommendations. Breastfeeding Medicine, 6(6), 393-399.

Jones, A. (2016). Dietary nitric oxide precursors and exercise performance. Sports Science Exchange, 2016(156), 1-6.

Jones, A. (2014). Dietary nitrate supplementation and exercise performance. Sports Medicine, 44 (1), S35-45.

Jeukendrup, A.E. (2017) Periodized Nutrition for Athletes. Sports Medicine.

Kelley, D., Rasooly, R., Jacob, R., Kader, A. y Mackey, B. (2006). Consumption of Bing sweet cherries lowers circulating concentrations of inflammation markers in healthy men and women. The Journal of Nutrition, 136(4), 981-986.

Kelly, T.L. Wilson, K.E. Heymsfield, S.B. (2009) Dual energy X-ray absorptiometry body composition reference values from NHANES. PLoS One

Maughan, R., Greenhaff, P., y Hespel, P. (2011). Dietary suplements for atletes: emergint trends and recurring themes. Journal of Sports Sciences, 29 (1), S57-66.

McCune, L., Kubota, C., Stendell- Hollis, N. y Thomson, C. (2011). Cherries and Health: a review. Critical Reviews in Food Science and Nutrition, 51(1), 1-12.

Mihic, S., MacDonald, J., McKenzie, S., y Tarnopolsky, M. (2000). Acute creatine loading increases fat-free mass, but does not affect blood pressure, plasma creatine, or CK activity in men and women. Medicine and Science in Sports and Exercise, 32(2), 291-296.

Mohr, M., Nielsen, J. Bangsbo, y J. (2011). Caffeine intake improves intense intermittent exercise performance and reduces muscel interstitial potassium accumulation. Journal of Applied Physiology, 111(5), 1372-1379.

Morton, J. (2014). Supplements for consideration in football. http://www.gssiweb.org/sports-science-exchange/article/sse-130-supplements-for-consideration-in-football

Mujika, I. Burke, L.M. (2011) Nutrition in team sports. Annals of Nutrition and Metabolism. Vol. 57. Supplement Nº 2 [pp. 26– 35].

Oliveira, C. Ferreira, D. Caetano, C. Granja, D. Pinto, R. Mendes, B. et al. (2017) Nutrition and Supplementation in Soccer. The American Journal of Sports Medicine. [Internet] Vol. 5 N° 2 [p. 28]. Taken from: http://www.mdpi.com/2075-4663/5/2/28

Ranchordas, M.K. Dawson, J.T. Russell, M. (2017) Practical nutritional recovery strategies for elite soccer players when limited time separates repeated matches. Journal of the International Society of Sports Nutrition.

Stegen, S., Bex, T., Vervaet, C., Vanhee, L., Achten, E. y Derave, W. (2014). Beta Alanine Dose for Mantaining Moderately Elevated Muscle Carnosine Levels. Medicine and Science in Sports and Exercise, 46(7), 1426-1432.

Stellingwerff, T., Decombaz, J., Harris, R. y Boesch, C. (2012). Optimizing human in vivo dosing and delivery of beta-alanine suplements for muscle carnosine synthesis. Amino Acids, 43(1), 57-65.

Wylie, L., Mohr, M., Krustrup, P., Jackman, S., Ermiotadis, G., Kelly, J., Black, M., Bailey, S., Vanhatalo, A. y Jones, A. (2013). Dietary nitrate supplementation improves team sport-specific intense intermittent exercise performance. European Journal of Applied Physiology, 113(7), 1673-1684.