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Nutritional Considerations And Dietary Supplement Use For The Performance Of Professional Footballers: A Review

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Abstract

The right diet is critical in preparing for games and in fostering recovery afterward. Getting the right amount of energy and nutrient to stay healthy and to perform well is key. Too much energy and body fat increases, too little energy and performance falls, injuries increase, and illness results. This article reviewed the importance of biomolecules and energy in line with improved performance in professional footballers. Rehydration and hydromineral balance of the athletes in general and the football players in particular are important factors of performance during training, competition and recovery. For optimal recovery, it is advisable to eat well because an adequate diet will provide the athlete with all the mineral elements he needs (Sodium, potassium, magnesium, calcium, iron) and some vitamins. The footballer should consume about 6-10 g/kg of glucose 24 h before a game, 0.25-0.4 g/kg of proteins in the meal before exercise, and drink slowly (5-7 mL/kg body weight) at least 4 h before exercise. During exercise, sodium loss ranges from 30 to 62 mmol/L of sweat, or "salt" losses from 3.9 to 6.9 g. For chloride and potassium, loss of 43 and 6 mmol/L of sweat are observed respectively. In addition to the recommended nutrient intakes, it is also advisable to regularly consume effort drinks to effectively compensate for the loss of water, energy and electrolytes. These recovery drinks or effort drinks are more and more widespread nowadays as modern games include high energy costs and electrolyte losses. Thus, good hydration practices, macronutrient periodization, and monitoring of micronutrient status are relevant to prevent excessive fatigue and even immune deficiencies. Other supplements can help to sustain the effort such as taurine, guarana, ginseng, niacin, gluconolactone, pyridoxine and cyanocobalamin. However, their consumption should be taken with cautious as some contains doping substances.

Keywords: Professional footballer, perfomance, nutrients intake, recuperation drink, effort drink

Introduction

Football is among the most popular sports in the world, being universal, and played by more than half a billion people and has become the biggest entertainment and spectacle in the world (Gayant, 2013). It is an intermittent, collective game, with intense efforts as well as violent and repeated actions in a short time interval (Ingebrigtsen, Dalen, Hjelde, Drust, and Wisloff. 2015). Modern games include more passing, running with the ball, dribbling, and crossing, thus suggesting a significant increase in the "pace" of matches (Strudwick, 2016).

During the competition, players cover an approximate distance of twelve kilometers per match (Di Salvo *et al*., 2007), with an energy expenditure of 1000 to 1500 Kcal (Bangsbo, Morh, and Krustrup, 2006, Bangsbo, 2014) and a sweat loss of 1.17 L/hour depending on the individual and the body composition (Burke, Castell, and Stear, 2009). This high-level sport requires not only physical and physiological qualities, but also psychological skills that allow players to handle professional challenges (Cuaz, 2016). They must optimise and maintain their performance, as well as increase their aerobic capacity and resistance to tiredness (Steinbacher and Eckl, 2015).

It is well known that the production and accumulation of metabolic waste products in the body (lactic acid, urea) cause acute/chronic acidosis often leading to cramps, soreness, muscle injuries, enzymatic system inhibition, tiredness, and stress (Blain, Vuillemin, and Jeandel., 2000). Nutritionists and physiologists are thus regularly working to find and develop natural products to regulate and reduce tiredness, body repair damage, restore glycogen load and maintain proper rehydration (Ikeuchi, Yamaguchi, Koyama, and Yazawa, 2006).

However, according to IFN. (2010), energy expenditure and more specifically nutrient losses for adenosine triphosphate (ATP) synthesis during exercise are the major objectives of the athlete's diet. According to Petroczi and Naughton (2008), more than 58% of high-level athletes consume vitamins, antioxidant, creatine, minerals supplement and plant extracts to support the body's effort, help recovery, and prevent injuries. However, dietary supplements are not 100% safe for the consumer. Geyer *et al* (2004) found that 15% of these supplements contain doping substances. In addition, their excessive consumption above the recommended dietary allowance (RDA), can lead to toxicity risks and deleterious effects on athlete health and performances (Haller and Benowitz, 2000).

This paper therefore shed light on the role of biomolecules that influence the performance of football players.

Definition of effort drink, also called energy drink

Energy drinks, or effort drinks, are defined by the Anses as "exercise drinks specifically formulated to meet the nutritional requirements of intense physical activity". These drinks have the advantage of providing the hydration necessary for sports, but also carbohydrates and minerals. These drinks are frequently consumed by athletes during their sports practices, whether during training or competitions (Jeukendrup A, and Barker L. 2018).

The effort drinks have 5 objectives in order to compensate the nutritional, energetic and sweat losses (Coombes JS and Hamilton KL. 2000):

- Ensure hydration during exercise and prevent dehydration
- Provide carbohydrates to increase available energy
- Provide electrolytes to compensate for sweat losses
- Be under the requirements imposed by the regulatory authorities
- Have a high palatability

The ability of an exercise drink to maintain fluid balance during exercise depends on the rates of fluid intake, gastric emptying and intestinal absorption (Coombes JS and Hamilton KL. 2000). The addition of carbohydrates to the drink increases water absorption, allowing for proper water balance.

Methods

For this review, database PubMed, Scopus, and Google Scholar were used and searches were performed up to December 2020. Combinations of the following keywords were used as search terms: Football, nutrition soccer, effort drink, hydration, carbohydrates, protein, fat, vitamins, supplementation, caffeine, creatine, taurine, nitrate, ergogenics plants. For their relevance, the manuscripts were individually selected. For the selection, we did not use any scientific approach.

Some Nutritional Requirements

A part from physical preparation, nutrition before, during and after matches play an important role in performance because it helps to sustain intensive training and limit some pathology risks after the event (FIFA, 2005).

Carbohydrate Ingestion And Tiredness Management

Carbohydrates are vitally important in sport because, during intensive exercise, muscle glycogen is the predominant energy production substrate (Krustrup *et al.*, 2006). General nutritional recommendations for peak performance favor strategies to achieve optimal muscle glycogen concentrations through high carbohydrate availability. It has also been shown that taking a substantial amount of carbohydrates (200-300g) 2-4 h before exercise can extend endurance performance (Wright, Sherman, and Dernbach 1991). Therefore, ingestion of 1-4 g/kg of carbohydrate 4 h before the match may be recommended, or alternatively an intake of 6-10 g /kg 24 h before a match (Wright et al., 1991), depending on the tolerance and their individual preferences (Wright *et al.*, 1991). It is also known that athletes' performance tends to decline during a match and thus adequate carbohydrate intake during the game can mitigate the progression of player fatigue. Indeed, carbohydrate intake at a rate of 30-60 g/h has been associated with a consistent beneficial effect on footballer's performances (Baker, Rollo, Stein, and Jekendrup, 2015). Russell and Kingsley (2014) recently reported in a systematic review, that six out of eight studies showed that ingestion of 30-60 g carbohydrate/h (via glucose, sucrose, 6-8% maltodextrin solution) was associated with an improvement in at least one aspect of footballer's performances.

Protein Ingestion And Muscle Repair Management

Recently, the Canadian Academy of Nutrition and Dietetics and *the American College of Sports Medicine* have suggested that protein requirements for athletes range from 1.2 to 2 g/kg/day. Thus high intakes may be indicated for short periods of intense training or when energy intake is reduced (Thomas, 2016). Football players in general appear to meet these guidelines (Bettonviel *et al.*, 2016). In order to improve muscle protein synthesis, players should ingest 0.25-0.4 g/kg of proteins in the pre-exercise meal (Morton, McGlory, and Philips, 2015), this allows a more rapid increase in post-exercise muscle protein levels during early recovery phases due to increased amino acid availability (Van Loon, 2014). To enhance protein synthesis for repair, remodeling, and adaptation, players should ingest 0.25-0.4 g/kg early in the recovery period (Morton *et al*., 2015, Moore *et al*., 2015). Alghannam (2011) found that adding a small protein quantity to a carbohydrate supplement can further improve performances. In this case, a drink containing 4.8% carbohydrates and 2.1% proteins, ingested before and during a 75-minute intermittent exercise, resulted in longer post-exercise running time to tiredness and reduced perceived exertion compared to an isolated supplement of 6.9% of carbohydrates.

Water Intake And Rehydration Management

During a football match, the rate of sweating varies from one player to another depending on their position, playing style and time (Shirreffs, Sawka, and Stone. 2006). During exercise, blood flow to the skin and plasma volume are reduced due to sweating, thus reducing heat dissipation and resulting in an elevated temperature (Coyle and Montain, 1992). Dehydration percentages of 2% of body water can have adverse consequences such as impaired cognitive function, alertness and physical performances (Coyle, 2004; Shirreffs *et al*., 2006;

Edwards *et al.*, 2007, Jecquier and Constant., 2010). Shirreffs *et al.* (2006) and Edwards *et al*. (2007) have demonstrated that dehydration of more than 2% body mass deficit impairs football-specific performances, including intermittent high-intensity sprinting and dribbling skills. It is also known that higher levels of dehydration further degrade aerobic exercise performances (Sakwa, 2005). The commonly used technique for measuring changes in hydration status is to measure changes in body weight occurring over short periods of time, as when an individual is in energy balance, body weight loss is essentially equal to water loss (Shirreffs, 2003). Prior to exercise, the goal is to begin physical activity hydrated and with normal plasma electrolyte levels (Sawka, 2005). Prior to exercise, the individual should drink slowly (5-7 mL/kg body weight) at least 4 h before the exercise. Drinking sodium-containing beverages (20-50 mEq-L^{-1}) and/or small amounts of sodium-containing foods with meals will help to stimulate thirst and retain the fluids consumed (Ray *et al.,* 1998. Shirreffs and Maughan 1998). The player should prioritize hydration during halftime (Maughan *et al*., 2004), these beverages should be served at a temperature of 15 to 20° C every 15-20 minutes in a volume of 150 to 300 mL to provide substrate, but not to limit the rate of gastric emptying (Maughan, Merso, Broad, and Shirreff, 2004, Sawka *et al*., 2007). It is recommended to drink approximately 1.5 L of fluid for each kg of body mass deficit (Shirreffs and Sawka, 2011).

Ingestion of Electrolytes and Vitamins Related to Cramp and Tiredness Management

In addition to water, electrolytes, principally sodium and chloride are also lost with sweat in small amounts. There is also loss of other electrolytes (potassium, calcium, magnesium) but at the lowest concentrations (Shirreffs and Sawka, 2006). Several studies reported sodium losses ranging from 30 to 62 mmol/L sweat (Shirreffs and Sawka, 2006 ; Maughan and Shirreffs, 2007), equivalent to "salt" losses of 3.9 to 6.9 g. For chloride and potassium, a study on 24 male professional players reported 43 and 6 mmol/L loss respectively (Maughan *et al*., 2004). Concerning potassium, one study (Shirreffs and Sawka, 2006) reported slightly different values of 4.2 ± 1 mmol/L. High salt loss is involved in the etiology of muscle cramps and can be alleviated by ingesting salt-containing beverages (Shirreffs and Sawka, 2006). Sodium is known to stimulate the thirst mechanism, improve the rate of water absorption and carbohydrates in the small intestine, help the body to conserve absorbed water by increasing the level of retained fluid while slowing down the urine output (Wendt, 2007). It is in this sense that Coyle (2004), showed that the addition of sodium to sports drinks does not have a negative impact on health.

Magnesium is a cofactor in the synthesis of ATP, which participates in the reduction of tiredness and the normal functioning of the muscle, it also helps in muscle recovery after exercise (Nadel and Nose, 1990).

Potassium, like sodium, is a natural mineral lost in sweat and involved in the reconstruction of muscle tissue and glycogen storage (Nadel and Nose, 1990 ; Sawka, 2005).

Vitamins play important roles in maintaining the health of physically active individuals. Regular physical activity may alter requirements for many of the micronutrients in several ways. Exercise may increase the turnover and metabolism, or the loss the nutrient in urine or sweat. In football special attention should be given to iron, vitamin D, and antioxidants. B vitamins (B1, B2, B3, B5, B6, B9 B12), which have crucial functions in energy metabolism, tend to be consumed in sufficient quantities and need to be replaced during adequate and balanced dietary intake (Eskici, 2016).

Iron Intake of Footballers

Iron deficiency can impair muscle function and limit work capacity, compromising training adaptation and athletic performances (Thomas, 2016). This is particularly important for footballers due to its heavy reliance on aerobic metabolism (Thomas, 2016). According to Thomas (2016), football players, especially those at high risk of deficiency, should have an iron intake at or above their Recommended Daily Allowance, RDA (more than 8 mg/day for men). In footballers with iron deficiency (low ferritin) without anemia, dietary strategies that promote increased intake of well-absorbed dietary iron (animal-derived heme iron, plant-derived non-heme iron and vitamin C-containing foods) should be promoted as the first line of nutrition (Thomas, 2016).

Vitamin D Intake for Footballers

Vitamin D regulates the absorption and metabolism of calcium and phosphorus, and plays a key role in maintaining bone health (Thomas, 2016). Football players with low vitamin D levels (<30 ng/mL or <75 nmol/L) may be more susceptible to musculoskeletal injuries and stress fractures (Thomas, 2016). The RDA for vitamin D varies by region, with recommendations ranging from 200 IU in Australia and New Zealand to 600 IU in the United States and Canada (Institute of Medicine USA, 2011). Athletes with inadequate vitamin D status require supplementation of at least 1500-2000 IU/day to maintain blood vitamin D concentration within an adequate range (Holick *et al.*, 2011). Blood vitamin D levels of 30-32 mg/mL (80 nmol/L) and up to 40 ng/mL (100 nmol/L) to 50 ng/L (125 nmol/mL) have been recognised as conservative goals for optimal training-induced adaptation (Thomas, 2016).

Vitamin B_1 (Thiamine) for Footballers

Thiamine plays a key role in carbohydrate and protein metabolism, energy production, immune system activation, signaling and maintenance processes in cells and tissues, in cell-membrane dynamics, and is also important for developing and maintaining a healthy nervous system (Fink, H.H, Burgoon, L.A. and Mikesky, A.E. 2006) As would be expected for a vitamin involved in energy reactions, early deficiency is characterized by muscular fatigue, and this develops into muscular weakness as the deficiency becomes more severe (Fink, H.H, Burgoon, L.A. and Mikesky, A.E. 2006 ; Benardot, D. 2000). Thiamine deficiency may lead to myocardial weakness. Other common symptoms of deficiency include loss of appetite, mental confusion, headache, fatigue, pain in the calf muscles, nausea, constipation, irritability, depression and loss of coordination (Maughan, R.J. and Shirreffs, S.M. 2007). Long-term thiamine deficiency can cause pyruvate accumulation, increase circulating lactate during work, cause fatigue, impair training, and thus reduce performance (Lukaski, H.C. 2004) The study of 56 elite football players found that average energy intake and thiamine intake of players were 0.17 mJ/kg/day and 1.7 mg/day, respectively (Burke, L.M. and Read, R.S. 1988). Thiamine dietary intake of female soccer players was found to be 1.6 mg/day (Burke, L.M. and Read, R.S. 1988). Another study explored food consumption of elite soccer players and found that thiamine consumption was 3.9 mg/day on average and this was above RDA (Fink, H.H, Burgoon, L.A. and Mikesky, A.E. 2006). No upper limit has been set for thiamine intake (Fink, H.H, Burgoon, L.A. and Mikesky, A.E. 2006).

Vitamin B2 (Rıboflavin) for Footballers

Riboflavin is involved in the aerobic production of energy from carbohydrates, proteins and fats (Fink, H.H, Burgoon, L.A. and Mikesky, A.E. 2006). Riboflavin is necessary for the synthesis of two important coenzymes in the body: flavin mononucleotide (FMN) and flavin adenine dinucleotide (FAD). These coenzymes are especially important in the metabolism of glucose, fatty acids, glycerol and amino acids (Manore, M.M. and Thompson, J.A. 2000). In athletics, riboflavin deficiency may lead to poor performance, weakness and fatigue (Fink, H.H, Burgoon, L.A. and Mikesky, A.E ; 2006 ; Benardot, D. 2012). Vegetarian athletes may face a higher risk of riboflavin deficiency, particularly if they avoid consumption of good sources of riboflavin including soy and dairy products (Leitzmann, C. 2005). A study on food consumption of football players found that average energy consumption was 3006 ±105 kcal/day, and riboflavin consumption was 0.46 ±0.13mg/1000 kcal/day. It was emphasized that athletes need to include more of fruits, vegetables, milk and dairy products in their daily diet (Noda, Y *et al.*, 2009). A study ran with 56 elite players (Australian football) found that the average energy intake and riboflavin intake of the players were 0.17 mJ/kg/day and 2.8 mg/day, respectively (Burke, L.M. and Read, R.S. 1988)

Vitamin B6 (Pyridoxine) for Footballers

All biologically active forms of vitamin B6 including pyridoxine, pyridoxal, pyridoxamine, pyridoxine phosphate, pyridoxal phosphate and pyridoxamine phosphate (Fink, H.H, Burgoon, L.A. and Mikesky, A.E. 2006). Vitamin B6 plays a major role in metabolic pathways required during exercise. It is required in the metabolism of proteins and amino acids and in the release of glucose from stored glycogen. Vitamin B6 is a component of more than 100 enzymes, including: The breakdown of glycogen for energy as well as gluconeogenesis in the liver, the synthesis of amino acids via transamination, the conversion of tryptophan to niacin., the formation of neurotransmitters, the production of the red blood cells' hemoglobin ring, the production of white blood cells (Fink, H.H, Burgoon, L.A. and Mikesky, A.E. 2006). This vitamin has recently been presented as a dietary protector against heart disease. Vitamin B6 deficiency can be detected by symptoms such as nausea, mouth sores, muscle weakness, depression, and impaired immune system (Fink, H.H, Burgoon, L.A. and Mikesky, A.E. 2006), Benardot, D., (2012). Although poor vitamin B6 status is associated with reduced athletic performance, there is no good evidence that consuming more than the recommend intake has a beneficial effect on athletic performance. The RDA for females and males is 1.3 mg/day. The upper limit for vitamin B6 is 100 g/day (Fink, H.H, Burgoon, L.A. and Mikesky, A.E. 2006)

Vitamin B12 (Cobalamin) For Footballers

Vitamin B12 is perhaps the most chemically complex of all vitamins. It contains the mineral cobalt (hence the name: cobalamin) and has a major role in red blood cell formation, folic acid metabolism, DNA synthesis and nerve development. It is essential forthe function of all cells (Benardot, D. 2000 ; 2012). Vitamin B12 deficiency can lead to specific neurologic disorders (subacute combined degeneration of the spinal cord and cognitive impairment) and hematologic disorders (megaloblastic anemia). Vegans are at risk. Also, malabsorption of the vitamin and dietary inadequacy lead to vitamin B12 deficiency (Benardot, D. 2012; Ontario, H.Q. 2013). The resulting anemia would clearly have an impact on performance by producing a reduction in endurance and potential reduction of muscular coordination (Benardot, D. 2000). Other symptoms are neurological disorders, weakness and developing fatigue quickly (Bernardot, D. 2000) Prolonged exercise and heavy training are associated with depressed immune function which can increase the risk of picking up minor infections. The RDA for vitamin B12 is 2.4 µg/day for adults (Dunford, M. and Doyle, J.A. 2008). Surveys of nutrient intake by groups of athletes suggest that certain groups may not be consuming adequate amounts of this vitamin based on the previous RDA of 2 µg/day. Athletes on energy-restrictive diets (Benson, J., Gillien, D.M., Bourdet, K. and Loosli, A.R. 1985) and strict vegetarians face the risk of vitamin B12 depletion (Leitzmann, C., 2005).

Some Supplements Used to Improve Sports Performance

Caffeine

The International Society of Sports Nutrition (ISSN) considers caffeine supplementation beneficial for intermittent exercise over a prolonged period, including team sports such as soccer (Van Thienen *et al.*, 2009). In nature, caffeine is found primarily in coffee (*coffea arabica*) and tea (*Camellia cinensis*). Studies carried out by Strudwick (2016) showed that ingestion of 6 mg/kg of caffeine 60 minutes prior to a simulated football activity could improve players' passing accuracy and jumping performance with no adverse effect on other performance parameters. In another study conducted by Trexler *et al.* (2015) with female players, ingestion of 3 mg/kg of caffeine in the form of an energy drink 1 h before a countermovement jump and a 7 × 30 m sprint test followed by a simulated football game (2 × 40 min) increased countermovement jump height and average peak running speed during the sprint test.

Creatine

Creatine monohydrate is the most widely used, studied, and clinically effective form in nutritional supplements in terms of accumulation in muscle and ability to increase tolerance to high intensity exercise. The most rapid method of increasing creatine in muscle is its consumption at 0.3 g/kg/day for at least 3 days, followed by 3-5 g/day as a maintenance dose. Creatine ingested in combination with carbohydrates significantly increased muscle creatine accumulation compared to ingesting creatine alone (Candow, 2011), but a combination of 50 g of carbohydrates and 50 g of protein appears to be as effective as an isolated dose of 100 g of carbohydrates (Ali *et al.*, 2016). The International Society of Sports Nutrition (ISSN) believes that creatine monohydrate is an effective ergogenic food additive currently available to athletes in terms of increasing high intensity physical activity and muscle mass during training (Watsford, 2003).

Taurine

It was first discovered in 1827 and is widely used in many specialized products for sports nutrition, the average dose of taurine in energy drinks is 100- 200 mg per 100 g (Hanferyan, 2016). In a similar vein, studies carried out by Ripps and Shen (2012) showed that taking 6 g of taurine could increase exercise tolerance likely due to its antioxidant effects. Schaffer, Ito, and Azuma (2014) publication in 2008 showed that the amount of taurine used in various beverages did not cause any side effects.

Nitrate

Dietary nitrate supplementation is known for its ability to reduce oxygen cost during submaximal exercise (Larsen, Weitzberg, Lundberg, Ekblom, 2007). Nitrate ingestion results in increased plasma nitrite concentrations and consequently increased nitric oxide production (Jones, 2014) with several metabolic and vascular effects contributing to improved exercise efficiency (Jones, 2014). Dietary nitrate is available in the form of beet balls, gels, and bars containing nitrates (Strudwick, 2016). Recommended intake is 6-8 mmol/day for 2-5 days before a game and 90 min before kickoff (Lanhers *et al*., 2015; Strudwick, 2016)

Ergogenic Plants

Ergogenic plants are substances that improve the amount of work, especially when associated with sport performances. They are available as fresh or dried products, liquid or solid extracts, tablets, capsules, powders or in the form of drinks, energy bars, tea bags or simply added to sports supplements (Kundrat, 2005). An increasing number of athletes are using dietary supplements containing plant extracts to optimize their performance and improve their physical conditions (Kundrat, 2005). Indeed, they could facilitate recovery, strengthen immune defenses during training sessions and competition, increase muscle mass and hepatic and muscular glycogen reserves and reduce fat mass.

Several works have shown the effect of plant extracts on both acute and chronic fatigue in both humans and animals (Nallamuthu, Tamatam and Khanum. 2014). The anti-fatigue effect of these plant extracts could be due to several mechanisms (Nallamuthu, Tamatam and Khamum. 2014). The have effects on:

- The metabolism of carbohydrates (glucose and glycogen), lipids (free fatty acids and triglycerides), protides (amino acids) and the reduction of metabolic waste production (lactate and uric acid) ;
- The response to stress (repair of damage (micro-lesions and injuries) caused by intense physical activity, stimulation of the immune system and effect on the nervous system).

Studies by Bonoy et *al* (2016) showed that the aqueous extract of *Moringa oleifeira* leaves has anti-fatigue properties; improves swimming ability in rats while delaying the accumulation of blood lactate and blood urea nitrogen. This increases the mobilization and utilization of body fat by slowing the depletion of glycogen reserves.

Similarly, the work of Jinchun and Chen Jie (2011) on Taxacum officinale extracts, after 6 weeks of treatment, these extracts showed a physical anti-fatigue effect. They also improved the maximum swimming capacity of mice, effectively delayed the decrease of glucose in blood and prevented the increase of lactate and triglyceride concentrations.

Conclusion

Professional football requires an optimal availability of energy resources which must be replaced by an adapted diet before and after the effort. If the players are not on an energy-giving diet, a state of muscular tiredness will be noted leading to a depletion of the glycogen load. Incoordination in the execution of technical gestures and a risk of hypoglycemia leading to performance decrease will also be experienced. A good balance between intake and expenditure then appears as the most important management strategy.

Soccer players must have a diet rich in carbohydrates, proteins, minerals and vitamins in order to meet their needs during a match or training session. They can also consume supplements enriched with plant extracts.

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