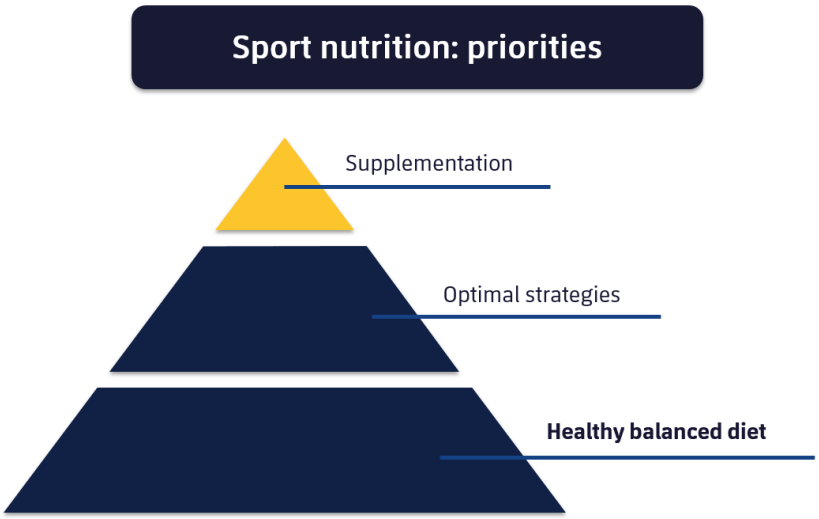
2.2 Dietary supplements for consideration in football

The main reason to use a dietary supplement programme in football is to improve player performance. To achieve this, the dietary supplement must have an indirect or direct impact on the performance of the player. The dietary supplements which have an indirect effect on player performance are those concerned with the player's health (allowing the player to accumulate training hours) and recovery (enhanced adaptation). Whereas, other dietary supplements may be ingested acutely to directly impact on the completion of match-specific activities. This Unit will discuss the supplements that are supported by a moderate to high level of evidence and which may be considered for football performance. The rationale and evidence for the supplement will be provided followed by a practical recommendation.

Nutrition priorities

Players should always be encouraged to adopt a healthy balanced diet using a "food first" approach prior to considering dietary supplements (Unit 1). Thus, when discussing the use of dietary supplements, it is assumed that the key components of the player's diet are optimised. First, players should be eating a variety of different (predominantly whole) foods to meet their daily energy needs (healthy balanced diet). Second, guidelines with regard to the timing and quantity of macronutrient (protein, carbohydrate, fats) ingestion to support performance and recovery are being followed (optimal strategies). Once these two building blocks are in place, dietary supplementation may be considered (Figure 1).

Figure 1: Nutritional priorities



Source: Prepared by author.

Dietary supplementation: indirect impact

There are periods of the season when the physical demands of football are intensified, such as pre-season or periods of fixture congestion (2-3 matches per week). A dietary supplement programme that assists the player to train harder, maximise their adaptation, speed recovery, reduce muscle soreness and avoid illness has obvious benefits to the player's performance. Below are those dietary supplements that may indirectly benefit player performance.

Essential Nutrients

The essential micronutrients were discussed in Module 1. On the occasion when players are accurately diagnosed with a specific nutrient deficiency, the first response should be to address with dietary modifications. However, there may be specific situations where dietary supplementation may provide a prompt and effective response. The most common micronutrients requiring a dietary supplement are Iron, Calcium and Vitamin D (Table 3). Correction of these micronutrients may maintain health and maximise performance gains from training. Additionally, players may also consider the ingestion of a daily pro-biotic. As recommended in Unit 1, the appropriate steps to ensure quality assurance of the nutrient product should be followed. If supplementation is commenced, it should be accompanied by a routine monitoring system to evaluate the impact of the supplementation programme and for a

duration required to restore the player's desired nutrient status (Maughan et al., 2018).

It is important to note that players engaged in frequent travel, disturbed eating patterns, or on body fat loss programmes may benefit from a broad spectrum, low dose multivitamin and mineral dietary supplement (Maughan et al., 2018). This recommendation should also be assessed on an individual player by player basis.

Table 3: Dietary supplements and guidance for use.

Dietary supplement	Examples	Use	Dose	Concerns
Essential Nutrients	Multi-vitamin-mineral Iron Vitamin D Calcium	Prevent or treat deficiency to help maintain health and performance	To meet RDA See Module 1	Inappropriate use or when taken with lack of monitoring or supervision can lead to health problems
Probiotics	Lactobacillus and/or Bifidobacterium species	Probiotics stimulate some aspects of immunity and may reduce infection incidence in players	Minimum dose of 10^{10} live bacteria per day	Expensive option that may not always be needed. Difficult to determine individual needs

Source: Prepared by author.

Tart cherry

Both sweet, tart and sour cherries contain high levels of antioxidants including melatonin, carotenoids, hydroxycinnamates, and several flavonoid groups including anthocyanins, as well as the flavonol quercetin (McCune et al., 2011). Although mechanisms are currently unknown, reports have suggested that both tart Montmorency and sweet cherries reduce inflammation (Kelley et al., 2006; Howatson et al., 2010), oxidative stress, muscle soreness, and improved recovery of muscle

(Connolly et al., 2006; Howatson et al., 2010; Kuehl et al., 2010; Bowtell et al., 2011). In sports like football, where eccentric muscle actions and multiple repeated short bouts of high-intensity exercise are common, mechanical stress is high, resulting in primary muscle damage. This damage is followed by a secondary inflammatory phase as part of the repair process during which the muscle is sore and function is impaired (Howatson & van Someren 2008). Cherry juice is believed to act mainly during this second phase, reducing inflammation, soreness and better maintaining muscle function.

Connolly et al. (2006) was the first to investigate the application of cherry juice supplementation in a damaging exercise model. The supplementation consisted of freshly prepared tart Montmorency cherry juice mixed with apple juice in a proprietary ratio, with each serving containing ~ 50–60 tart cherries. In a single blind crossover design, participants were supplemented 4 days before exercise, on the day of exercise, and 4 days after exercise, consuming two 237-ml servings per day (am/pm). In the 96 h following eccentrically biased contractions of the elbow flexors, maximal isometric strength loss was attenuated with the tart Montmorency cherry juice blend vs placebo (4% vs 22%); consequently, recovery was accelerated with the cherry juice blend. Furthermore, more recent research supported these findings using a similar study design with a damaging bout of knee extensor exercise. Bowtell et al. (2011) reported faster recovery of isokinetic knee extensor force when supplementing with a tart Montmorency cherry juice concentrate versus isoenergetic placebo. Creatine kinase (CK) showed a trend to be raised in the placebo trial when compared to cherries, although this did not reach statistical significance. Recent review articles and meta-analyses have concluded that, on balance, the evidence seems to suggest that there are a number of positive effects of consuming cherry juice before and after damaging exercise (Bell et al., 2014; Nedelec et al., 2015).

Practical Recommendation

Tart cherry supplementation may be particularly relevant during busy periods of the competitive season (2-3 matches per week). The recommended delivery system is a tart cherry concentrate which can be ingested to achieve an equivalent of approximately 100 tart cherries every day. The cherry concentrate can be added to protein shakes or added to breakfast meals. Tart cherry intake should be considered when recovery is a priority, but not during periods when physiological adaptation is the objective (as the attenuation of the inflammatory response may impair adaptation).

Dietary supplementation: direct impact

A player's individual performance is under constant scrutiny from their manager, coaches, teammates and fans. For success, the individual player must outperform their peers in order to be selected in the starting line-up, and then outperform their opponents and win matches. There are many factors which will contribute to successful football performance. From a nutrition perspective, the most researched and potent nutrient which may benefit football performance is carbohydrate. The benefits of carbohydrate have been extensively covered in previous courses. Thus, this Unit will discuss those other dietary supplements which may result in marginal gains in physical and technical performance of the player. These dietary supplements include caffeine, creatine (in the form of creatine monohydrate), nitrate, and β-alanine.

Caffeine

Caffeine is unique dietary supplement. This is because caffeine is found in various socially accepted beverages and foods (e.g. tea, coffee, cola, chocolate, etc.). In addition, caffeine is one of the most widely investigated and research-proven of all dietary ergogenic aids. Caffeine has been consistently shown to improve both cognitive and physical performance across a range of endurance sports including running, cycling, rowing and swimming (Burke 2008). Studies also suggest that caffeine improves the physical and technical elements of performance that are relevant to football. For example, caffeine can enhance repeated sprint and jump performance (Gant et al., 2010), reactive agility (Duvnjak-Zaknich et al., 2011) and passing accuracy (Foskett et al., 2009) during intermittent-type exercise protocols. The ergogenic effects of caffeine are typically achieved with ingestion of 2-6 mg/kg body mass (BM) (Burke 2013). Knowing that plasma caffeine levels peak approximately 45-60 min after ingestion (Graham & Spriet 1995), it is recommended that players consume caffeinated drinks, capsules or gels (depending preference) within the warm-up period prior to kick-off.

Although the precise ergogenic mechanisms are still considered elusive, most researchers agree that the ability of caffeine to modulate the central nervous system (CNS) is the predominant mechanism (Meeusen 2014). Indeed, caffeine is readily transported across the blood-brain barrier and can act as an adenosine antagonist, thereby opposing the action of adenosine. As such, caffeine can increase concentrations of important neurotransmitters such as dopamine (Fredholm 1995), the result of which manifests itself as increased motivation (Maridakis et al., 2009) and motor drive (Davis et al., 2003). In addition to its effect on the CNS, recent data suggest that caffeine may also exert its ergogenic influences during high-intensity intermittent exercise through an additional mechanism related to maintenance of muscle excitability. Indeed, Mohr, Nielsen, &

Bangsbo (2011) observed improved performance on the Yo-Yo Intermittent Recovery Test 2 following caffeine supplementation that was associated with reduced muscle interstitial accumulation of potassium (K^+) during intense intermittent exercise. The latter observation is consistent with the notion that extra-cellular accumulation of K^+ is a contributing cause of fatigue during very high-intensity exercise (Mohr et al., 2011). Several studies simulated the exercise pattern of a football match and studied the effects of caffeine. For example, Del Coso et al. (2012) reported total distance covered at speeds above 13 km/h during the game and the total number of sprints during the match were improved with a caffeine containing drink versus a non-caffeine containing drink (Del Coso et al., 2012).

The influence of caffeine ingestion has also been investigated on football specific tasks. In one study the effect of adding a moderate dose of caffeine to a carbohydrate solution during prolonged soccer activity was investigated (Gant et al., 2010). It was concluded that the addition of caffeine to the carbohydrate-electrolyte solution improved sprinting performance, countermovement jumping, and the subjective experiences of players. Caffeine appeared to offset the fatigue-induced decline in certain components of performance. Similarly, Foskett et al. (2009) reported that caffeine ingestion before simulated football activity improved players' passing accuracy and jump performance without any detrimental effects on other performance parameters (Foskett et al., 2009). Recent studies by the same research group found similar effects in female football players (Ali et al., 2016a; Ali et al., 2016b).

In contrast to competition days when specialised caffeinated sports products are typically consumed, players may achieve ergogenic effects on training days by consuming caffeine in the form of tea or coffee with their breakfast meal prior to training (Morton 2014). Indeed, this strategy seems appropriate given recent evidence that pre-exercise coffee ingestion induces similar performance benefits to that of non-fluid based caffeine ingestion (Hodgson et al., 2013).

Given that substantial literature supporting caffeine ingestion for football performance, caffeine may be considered for use by players. However, it is highly recommended that players first experiment with caffeine ingestion during training sessions. This is because caffeine can potential result in a number of adverse side-effects that may limit its use in some sports or by sensitive individuals. Potential negative side-effects include insomnia, headache, gastrointestinal irritation and bleeding, and a stimulation of diuresis (Maughan et al., 2011). Indeed, not all individuals display performance enhancements after acute caffeine ingestion, and large doses (i.e. especially > 6 mg/kg BM) may often induce negative symptoms such as increased heart rate, irritability, tremor, confusion, reduced concentration and shortness of breath (Graham & Spriet 1995), many of which would have negative implications for skill-based

performance. Furthermore, consuming high doses of caffeine prior to or during night competition can also be problematic given that sleep quality can be negatively affected (Drake et al., 2013).

Practical Recommendation
Players should experiment with caffeine in training to find an appropriate dose. Players should aim to ingest 3 mg/kg (range 2-5 mg/kg) to gain potential benefits of ingestion. Caffeine should be ingested between 45 and 60 minutes before a match. If a caffeine gum is used as a method of caffeine delivery, then players should use this immediately after the warm up. Players should not exercise whilst chewing the caffeine gum which should be removed from the mouth before kick-off. The chosen method to deliver caffeine can be modified depending on the player's personal preferences.

Creatine

Creatine is a widely researched dietary supplement and has strong supporting evidence for its use in football. Creatine can be generated endogenously by the body or provided exogenously by dietary sources. In the players body creatine is synthesized in the liver and kidneys from the amino acids arginine and glycine. The main dietary sources of creatine are fish and red meat. As an example, approximately 5 g of creatine is contained in 1 kg of fresh beef steak (Maughan et al., 2011). The largest store of creatine in the body is skeletal muscle (Wyss & Kaddurah-Daouk 2000). In skeletal muscle approximately 60-70% is stored as a phosphorylated form known as phosphocreatine (PCr). Creatine supplementation for sport has traditionally been associated with strength and power athletes, such as weightlifters and sprinters, given the role of PCr hydrolysis in regenerating ATP during the initial seconds of supra-maximal activity (Morton 2014). However, in the context of high intensity intermittent team sports, creatine supplementation is also of particular interest given that PCr stores exhibit significant declines during football match play (Krustrup et al., 2006). Accordingly, creatine supplementation improves repeated sprint performance during both short duration (Casey et al., 1996) and prolonged intermittent exercise protocols (Mujika et al., 2000), likely due to increased resting muscle PCr stores as well as improved rates of PCr re-synthesis in the recovery periods between successive sprints (Casey et al., 1996). Sprint performance improvements following creatine supplementation (compared to a placebo) were in the range of 1-4%. In addition to improving repeated sprint performance, players may also wish to consume creatine in context of other football specific nutrition objectives such as augmenting training-induced improvements in muscle mass, strength and power (Branch 2003).

Harris and colleagues completed the first study to show that dietary creatine supplementation (using a loading protocol of 20 g/d for 5 days) increased (+ 20%) both total creatine and PCr stores in skeletal muscle (Harris et al., 1992). As such, the conventional creatine dosing strategy is to undertake a loading protocol (usually involving 4 x 5 g doses/d for 5-7 days) followed by a daily maintenance dose of 3-5 g/d (Hultman et al., 1996). However, given that player adherence to such a protocol may be limited, it is noteworthy that daily consumption of a lower dose over a longer period (i.e., 3 g/d for 30 days) will eventually augment muscle creatine to a similar level as that observed with classical loading protocols (Hultman et al., 1996). If creatine supplementation is stopped, players should expect muscle creatine stores to return to basal levels within 5-8 weeks. To facilitate creatine storage , it is recommended that creatine is ingested post-exercise and in combination with carbohydrate and/or protein feeding, given that contraction and elevated insulin are known to increase muscle creatine uptake (Robinson et al., 1999). In a practical context, this means ensuring creatine provision before and after training periods in conjunction with other sports nutrition products containing carbohydrate (and/or protein) or with whole food provision at the main meals of breakfast, lunch and dinner (Morton 2014). Prior loading with creatine may also enhance post-exercise muscle glycogen re-synthesis rates (Robinson et al., 1999). It may be difficult to replenish post-game muscle glycogen stores even with enough carbohydrate and protein intakes. The ingestion of creatine may therefore be relevant during those periods of intense fixture schedules when multiple games are played with limited recovery time.

It is important to note that not every player will respond similarly to creatine supplementation in terms of both augmentation of muscle creatine stores and subsequent improvements in performance (Morton 2014). The magnitude of elevation of muscle creatine to a given dose of creatine supplementation is highly variable and appears to be largely determined on the initial level of muscle creatine concentration prior to supplementation, the latter likely determined by habitual diet (Hultman et al., 1996). To this end, players with lower muscle creatine stores are likely to experience greater increases in total muscle creatine during supplementation compared with those players who already exhibit high concentrations of muscle creatine. Accordingly, creatine-induced improvements in intermittent exercise performance are greater in those individuals who exhibited larger increases in muscle (especially Type II fibres) creatine and PCr (Casey et al., 1996).

The creatine supplementation loading regime may induce a 1-1.5 kg gain in body mass, an effect that has been reported to be greater in men compared with women (Mihic et al., 2000). Such increases are confined to fat free mass and are likely due to an increase in intra-cellular water accumulation. For this reason, not all players may choose to supplement with creatine given the perception that they feel heavier and slower, an

effect that may be especially relevant for those who rely on speed and agility as key physical attributes, such as strikers and wide midfielders in football (Morton 2014). Additionally, creatine supplementation is also often perceived to have negative health effects in terms of liver and kidney function. It is noteworthy, however, that prospective studies demonstrate no adverse health effects in healthy individuals who were long-term creatine users (Kim et al., 2011).

In general, the available evidence supports a beneficial effect of creatine on short term high intensity and repeated sprint exercise. Creatine has several key roles within skeletal muscle as a temporal energy buffer, energy carrier and maintaining ATP/ADP ratios (Greenhaff 2001). Given that it takes weeks for creatine stores to return towards basal levels upon the cessation of supplementation (hence ergogenic effects should still occur), it may be prudent for players to "cycle" creatine supplementation at specific stages of the season (e.g. pre-season, congested fixture schedules) and/or training goals (e.g., strength / hypertrophy goals) (Morton 2014).

Practical recommendations

The loading phase for creatine supplementation may be short (5 x 20 g per day) or gradual 3 g/day for 30 days. Thus, players should develop individual strategies and dosing protocols, and they should be monitored regarding potential side effects and body mass changes. Creatine supplementation may be taken continuously or periodized over a competitive season. As an example, creatine supplementation may be targeted during pre-season, and maintained during the season, and then stopped during the off-season. Ideally, supplementation should be mapped against key performance indicators. For example, an independent repeated sprint test.

β-alanine

In skeletal muscle cells, β-alanine combines with L-histidine to form the dipeptide β-alanyl-L-histidine. This the dipeptide β-alanyl-L-histidine is more commonly known as carnosine. Carnosine is of particular reference for high-intensity exercise performance given that it can act as an intracellular buffer to hydrogen ions (H^+) (e.g. 10-60 mmoL/kg d.w) (Hobson et al., 2012). Given the repeated sprint nature of football match play, muscle pH declines to levels that may impair the capacity to generate ATP through glycolytic metabolism (Krustrup et al., 2006). As such, it has become common practice for football players to consume daily β-alanine supplements (as the rate-limiting determinant of carnosine synthesis) to increase muscle carnosine stores and hence, potentially improve high-intensity exercise performance (Morton 2014). Indeed, in relation to the former, daily β-alanine supplementation has

been consistently shown to elevate skeletal muscle carnosine concentration by approximately 50% in both type I and II human skeletal muscle fibres (Harris & Sale 2012). Furthermore, in recent meta-analyses, Hobson et al. (2012) concluded likely ergogenic effects of β-alanine supplementation during high-intensity sports lasting from 1-6 min, such as track and field events, cycling, rowing and swimming.

Unfortunately, investigations evaluating the effects of β-alanine supplementation during high-intensity intermittent exercise protocols that are applicable to field sports such as football are both limited and conflicting (Morton 2014). For example, Saunders and colleagues observed no beneficial effect of four weeks of β-alanine supplementation (6.4 g/d) on sprint performance during the field-based LIST (Saunders et al., 2012a). In contrast, the same researchers later observed improved performance during the Yo-Yo Intermittent Recovery Test Level 2 following 12 weeks of daily supplementation with 3.2 g of β-alanine (Saunders et al., 2012b). Unfortunately, neither studies measured changes in muscle carnosine stores following supplementation, though it is possible that the enhanced effect observed in the latter study was due to the longer period of supplementation. This hypothesis is relevant given that the duration of β-alanine supplementation will determine the increases in muscle carnosine concentration (Hill et al., 2007).

A negative side effect of β-alanine supplementation when administered in single doses >10 mg/kg BM (especially when in solution or as gelatin capsules) is a flushing of the skin and a tingly sensation (Harris et al., 2006). This phenomenon is known as paraesthesia. To reduce paraesthesia symptoms, sustained release formulations have been developed that allow two 800 mg doses to be ingested simultaneously without any symptoms (Decombaz et al., 2012). Although the optimal dosing and delivery strategy of β-alanine supplementation is not currently known, it is noteworthy that a significant linear relationship exists between total β-alanine intake (within the range of 1.6 - 6.4 g/d) and both relative and absolute increases in muscle carnosine (Stellingwerff et al., 2012a). To this end, Stellingwerff and colleagues (2012b) observed that four weeks of supplementation with 3.2 g of β-alanine daily induced 2-fold greater increases in muscle carnosine stores compared with 1.6 g daily. Moreover, these researchers also observed that subsequent daily doses of 1.6 g/d continued to induce further increases despite already high carnosine stores following the four weeks of higher dose β-alanine supplementation (Stellingwerff et al., 2012a; Stellingwerff et al., 2012b). It has been reported that following 6 weeks of 3.2 g β-alanine/d a further daily maintenance dose of 1.2 g/d was required to maintain muscle carnosine content elevated at 30-50% above baseline values (Stegen et al., 2014). When β-alanine supplementation is stopped players may expect muscle carnosine stores to return towards basal levels within 10-20 weeks (Baguet et al., 2009). On the basis of the aforementioned studies, it is recommended that when muscle carnosine

stores are required to be elevated quickly (perhaps during important stages of competition such as intense fixture schedules), loading with larger doses (e.g. 3-6 g daily for 3-4 weeks) may be initially beneficial followed by daily maintenance doses >1.2 g. To minimize symptoms of paraesthesia, players may benefit from consuming slow-release formulas in a number of doses spread evenly throughout the day. Finally, it has been shown that carnosine loading via β-alanine supplementation is more pronounced in athletes (i.e. trained muscle) in comparison to untrained individuals (Bex et al., 2014). Thus the same response would be expected in football players engaged in routine training or match play.

Practical recommendation

Players are advised to ingest 3-6 g daily for 3-4 weeks; this may be followed by daily maintenance dose of doses of 1.2 g /day. The concentration of muscle carnosine will remain elevated for 4 to 8 weeks following the cessation of intake. There does not appear to be a benefit of one off or acute intake strategies. Although Beta-alanine can be used continuously, it is recommended to periodise supplementation. For example, supplementation may be targeted during periods of the year to support performance rather than continuous use. In addition, because of the prolonged "wash-out" period following supplementation, ingestion may stop approximately 3 weeks before the end of the season. The use of a slow release form of beta alanine may alleviate some of the known side effects.

Dietary nitrates

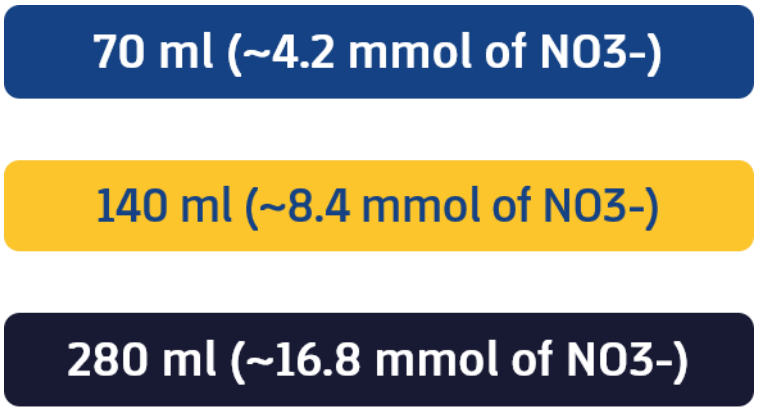
Dietary inorganic nitrate supplementation may be considered for football players. This is because there is considerable body of research detailing the effects of nitric oxide on a variety of physiological functions. Specifically, nitric oxide has well-documented roles in regulating blood flow, muscle glucose uptake and the contractile properties of skeletal muscle (Jones 2014; Jones 2016). The traditional pathway of endogenous nitric oxide production is recognised as that of L-arginine oxidation, facilitated by the enzyme nitric oxide synthase. However, it is now known that dietary ingestion of inorganic nitrate can also be metabolized to nitrite and subsequently, nitric oxide, thereby complementing that produced from the L-arginine pathway (Hord et al., 2011). Identification of this biochemical pathway has, therefore, led to a series of studies conducted in the last decade evaluating the effects of inorganic nitrate ingestion on exercise performance (Morton 2014).

Nitrates in the diet are especially prevalent in green leafy vegetables such as beetroot, lettuce and spinach. The exact content of nitrates in these foods will vary considerably depending on soil conditions and time of year. To provide a standardised intake of nitrate, researchers have used

standard doses of beetroot juice (0.5 L is equivalent to approximately 5 mmol nitrate) to elevate nitrate and nitrite availability (Jones 2016). Using both chronic (ranging from 3-15 days of 0.5 L beetroot juice per day) and/or acute ingestion 2.5 h before exercise, it was demonstrated that nitrate ingestion reduces blood pressure, lowers oxygen consumption for a given workload or velocity during steady-state exercise, as well as improving exercise capacity during short-duration high-intensity cycling or running (Bailey et al., 2009; Vanhatalo et al., 2010; Lansley et al., 2011a). These initial studies were later supported by experiments demonstrating that acute (Lansley et al., 2011b) and chronic beetroot juice ingestion (Cermak et al., 2012) in trained but sub-elite athletes also improved cycling time trial performance in distances ranging from 4 km to 16.1 km (i.e., approximately 5-30 min of exercise). It is noteworthy, however, that the performance-enhancing effects of nitrate are not readily apparent in elite endurance athletes (Wilkerson et al., 2012). Although the exact reason for these findings are yet to be established it may be due to a combination of underpinning differences in the physiology of elite versus sub-elite athletes. Specifically, a trained athlete may be less sensitive to additional nitric oxide availability e.g. higher nitric oxide synthase activity, plasma nitrite values, greater muscle capillarization, higher type I fibres (Jones 2014). Whether this applies to “elite” versus “sub-elite” footballers is yet to be established.

The mechanisms underpinning the reduced oxygen cost of exercise and improved exercise capacity/performance are currently thought to involve improved muscle efficiency and energy metabolism (Jones, 2014). For example, Bailey and colleagues observed that reduced oxygen uptake during exercise (following six days of 0.5 L beetroot juice ingestion per day) was associated with reduced PCr degradation and accumulation of ADP and Pi, thus implying a reduced ATP cost of contraction for a given power output and hence reduced signals to stimulate respiration (Bailey et al., 2010). Larsen et al. (2011) suggested that mitochondrial efficiency might be improved in human skeletal muscle following three days of sodium nitrate ingestion (0.1 mmol/kg BM) (Larsen et al., 2011). Haider and Folland (2014) observed that seven days of nitrate loading in the form of concentrated beetroot juice (9.7 mmol/d) also improved in vivo contractile properties of human skeletal muscle, as evidenced by improved excitation-coupling at low frequencies of stimulation as well as explosive force produced by supra-maximal stimulation (Haider & Folland 2014).

Figure 2: Volume of concentrated beetroot juice and the associated nitrate content.



Source: Prepared by author.

The optimal loading dose to facilitate the ergogenic effects of nitrate is not well established, especially in relation to whether acute (i.e. 2.5 h before exercise) or chronic (i.e. several days) loading protocols are required. Nevertheless, in the acute context, Wylie and colleagues (2013) observed that the improved exercise tolerance (relative to placebo) was not different when 8.4 or 16.8 mmol of nitrate was ingested 2.5 h before exercise, but that both were more efficacious than 4.2 mmol (Wylie et al., 2016). It is noteworthy, however, that the reduction in oxygen cost during exercise associated with nitrate ingestion was greater with the higher dose (Wylie et al., 2013). Such data suggest that the inability to detect physiological effects of nitrate in acute scenarios (especially with elite athletes) may be overcome by using higher pre-exercise dosing strategies and/or longer duration dosing protocols (>3 days).

DID YOU KNOW
Peak increases in plasma nitrite concentrations occur 2-4 h post ingestion. 140 ml has been reported to be beneficial for intense exercise, with no further benefit at 280 ml.

Although initial studies were performed during high intensity continuous exercise, more recently, studies have begun to investigate the potential effects of beetroot juice in high intensity intermittent exercise. Using a more aggressive loading dose of concentrated beetroot juice (approximately 30 mmol in a 36 h period), Wylie and colleagues (2013) observed significant improvements in the distance run on the Yo-Yo Intermittent Recovery Test Level 1 when compared with placebo supplementation. Improved performance may have been due to maintained muscle membrane excitability given that plasma K^+ was lower during exercise following beetroot juice supplementation. The same research group have recently reported that a similar loading dose

spread over a longer duration (6.4 mmol for 5 days) also enhances maximal sprint and high-intensity intermittent running performance in competitive team sport players (Thompson et al., 2016). From a practical perspective, the use of an intense 36 h nitrate loading protocol is likely to gain more acceptance amongst football players than the conventional 3-6 day loading approach.

It is highly recommended that players experiment with nitrate supplementation (perhaps even more so than the supplements reviewed previously) prior to implementing in high-level competition (Morton 2014). Furthermore, and to promote the potential beneficial effects of nitrate supplementation, players are also advised to avoid antibacterial mouthwash and chewing gum, as these products diminish the nitrate-nitrite conversion (Jones 2014; Jones 2016).

Practical considerations

Players are recommended to ingest dietary nitrate for 3-4 days prior to competition. Typically, this is achieved by ingesting a concentrated beetroot shot with morning and evening meals. The acute ingestion of nitrate (5-8 mmol) with the pre-match meal, 3 h before kick-off, may also be of benefit to the player. As with all dietary supplement recommendations, players should practice loading and acute strategies in training first. To date, the forms of delivery of concentrated dietary nitrate (typically beetroot) is not an appealing flavour for the player. Players should also be made aware that the potential side effect of concentrated beetroot juice ingestion is a change in urine colour. Specifically, urine may have “pink” tones. The urine colour change is completely harmless. However, players may worry if not informed of this change. In addition, it is important to note that the change in urine colour may make self-monitoring of hydration status difficult for the player (assessed by urine colour). Finally, to facilitate the mechanism by which nitrate has an effect in the body, players are advised to avoid antibacterial mouthwash and chewing gum when adopting this dietary regime.

Table 4 lists the dietary supplements to be considered in specific situations in football using evidence-based protocols. They should be used by some players to directly contribute to optimal performance. The supplements should be used in individualised protocols under the direction and monitoring of an appropriate sports nutrition/medicine/science practitioner. While there may be a general evidence base for these products, additional research may often be required to fine-tune protocols for individualised player and event-specific (training/match) use. Quality assurance programs are in place for sports nutrition products, suppliers to the sports nutrition industry, and supplement manufacturing facilities. These programs will help make sure that supplements are safe to take and reduce the risk of the product containing banned substances.

Table 4: Summary of the dietary supplements to be considered in specific situations in football using evidence-based protocols.

Indirect: player health	Supplement
Medical supplement are used to treat clinical issues, including diagnosed nutrient deficiencies. Requires individual dispensing and supervisión by appropriate sports dietician / medical proffesional.	Iron
	Multivitamin / mineral
	Vitamin D
Player recovery	
Food polyphenols – food chemicals which have purported bioactivity., including antioxidant and anti-inflammatory activity. May be consumed in food form or as a concéntrate.	Tart cherry juice
Direct: performance	
Performance supplements are used solely to contribute to optimal performance. Should be used in individualised protocols under the direction of an appropriate sports medicine / science practitioner. While there may be a general evidence base for these products, additional research may often be required to fine-tune protocols for individualised and event-specific use.	Caffeine
	Creatine
	B-alanine
	Dietary nitrate

Source: Prepared by Author.

Supplement considerations

Very few dietary supplements have been tested using football-specific tests simulating match-play. In general, dietary supplements recommendations are based on those studies which have reported a supplement to be effective at improving specific exercise performance. In addition, most participants used in these studies have been recreational players or even non-footballers. Thus, the evidence that professional footballers will benefit from these supplements is therefore very limited.

Although many supplements can be used continuously, from experience, it is recommended to periodise/cycle their use. This is because the adherence to dietary supplement programmes is likely to be improved when adopting a "targeted" approach. During periods of the off-season, players may benefit from psychologically "switching off" from football, and this may include additional nutrition strategies.

Finally, although not discussed in this module, the potential placebo effect on player's performance by using dietary supplements should not be underestimated (Clark et al., 2000). Strategically, introducing appropriate supplementation also helps to provide players with the "boost" required at targeted periods of the season, such as periods of fixture congestion or finals.

SUMMARY

- The daily diet, lifestyle and training of the player should be optimised before dietary supplementation is considered.
- Dietary supplements may indirectly benefit performance by maintaining the player's health.
- Dietary supplements may directly benefit performance by improving physical or skill capabilities over the duration of competition.
- Key "indirect" dietary supplements include micronutrients, pro-biotics and tart cherries.
- Key "direct" dietary supplements include caffeine, creatine, beta-alanine, and dietary nitrate.
- Potential dietary supplementation should be delivered with respect to quality assurance programs (Unit 1), the risk/benefit trade-off, and the needs and preferences of the individual player.

Disclaimer: Ian Rollo is an employee of the Gatorade Sports Science Institute, a division of PepsiCo, Inc. The views expressed in this course are those of the authors and do not necessarily reflect the position or policy of PepsiCo, Inc.

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