

## Review Article

# Dietary and Ergogenic Supplementation for Improve Elite Soccer Players Performance

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## Abstract

Soccer is an extremely competitive sport, where the most match important moments can be defined in details. Use of ergogenic supplements can be crucial to improve the performance of a high-performance athlete. Therefore, knowing which ergogenic supplements are important for soccer players can be an interesting strategy to maintain high level this sport until final and decisive moments of match. In addition, other supplements, such as dietary supplements, have been studied and increasingly referenced in the scientific literature. But, what if ergogenic supplements were combined with dietary supplements? This review brings some recommendations to improve performance soccer athletes on the field through dietary and / or ergogenic supplements that can be used simultaneously such creatine 3 to 5 g • day<sup>-1</sup> or 0.075 g • kg<sup>-1</sup> body weight (BW) • d<sup>-1</sup>, caffeine 3 to 6 mg • kg<sup>-1</sup> BW around 60 minutes before match, sodium bicarbonate 0.1 to 0.4 g • kg<sup>-1</sup> BW starting from 30 to 180 minutes before the match and a progressive dose regimen can be used to with doses 25 to 100 mg • kg<sup>-1</sup> BW, β-alanine 3.2 and 6.4 g • d<sup>-1</sup> provided in the sustained-release tablets divided four times a day, nitrate-rich beetroot juice 60g in 200mL of water (6 mmol of NO<sub>3</sub><sup>-</sup> • L) around 120 minutes before match or training. Including a combination possible with taurine 50 mg • Kg<sup>-1</sup> BW • d<sup>-1</sup>, citrulline 1.2 to 3.4 g • d<sup>-1</sup> and arginine 1.2 to 6 g • d<sup>-1</sup>.

## INTRODUCTION

Practiced in more than 180 countries involving more than 240 million individuals, soccer's considered the most popular sport in the world [1], which has characteristics of short and long duration and low and high intensity [2]. As a soccer match lasts 90 minutes, this sport consists of intermittent exercises of prolonged duration [3]. The soccer match involve more than 200 high-intensity actions, such as sprints, changes of direction, jumps, accelerations and decelerations, are applied and approximately 70% of the game involving walking or light running [4]. In the final and decisive moments of the match, in the last 10 minutes of the second half, can happen a greatest loss of performance of the athletes [4] highlighting the importance of ergogenic supplementation to optimize their performance. Recently, the Academy of Nutrition and Dietetics, Dietitians of Canada and the American College of Sports Medicine provided a guideline prepared mainly by members of the Academy of Nutrition and Dietetics, Dietitians of Canada (DC) and the American College of Sports Medicine (ACSM) with the main sports supplements with ergogenic functions to improve the athletes performance [5]. Therefore, the purpose of this review is to provide precise recommendations for ergogenic supplements prescription including dietary supplements to improve elite soccer players performance.

## Creatine

The creatine is popular among soccer players [6], synthesized

from the amino acids arginine, glycine and methionine, and stored about 95% in skeletal muscle can be found free form or linked to a phosphate molecule (phosphocreatine) [7]. During exercise, the breakdown of muscle glycogen by glycogenolysis will contribute approximately 50% of ATP production, with about 48% of phosphocreatine and 2% of muscle adenosine triphosphate (ATP) stock [8]. The soccer has high intensity and short duration activities [4], creatine supplementation is interesting. In addition, creatine supplementation acts on the fluid level of skeletal muscle cells, as demonstrated by a double-blind, controlled work with 0.3 g • kg<sup>-1</sup> of body weight (BW) of creatine supplementation during 7 days involving 13 soccer players [9] promoting ATP resynthesis and subsequent improvements in the performance of soccer players.

A double-blind, controlled study with 19 soccer players, supplemented with creatine (0.3 g • kg<sup>-1</sup> BW • d<sup>-1</sup>) for 14 days and concluded significant improvements in power tests using 30s of Wingate anaerobic test (WAnT) [10]. Other study randomized, double-blind and controlled with parallel groups containing 14 brazilian elite soccer players, who did not use creatine, were supplemented with 20 g • d<sup>-1</sup> for one week divided four equal doses to enhance phosphocreatine concentration (overcompensation), followed by daily doses of 5 g during 6 weeks, performed and soccer-specific physical tests, and concluded significant improvements in jumping performance [11]. In summary, the creatine recommendation for professional

soccer players consists 3 to 5 g • day<sup>-1</sup> or 0.075 g • kg<sup>-1</sup> BW • d<sup>-1</sup> [8].

### Caffeine

Caffeine supplementation is recognized by the International Olympic Committee and the International Sports Nutrition Society [12], acts to improve performance by attenuating the potassium output of muscle cells [13], alert effect due antagonism of caffeine to adenosine receptors in the central nervous system (CNS) [14] and improves the use of muscle glycogen during exercise [15]. Therefore, athlete have a longer time until fatigue, helping effects if there's a desensitization in the 24 h before the competition (abstaining from caffeine) [16].

A controlled, crossover and randomized study with 12 soccer players evaluated 6 mg • kg<sup>-1</sup> BW caffeine one hour before test and found improvements in time to hit a penalty and performance in the countermovement jump (CMJ) [17]. 250 ml of a drink containing caffeine (3 mg • kg<sup>-1</sup> BW) and 7% carbohydrates was tested on 18 soccer players and induced significant improvements in the vertical jump tests performed after a soccer match [18]. In addition, two meta-analyzes with more than 60 studies, the effectiveness of caffeine for endurance is proven and its additional ergogenic effect on the athlete's performance can reach more than 3% [19,20]. In summary, the caffeine supplementation recommended for professional soccer players consists 3 to 6 mg • kg<sup>-1</sup> BW around 60 minutes before match, if possible with no caffeine products in the 24 h before the match.

### Sodium bicarbonate

During the high-intensity exercise, a soccer game for example, there's an increase blood lactate concentration, a product of the glycolytic pathway used to provide energy and maintain the intensity of the exercise [21,22], and to keep the amount of lactate into the skeletal muscle high for a longer period has been used the supplementation with sodium bicarbonate (NaHCO<sub>3</sub>), a buffering agent that attenuates the decline muscle pH, decreasing acidity and improving performance [22,23]. However, it's can to contain risks of gastrointestinal problems and metabolic alkalosis due dose and time of ingestion, respectively [24].

A study supplemented 16 men using 3 doses of sodium bicarbonate, 0.1 g • kg<sup>-1</sup> BW, 0.2 g • kg<sup>-1</sup> BW and 0.3 g • kg<sup>-1</sup> BW, and found respectively a increased blood NaHCO<sub>3</sub> concentrations per dose (+ 2.0 - 5; + 5.1 - 8.1; and + 6.0 - 2.3 mmol • L<sup>-1</sup>) and dose over time (30 - 150; 40 - 165; and 75 - 180 minutes) [25]. A study of 13 men tested 0.4 g • kg<sup>-1</sup> BW of NaHCO<sub>3</sub> in intermittent Yo-Yo running tests and obtained 14% improvements in performance and 7% decrease in the perceived exertion rate [26]. Another study with 11 participants examined supplementation with 0.4 g • kg<sup>-1</sup> BW of NaHCO<sub>3</sub> in running-based anaerobic sprint test (RAST) and concluded significant improvements in total amount of work with lower blood pH [27]. After ingesting 0.4 g • kg<sup>-1</sup> BW of NaHCO<sub>3</sub>, 10 soccer players were evaluated with Yo-Yo tests and got better 70% the running high speed (17 to 21 km • h<sup>-1</sup>) [28]. The progressive dose on the eve of the competition has been used a study with 58 athletes supplementing with NaHCO<sub>3</sub> in ten consecutive days progressive dose regimen (25 mg • kg<sup>-1</sup> BW on days 1 and 2, 50 mg • kg<sup>-1</sup> BW on days 3, 4 and 5, 75 mg • kg<sup>-1</sup> BW

on days 6 and 7 and 100 mg • kg<sup>-1</sup> BW on days 8, 9 and 10) which resulted significant improvement in peak power time on Wingate tests [29]. A double-blind, crossover, randomized, controlled study using 7-day wash-out tested effects of combining 6 mg • kg<sup>-1</sup> caffeine with 0.3 mg • kg<sup>-1</sup> • d<sup>-1</sup> sodium bicarbonate in 8 athletes and concluded that combining caffeine with NaHCO<sub>3</sub> can increase performance in aerobic exercises [30]. Maybe this methodology can be applied to elite soccer players when they want greater performance, as in finals and / or very decisive matches. In summary, the sodium bicarbonate supplement recommended for professional soccer players consists 0.1 to 0.4 g • kg<sup>-1</sup> BW starting from 30 to 180 minutes before the match and a progressive dose regimen can be used to with doses 25 to 100 mg • kg<sup>-1</sup> BW using combined 6 mg • kg<sup>-1</sup> caffeine.

### Beta-alanine

Muscle carnosine is dipeptide formed by the combination of the amino acids β-alanine and L-histidine and participates in the buffering of muscle cells by accepting protons during the induced pH increase where your limiting factor is the the availability of β-alanine [31]. As the muscle is unable to synthesize carnosine precursors, β-alanine supplementation induces an increase in intramuscular carnosine content and increasing buffering capacity [32]. A systematic review and meta-analysis involving 40 studies with β-alanine supplementation concluded that this practice can have an ergogenic effect on performance depending on the athlete's modality [33].

A randomized, double-blind, placebo-controlled trial tested β-alanine supplementation in 16 soccer athletes with 4.8 g • d<sup>-1</sup> (approximately 84 mg • kg<sup>-1</sup> BW) divided six doses every two hours during six weeks and obtained significant improvements in jumping performance, repeated sprint and resistance compared to the control group [34]. 17 soccer players were recruited for a double-blind, controlled study to supplement β-alanine in 3.2 g • d<sup>-1</sup> provided in the form of 800 mg sustained-release tablets for 12 weeks (at the beginning and middle of the season) and obtained significant improvements in Yo-Yo performance compared to placebo [35]. The total daily recommendation remains between 3.2 and 6.4 g • d<sup>-1</sup> provided in the sustained-release tablets divided from 2 to 6 for at least 4 weeks of continuous use up to 24 weeks [36-38]. A double-blind, crossover and controlled study evaluated 20 athletes to test beta-alanine with or without sodium bicarbonate on total time performance and concluded significant changes when the combination was used [39]. In summary, the β-alanine supplementation recommended for professional soccer players consists 3.2 and 6.4 g • d<sup>-1</sup> provided in the sustained-release tablets divided four times a day during one season (about 24 weeks) can be used in the presence of concomitant use of sodium bicarbonate.

### Nitrate

Dietary supplementation of nitrate (NO<sub>3</sub><sup>-</sup>) through beet juice induces an increase in the concentration of nitrite (NO<sub>2</sub><sup>-</sup>) in plasma [40] subsequently increase production of nitric oxide (NO) [41]. The high bioavailability of nitric oxide increase release of calcium (Ca<sup>2+</sup>) improving contractile function of the skeletal muscle [42] and helping recovery of phosphocreatine reserves, what prevent depletion during repeated efforts and improve

release and reuptake of calcium in reticulum sarcoplasmic [43,44]. However, how nitrate metabolism to nitric oxide requires oral cavity bacteria [41] and peak in the blood occurs 2 to 3 hours after ingestion [45], the athletes can't use antibacterial mouthwash or toothpaste before consuming beet juice [40].

A double-blind, crossover, randomized study with 36 male players tested 5 days supplementation with beet juice at 6 mmol  $\text{NO}_3^-$  for a high-performance team sport using Yo-Yo tests and the results were significantly better (+ 4 %) on the athletes performance [46]. Another randomized, crossover, double-blind, placebo-controlled study using drink 70 mL of beet juice on 15 participants got significantly increased peak and average potency and blood lactate levels [47]. 14 male recreational team sports players were assigned to a double-blind, randomized, crossover project to consume 490 mL of nitrate-rich beet juice (6 mmol  $\text{NO}_3^-$ ) and nitrate-low beet juice (placebo), what increase significantly (+4, 2%) Yo-Yo test performance [48]. A double-blind, crossover, randomized, parallel design study involving 29 athletes compared 14 days with supplementation of nitrate-rich beet juice versus placebo (nitrate-poor beet juice) where the two groups drinking extra dose nitrate-rich beet juice two hours before the experiment and how conclusion, just the group with nitrate-rich beet juice for chronic use (14 days) reduced testing time and increased potency [49]. In summary, supplementation with nitrate-rich beet juice consists 60g of beet in 200mL of water (6mmol of  $\text{NO}_3^- \cdot \text{L}$ ) recommended for at least 5 days of continuous use, around 120 minutes before match or training with double consumption on the match day.

## Taurine

Taurine supplementation aids human maximal voluntary muscle contraction [50], reduces muscle damage and bringing additional benefits hepatic metabolism [51,52]. Actually, it's use for improve soccer performance was little studied in the scientific literature. However, a meta-analysis, involving 10 prospective studies, demonstrated possible significant effects on the performance of endurance athletes [53]. Another study, a randomized, crossover and controlled model evaluated the supplementation 5g  $\cdot \text{d}^{-1}$  taurine for one week in 20 athletes and concluded improvements reaction time plays [54]. Other crossover, randomized, controlled model study evaluated 3g  $\cdot \text{d}^{-1}$  taurine for 8 weeks for 14 professional swimming athletes, concluding a possible increase in lactate production together with a possible additional effect on anaerobic lactic metabolism [55]. Besides these, other studies with young strength athletes, found that taurine can mitigate muscle pain and induce positive effects on muscle contraction [56,57].

But taurine supplementation looks improve the results with caffeine combination, as show a crossover, randomized, double-blind, controlled study with 7 soccer players that tested 5 mg  $\cdot \text{Kg}^{-1} \text{BW} \cdot \text{d}^{-1}$  of caffeine combined with 50 mg  $\cdot \text{Kg}^{-1} \text{BW} \cdot \text{d}^{-1}$  of taurine and found this combination improve the rate of intra-sprint fatigue, heart rate and the rate of blood pressure produced [58]. Another double-blind, acute and crossover study involved 16 active men tested the effects 3 and 6 g  $\cdot \text{d}^{-1}$  taurine doses in moderate fasting running training protocol and concluded lower respiratory coefficients with use of taurine [59]. 12 recreational active men participated this crossover, randomized,

controlled and double-blind study to test the effects of taurine on performance on a cycle ergometer with 50 mg  $\cdot \text{Kg}^{-1} \text{BW} \cdot \text{d}^{-1}$  taurine dose for 7 days and concluded a significantly improve on time to exhaustion, peak power and critical power, in addition to increasing the biochemical lactate levels numerically [60]. In summary, the supplementation with taurine recommended for professional soccer players consists 50 mg  $\cdot \text{Kg}^{-1} \text{BW} \cdot \text{d}^{-1}$  for up to 8 weeks and preferably combined with caffeine at 5 mg  $\cdot \text{Kg}^{-1} \text{BW} \cdot \text{d}^{-1}$ .

## Citrulline

Citrulline supplementation involved in arginine metabolism, in the kidneys citrulline is converted into arginine up to the endothelial vessel wall, where the endothelial nitric oxide (eNOS) synthase and converts arginine to nitric oxide (NO) and citrulline to start the cascade of using  $\text{Ca}_2^+$  from sarcoplasm to sarcoplasmic reticulum, increasing muscle relaxation [61]. A double, controlled and randomized study with acute dose 500mL of watermelon juice enriched with citrulline (3.4g) for 21 runners decreased perception of muscle pain 24 to 72 hours after running [62].

A 3-week, double-blind, randomized, crossover, controlled study with 22 trained cyclists tested citrulline supplementation (2.4g  $\cdot \text{d}^{-1}$ ) for 7 days using time tests and found significant reductions total test time and significant increases at power [63]. A double-blind, randomized, controlled study with 20 professional soccer players, tested combined supplementation with 1.2g arginine and 1.2g citrulline for 6 days and found additional benefits in performance and subjective perceptions effort [64]. 10 healthy, trained men participated in a crossover, randomized, double-blind, placebo-controlled study to test the acute effects 12g citrulline in high-performance tests on 3 occasions separated by 7 days (wash out) concluding significantly improve in frequency cardiac output but not in performance [65]. Another randomized, double-blind, placebo-controlled, crossover and counterbalanced study included 12 men with 8g citrulline acutely and found no improvement in strength training performance [66]. In summary, citrulline supplementation recommended for professional soccer players consists 1.2 to 3.4 g  $\cdot \text{d}^{-1}$  at least 6 consecutive days and preferably combined with 1.2 g  $\cdot \text{d}^{-1}$  of arginine.

## Arginine

All ingested arginine is degraded mainly in gastrointestinal tract and liver through enzyme arginase, in which it's inhibited in citrulline ingestion, so co-ingestion of these amino acids can increase circulating arginine concentrations [64]. A controlled, randomized, double-blind study involving 19 soccer players tested 0.15 g  $\cdot \text{Kg}^{-1}$  arginine acute dose in RAST and concluded that there was no improvement significant [67]. That is, acute supplementation of 3g arginine wasn't able induce improvements vasodilation or performance [68].

However, a double-blind, controlled and randomized study tested the effectiveness 2g arginine supplementation on performance of 56 soccer players during 45 days and found significant improvements in maximum oxygen consumption ( $\text{VO}_2\text{max}$ ) with subsequent performance increase [69]. 28 soccer players were selected supplement 6g arginine during 14 days

Table 1: Recommendation of dietary and ergogenic supplements to improve the performance of elite soccer players.		
Elements	Recommendations	References
<b>Creatine</b>	3 - 5g • d <sup>-1</sup> ou 0,075 g • kg <sup>-1</sup> BW • d <sup>-1</sup> . *If necessary: overcompensation to quickly saturate phosphocreatine stocks (20g • d <sup>-1</sup> ou 0,3 g • kg <sup>-1</sup> BW • d <sup>-1</sup> ).	9-11
<b>Caffein</b>	3 a 6 mg • kg <sup>-1</sup> BW approximately 1 hour before matches.	17-20
<b>Sodium bicarbonate</b>	0,1 a 0,4 g • kg <sup>-1</sup> BW starting 30 to 180 minutes before matches. *If necessary: make progressive dose starting 10 days before a very important match 25 to 100 mg • kg <sup>-1</sup> BW using combined 6 mg • kg <sup>-1</sup> caffeine.	25-30
<b>β-alanine</b>	3,2 a 6,4 g • d <sup>-1</sup> provided in the sustained-release tablets divided four times a day during one season (about 24 weeks) can be used in the presence of concomitant use of sodium bicarbonate.	34-39
<b>Nitrate</b>	Nitrate-rich beet juice consists 60g of beet in 200mL of water (6mmol of NO <sup>3-</sup> • L) recommended for at least 5 days of continuous use, around 120 minutes before match or training with double consumption on the match day. *It's important double consumption on match day.	40,45-49
<b>Taurine</b>	50 mg • Kg <sup>-1</sup> BW • d <sup>-1</sup> for up to 8 weeks and preferably combined with caffeine at 5 mg • Kg <sup>-1</sup> BW • d <sup>-1</sup> .	54-60
<b>Citrulline</b>	1.2 to 3.4 g • d <sup>-1</sup> at least 6 consecutive days and preferably combined with 1.2 g • d <sup>-1</sup> of arginine.	62-66
<b>Arginine</b>	1.2 to 6 g • d <sup>-1</sup> for at least 14 consecutive days and preferably combined with 1.2 g • d <sup>-1</sup> of citrulline.	67-70

and test their performance in the RAST protocol on six 35 meters consecutive sprints with ten seconds of active rest, concluding dose influenced the body's lactate levels and reduced the damage post-workout muscle by decreasing lactate dehydrogenase (LDH) [70]. In summary, the arginine supplementation recommended for professional soccer players consists 1.2 to 6 g • d<sup>-1</sup> for at least 14 consecutive days and preferably combined with 1.2 g • d<sup>-1</sup> of citrulline.

## CONCLUSION

Elite soccer players have nutritional weapons to improve performance on the field through dietary or ergogenic supplements such as taurine, citrulline and arginine, and ergogenic supplements such as creatine, caffeine, sodium bicarbonate, beet juice (nitrate) and beta alanine. Besides everything, some combinations has been demonstrated improve performance such for example arginine with citrulline, caffeine with sodium bicarbonate, beta-alanine with sodium bicarbonate, and taurine with caffeine. This way, additional benefits of mixtures containing ergogenic supplements and dietary supplements can be welcomed for elite soccer players. In summary, Table 1 presents a direct and elaborate outline of dietary and ergogenic supplements evidence-based recommendations to improve the performance of elite soccer players that can be combined.

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