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REVIEW ARTICLE

A Review of Nutritional Ergogenic Aids on Physiological Responses and Skilled Performance among Football Players

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KEYWORDS

Exercise Training,
Performance,
Physical Activity,
Body Weight.

ABSTRACT

Background. The exact amount, timing, and types of supplements should be based on physiological demands and level of training. **Objectives.** This review aims to investigate the effects of supplements among football players. **Methods.** Literature was searched systematically based on Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, using the following keywords: (#drink or #supplement) and (#soccer or #football) in Web of Science, ScienceDirect, PubMed, ProQuest, and Scopus databases from year 2016 up to 2024. Out of 15 studies, four were conducted to determine the effects of hydroelectrolytic beverages, while the remaining eleven were conducted using various beverages. **Results.** Some physiological responses, such as plasma urea, aspartate aminotransferase, and alanine aminotransferase, improved after consumption of whey permeated with phenolic extract from the jaboticaba peel. Another study using deep ocean minerals (DOM) and carbohydrate electrolytes (CE) showed that skilled performance, such as high-intensity running capacity, dribbling speed, and other soccer-specific performance, was increased. Meanwhile, watermelon beverages combined with the Running-based Anaerobic Sprint Test (RAST) protocol reduced fatigue index (FI) and thus induced recovery phases. Isomaltulose ingestion led to increased blood glucose. A combination of TeaCrine (TCr) and caffeine ingestion combined with four sessions of a 90-minute simulated treadmill soccer match increased running time-to-exhaustion (TTE). **Conclusion.** Therefore, supplements have shown beneficial effects on fitness and performance among football players and are recommended as an ergogenic aid. The most popular form is the drink type.

INTRODUCTION

It is well known that football players need to cover a certain amount of distance on the big football pitch during attacking and defending (1). They are also assigned to a position in the football team, either as a goalkeeper, defender, midfielder, or striker, which means that they have separate tasks given to them. Thus, energy demands in football differ because of factors such as the position of the player and match activities (2). Demands for a football player depend on the positional role that the player plays. Central defenders covered less overall distance and participated in running less vigorously than players in the other positions (3). Differences also occur within the same position because of the different tasks given for each position. The least high-speed running and sprinting distances were covered by central defenders and central defensive midfield players, while forwards covered the most extended high-speed running distances (4). In contrast, central attacking midfielders covered the most distance in high-speed running while their team owned the ball (5). Because of all these energy demands, football players must have enough energy from a proper nutritional intake to fulfill the demands.

With the competition level and individual characteristics, the energy and physiological demands of soccer training and match-play differ over the season. Consensus (6) stated that the typical energy expenditure of training or match-play in elite football players is about 6 MJ (6000 kJ) per day for men and about 4 MJ (4000 kJ) per day for women. Some studies have stated that the energy intake of football players (from their nutrition) is not enough to meet the nutritional requirements, which is the energy expenditure during training and competition (7, 8) with an average daily energy deficit of -3299±729 kJ (9).

In football, training and competition can greatly increase the need for macro and micronutrients. This increase can be significant at a professional level, sometimes with prolonged periods of two matches per week and interspersed with training sessions (10). Football players must fulfill this need by consuming supplementation as a booster to provide enough energy to fulfill the demands. Ergogenic aids would be helpful for football players. Ergogenic aids can be defined as a technique or product used for performance enhancement purposes in sports (11). Ergogenic aids have been classified as nutritional, mechanical, pharmacologic, physiologic, or psychologic. In this review, nutritional ergogenic aids will be focused on providing supplementation for football players. Types of nutritional ergogenic aids are carbohydrate loading, sports drinks, energy drinks, and capsule supplementation, but for this review, we focused only on sports drinks, energy drinks, and capsule supplementation.

Nutritional ergogenic aids may be helpful for football players to meet the physiological demands as football is an intermittent sport that includes high-intensity exercise periods interspersed with lower-intensity exercise periods. The physiological demands vary between a single football player and another because of the changing intensities in football. The common physiological responses and demands used as physiological measurements in football are energy expenditure, maximal oxygen uptake, and heart rate, where the latter is represented in a sampling of body fluids and tissues such as blood samples (12). Football players and coaching staff use these physiological responses as guidance to improve football performances through practices and games. Next, nutritional ergogenic aids can also improve skilled performance in football. Skilled performances in football are sprints, changes in direction and pace of running, acceleration/deceleration, jumps and tackles, and technical activities such as kicking, dribbling, shooting, and passing (12, 13). According to Russell et al. (14), the level of skill performance has been recorded as a major indicator of overall good football performance. Higher physiological responses and skilled performance can be achieved by football players who consume nutritional ergogenic aids (15-17).

Thus, this review aims to investigate the recommended nutritional ergogenic aids intake for football players to improve their physiological effects and sports performance using data from Scopus, Science Direct, Pub Med, ProQuest, and Web of Science. Based on our knowledge, this would be the first scoping review to review the literature of the selected articles and suggest the best amount, timing, and type of nutritional ergogenic aid for football players.

MATERIALS AND METHODS

Protocol Registration. All methods and search strategies were aligned with Preferred Reporting Items for Systematic Review (PRISMA) guidelines. This review was registered with the International Prospective Register of Systematic Reviews (registration number CRD42024598883). A PICOS criteria (i.e., Participants, Intervention, Comparison, Outcome, and Study design) for review is defined in Table 1. A systematic search using terms such as drink supplement soccer or football was conducted by one researcher (NSA). All keywords used in the search are listed in Table 2.

Literature Search. Related studies were searched electronically using the following databases: Web of Science, ScienceDirect, PubMed, ProQuest, and Scopus. The selected studies were briefly searched using the same selection criteria described below. In addition, cross-referencing on related previously published studies was done to obtain additional information. Peer-reviewed articles in the English language from January 2016 until September 2024 were used. No attempts were made to contact the authors for additional information. Comparable searches were made for the other databases.

Table 1. Participants, Intervention, Comparison, Outcome, and Study (PICOS) criteria for inclusion and exclusion of studies.

Parameter	Description
Population	Professional and recreational player
Intervention OR exposure	Exercise or physical activity
Comparison	Supplements in comparison to placebo or water
Outcomes	The best amount of supplement, appropriate timing, type of nutritional ergogenic aids, and recommended dosage to improve sports performance and physiological parameters
Study design	Randomized Control Trial

Table 2. Table of keywords.

Concept	Keywords
Drink or supplement	"drink" OR "supplement" OR "juice" OR "beverage" OR "ingestion" OR "supplementation" OR "intake" OR "fluid"
Soccer or football	"soccer" OR "football"

Eligibility Criteria. The inclusion criteria for this study are (i) Recreational and professional football or soccer players; (ii) male and female age between 18 and 30 years old; (iii) consumed any kind of supplement before, during, or after intervention; (iv) underwent an intervention for a certain period; (v) randomized controlled trial design.

The exclusion criteria are (i) participants who are on medication or taking any supplement prior to the study period; (ii) having any health problems (such as asthma, cardiac problem, diabetes, spinal cord injury); (iii) having a history of physical injuries in the past 6 months.

Study Selection. The search was conducted per the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (18). The following keywords were used during the search: (#drink or #supplement) and (#soccer or #football). The selection criteria must include dietary supplementation and recruiting soccer or football players as participants. PRISMA flow has been produced based on a pre-determined stage: identification, screening, eligibility, and inclusion. Randomized controlled trials on males and females were included in this review. The intervention comprised i) hydroelectrolytic drinks, ii) fruit beverages, iii) alcohol, and iv) tea and caffeine capsules in combination with an exercise program versus exercise alone. Exercise performance or physical activity described as (i) Intermittent-running protocol on the treadmill, (ii) Intermittent Shuttle Run Test, (iii) Running based anaerobic sprint test, (iv) Modified version of Soccer Match Simulation, or (v) Soccer-specific aerobic field tests.

Data Extraction. The titles and abstracts of retrieved articles were reviewed using criteria specified to determine whether full texts were required for further analysis. Each full-text manuscript was evaluated systematically according to the study: (1) objective/s, (2) characteristics of the study (study design, participants, age, and sample size), (3) contents of intervention (intervention types, length of intervention or mode of exercise tested, (4) targeted outcome/s, and (5) main findings. The outcomes extracted from those studies were not combined, reanalyzed, or changed due to the nature of this scoping review. The study was approved by the ethical researcher committee of the University Sains Malaysia (USM/JEPeM/19100617).

Methodological Quality Assessment. The authors evaluated each paper's methodology quality using the Physiotherapy Evidence Database Scale (PEDro) for randomized controlled trials. The PEDro scale is an 11-point list using yes and no responses. The first statement pertains to the study's external validity and is not included in computing the final score. A PEDro score of 6 or above represented a high-quality study, whereas a score of 5 or below represented a low-quality study. Differences in opinion on any PEDro item score were resolved through discussion until a consensus was reached.

RESULTS

Search Results. The initial search from the databases identified 1324 potential articles, while another one was found through cross-referencing. After removing duplicates, 243 articles were assessed based on titles and abstracts against the selection criteria. A total of 208 articles were excluded because they did not investigate drink or supplements and physical activity. After a detailed analysis of 35 full-text articles, only 15 were included in this systematic review. The excluded articles were not in English language (n=1), prescribed Gaelic football as an intervention (n=5), did not prescribe proper intervention training (n=10), and had no control groups (n=4). Therefore, only 15 articles were included in this review for quantitative synthesis. Figure 1 describes the PRISMA flow diagram for the study selection.

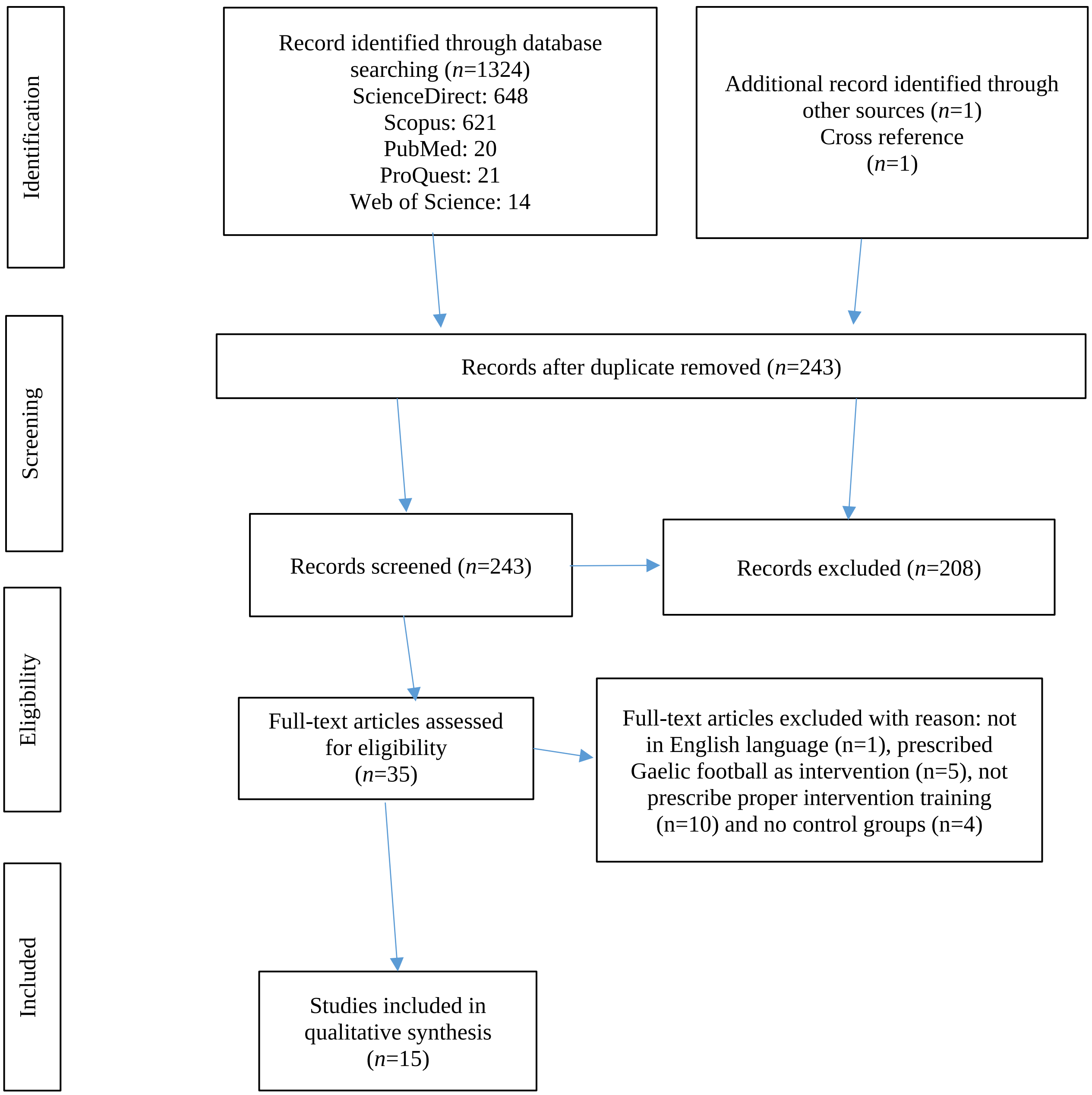

Figure 1. PRISMA flow for study selection.

Four of the 15 studies reviewed were conducted using hydroelectrolytic beverages, while the remaining eleven used various beverages such as fruit drinks, alcohol, caffeine, maltodextrin, and probiotics. The scope of the study for those retrieved articles was primarily on the combination of exercise programs and hydro-electrolytic drinks on physiological responses and skilled performance among football players. Only one study investigated both physiological responses and skilled performance.

Secondarily, those retrieved articles were scoped based on the effects of other beverages such as fruit drinks, alcohol, caffeine, MDX, and probiotics in combination with exercise programs on physiological responses and skilled performance among football players. Four of these studies investigated both physiological responses and skilled performance.

Nine studies used the drink type, and the other two used the capsule type. The dosage of the supplements varies in all studies, ranging between 1 mg/kg BW to 4 mg/kg BW (capsule supplement) and 0.48 ml/kg BW to 17.25 ml/kg BW (drink supplement). The timing of beverage consumption prescribed pre-exercise (19-23) pre and during exercise (24-28) and post-exercise (29).

Combination of exercise programs and hydro electrolytic drinks on physiological responses and skilled performance. Table 3 summarises the effects of combining exercise programs and hydroelectrolyte drinks on physiological responses and skilled performance. Carbohydrate-electrolyte solution or carbohydrate-electrolyte-protein solution ingestion (2.00-5.00 ml/kg BW) led to an increase in some aspects of cognitive function by using electrophysiological devices (24). The study by Ferreira et al. (25) found improvement in some physiological responses such as plasma urea, aspartate aminotransferase, and alanine aminotransferase after consumption of whey permeated with phenolic extract of jaboticaba peel. Another two studies reported increased skilled performance, such as high-intensity running capacity, dribbling speed, and other soccer-specific performance (26, 29). Three studies reported no differences in blood glucose and lactate concentration (24, 26, 29).

Effects of fruit beverages, alcohol, caffeine, maltodextrin, and probiotics in combination with exercise programs. Table 4 summarises the effects of fruit beverages, alcohol, caffeine, maltodextrin, and probiotics in combination with exercise programs on physiological responses and skilled performance. Three studies reported physiological changes only; all were conducted on male subjects. In these three studies, different supplementations were used. The study by Adikari et al. (19) has given daily probiotic supplementation (3.22 ml/kg BW) in combination with regular food practice, training, and competition for eight weeks, which resulted in better training, brain function, and physiological improvement to exercise. The second study was given on non-alcoholic beer followed by steady-state exercise at 65% of HRmax for 45-min had maintained blood electrolyte homeostasis during exercise (23). The third study by Rizal et al. (21) prescribed watermelon beverages as an intervention (7.00–10.00 ml/kg BW) and combined them with a Running-based Anaerobic Sprint Test (RAST) protocol, which resulted in the reduction of fatigue index among football players, thus induced recovery phases.

The remaining four studies investigated the effects of nutritional ergogenic aids on physiological responses and skilled performance: two studies on the liquid type and another two on capsule type—the study on the liquid type used both carbohydrate drinks. In one of the studies, isomaltulose or maltodextrin ingestion (4.50–6.00 ml/kg BW) led to increased blood glucose and no significant reduction in skilled performance (27). In addition, there was an increase in blood glucose; however, there was no effect on blood lactate and self-selected running performance or sprint times in a randomized, counter-balanced design of carbohydrate intake (3.25 ml/kg BW) among football players (28). The capsule-type study was conducted on 10 female football teams; an anhydrous caffeine capsule (1 mg/kg BW) was ingested in combination with intermittent exercise protocol leg strength and power and countermovement jump could enhance eccentric knee flexor performance but did not affect physiological responses such as plasma glucose concentration, plasma insulin concentration, FFA concentration and USG (22). Meanwhile, a combination of TCr and Caf ingestion (4 mg/kg BW, capsule type) combined with four sessions of 90-minute simulated treadmill soccer match increased running time-to-exhaustion and improved cognitive function (20).

Table 3. Combination of exercise programs and hydroelectrolytic beverages.

Authors and year	Study target/ target population	Types/dosage/timing	Intervention/ exercise program	Outcome measures	Main finding	Quality assessment score
Sun et al., (2020) (24)	Randomized cross-over design: 16 male college soccer players, age 21±1 years old	Intervention: carbohydrate-electrolyte solutions (CES); carbohydrate-electrolyte-protein solutions (CEPS); placebo (PLA) Drink 2–5 ml/kg BW Pre- and during exercise	Participants performed a standardized 5-minute warm-up. Then, they completed the LIST protocol. The data for each cognitive function test is collected at each time point across all trials. Different subjects consumed different solutions before warming up and during the resting period of the soccer-specific exercise protocol.	Cognitive function Blood glucose Blood lactate Heart rate	CES and CEPS consumption show certain benefits in some aspects of cognitive function. There is no difference in blood glucose concentration and lactate concentration. HR was higher after each session than resting	10
Ferreira et al., (2020) (25)	Randomized single-blinded study: Nine males with previous 5 years experience in systematized soccer training, 18 years old	Intervention: 3 groups (Commercial beverages; CB, hydro electrolytic beverages; HB, water intake; WA) Drink 3 ml/kg BW Pre- and during exercise	After standardized and typical soccer warm-up, subjects the SAFT90 protocol with audio equipment. Subjects drank the prescribed beverages starting at “zero” minutes of the protocol and every 15 min, using as reference the intake of 3 mL/kg of their body mass.	Plasma sodium normality Plasma potassium normality Plasma urea Plasma uric acid Creatine kinase (CK) Aspartate aminotransferase (AST) Lactate dehydrogenase (LDH) Alanine aminotransferase (ALT) Total antioxidant capacity (TAC) Glutathione S-transferase (GST) Superoxide dismutase (SOD)	Plasma urea increases in all groups. The CB and HB groups presented a lower concentration of CK than the WA group. The group that ingested WA had an increase of 82.9% of AST, while the HB and CB groups had an increase of 39.5% and 22.9%, respectively. The concentration of ALT increased after exercise concerning baseline in the WA and HB groups but was similar in the CB group. The levels of GST increased 97.3% in the HB group, while the WA and CB groups did not show significant changes after exercise	9
Harper et al., (2017) (26)	Randomized, double-blind cross-over:	Intervention: water intake (WA) carbohydrate-electrolyte (CHO), placebo-electrolyte (PL)	Subjects performed a 90-minute soccer-specific exercise (modified Soccer Match Simulation; SMS)	Blood glucose Blood lactate Urine osmolarity Body mass	Compared to equivalent volumes of water and placebo, improved aspects of dribbling (i.e., speed)	10

Authors and year	Study target/ target population	Types/dosage/timing	Intervention/ exercise program	Outcome measures	Main finding	Quality assessment score
	Fifteen male university soccer players (age: 22±2 years old)	Drink 3 ml/kg BW Pre- and during exercise	requiring audio-prescribed (ten blocks) and self-paced (four blocks) activity equally split across two halves. Subjects ingested beverages towards the end of the warm-up (250 ml) and at HT (250 ml), both <15 minutes before each half commenced.	Sprint speed Self-paced distance covered Self-paced acceleration Self-paced deceleration Dribble speed Dribbling precision	and self-paced soccer-specific exercise performance in the latter stages of soccer-specific exercise.	
Higgins et al., (2019) (29)	Double-Blind, Placebo-Controlled Cross-over Trial: Nine healthy recreational male soccer players (age: 22±1 years old)	Intervention: Deep Ocean mineral water (DOM), Placebo (PLA) Drink 17 ml/kg BW Post-exercise	Subjects performed graded incremental tests followed by two familiarization trials. Subjects then completed experimental trials. Experimental and familiarization trials are all the same and used a motorized treadmill (~60 min running at 75% VO_2 max). Subjects consume tap water during recovery in familiarisation trials. Subjects were provided either deep ocean mineral water or a placebo during recovery in experimental trials, mixed with 6% sucrose.	High-intensity running capacity Heart rate (HR) Exercise capacity Urine osmolarity Body mass Blood lactate Blood glucose	DOM increased high-intensity running capacity compared to PLA. DOM increased exercise capacity compared to PLA. Body mass was greater for DOM vs. PLA.	10

Table 4. Effects of fruit beverages, alcohol, caffeine, maltodextrin, probiotics, and amino acids combined with exercise programs.

Authors and year	Study target/ target population	Types/dosage/timing	Intervention/ exercise program	Outcome measures	Main finding	Quality assessment score
Adikari et al., (2020) (19)	Randomized, double-blind, placebo-	Intervention: probiotic group, placebo group Drink	Subjects continue regular food practice, training, and competition. They had a practice match and a gym	Brain wave activities Electrodermal responses	Daily probiotic supplementation may modulate the brain waves, namely, theta (relaxation) and	10

Authors and year	Study target/ target population	Types/dosage/timing	Intervention/ exercise program	Outcome measures	Main finding	Quality assessment score
	controlled study: Twenty right-handed young adult male football players aged 18 to 21 years old.	3 ml/kg BW Pre-exercise	session. Portable electrophysiological devices were used. Data were gathered at the baseline (week 0), fourth week (week 4), and eighth week (week 8). Subjects consumed either a probiotic supplement or a placebo daily.	Heart rate Cognitive tasks Anthropometric measures and diet intake	delta (attention), for better training, brain function, and physiological improvement to exercise.	
Bello et al., (2019) (20)	A within-subjects, placebo-controlled, double-blind design: Male (n=10) and female (n=14) Division I and professional soccer players (age: 20.96±2.05 years old)	Intervention: 4 groups (PLA, TCr, Caf, TCr+Caf) Capsule 4 mg/kg BW Pre-exercise	Subjects completed four test sessions (90-minute simulated treadmill soccer match) in randomized order. Subjects ingested either placebo (PLA), TeaCrine® (TCr), caffeine (Caf), or a combination of TeaCrine® and caffeine (TCr + Caf)	Simple reaction time (SRT) Cognitive load reaction time Running time-to-exhaustion (TTE) Heart rate Rating of perceived exertion	The increases in TTE across all conditions compared to PLA suggest that players can maintain a higher level of performance at later stages in a match with consumption of Caf and TCr. These findings suggest that TeaCrine® favorably impacts endurance and the combination with caffeine provides greater benefits on cognitive function than either supplement independently.	9
Rizal et al., (2019) (21)	Randomized, 2-period cross-over design: Twenty-six recreational football players aged 15-17 years old	500 mL of watermelon beverage in 1 of the 2 periods and 500 mL of red sucrose syrup as placebo in the other for 7 days, respectively Drink 7–10 ml/kg BW Post-exercise	Subjects performed the Running-based Anaerobic Sprint Test (RAST) four times. Subjects receive a watermelon beverage or placebo for 7 days, approximately 01.30-02.30 PM. Each period is separated by 7 days of washout.	BMI Fat percentage Nutritional intake Fatigue index (FI)	FI declined Watermelon beverage ingestion for 7 days, effectively relieving fatigue index in young, recreational football players.	9
Ali et al., (2016) (22)	Randomized, double-blind, placebo-controlled crossover-	Intervention: anhydrous caffeine or artificial sweetener (placebo) Capsule	90-min intermittent treadmill-running protocol	Isometric strength performance and eccentric and concentric strength and power of the	Caffeine ingestion enhances eccentric knee flexor performance in this cohort. This result has implications for sprinting and kicking	10

Authors and year	Study target/ target population	Types/dosage/timing	Intervention/ exercise program	Outcome measures	Main finding	Quality assessment score
	design trial. Ten healthy females (24±4 years old)	6 mg/kg BW 60 minutes before exercise		knee flexors and knee extensors, countermovement jump (CMJ), glucose, insulin, and free fatty acids (FFA).	activities dominated by eccentric muscle contraction, suggesting that caffeine supplementation may enhance performance during competition.	
Castro-Sepulveda et al., (2016) (23)	Double-blind, randomized study: Seven male soccer players (age:19.1±0.4 years old)	Intervention: Beer (AB), Non-Alcoholic Beer(NAB), Water intake (WA) Drink 0.48±0.06g 45 minutes before exercise	Steady-state exercise was performed at 65% of HRmax for 45-min.	Body mass USG Plasma N+ and K+ Excretion of urine Sweat rate Total evaporative water loss	Consuming non-alcoholic beer before exercise could help maintain blood electrolyte homeostasis during exercise. The consumption of 0.7 L of alcoholic beer before exercise increased plasma K+ and decreased plasma Na+ during exercise, which could negatively affect sports performance and health. Water ingestion before exercise also resulted in a decrease in plasma Na+ during exercise.	9
Stevenson, et al., (2017) (27)	Double-blind, randomized, and cross-over: Twenty-two male university standard soccer players (age: 22±2 years old)	Intervention group: (Maltodextrin: MDX, high-GI; PALATINOSE™: PSE, low-GI; placebo: PLA, no carbohydrates) Drink 4–6 ml/kg BW Pre and during exercise	Subjects performed 120 min of intermittent exercise. Subjects consume drinks containing maltodextrin, isomaltulose or a carbohydrate-energy-free placebo in a manner replicating the practices of soccer players.	Blood glucose Blood lactate Plasma insulin Plasma epinephrine Glycerol IL-6 responses Plasma osmolarity Abdominal discomfort Peak HR Mean HR Repeated 20-m sprint performance Jump performance Shot precision Shot speed Dribble speed	Blood glucose increased. Blood lactate influenced by exercise. Isomaltulose proved more effective in lowering the epinephrine response to prolonged exercise. The consumption of low-GI isomaltulose before soccer-specific exercise may offer an alternative to the use of high-GI carbohydrates (e.g., maltodextrin). No significant reductions over time in physical (i.e., sprinting and jumping) or skilled (i.e., soccer shooting and dribbling) performances	11
Funnell et al., (2017) (28)	Double-blind, randomized,	Intervention: CHO, Placebo	Subjects completed a 10-minute self-selected warm-	Urine osmolarity Body mass	The CHO trial increased blood glucose, but no lactate	11

Authors and year	Study target/ target population	Types/dosage/timing	Intervention/ exercise program	Outcome measures	Main finding	Quality assessment score
	counter-balanced design: Sixteen male soccer players (age 23 and 4 years old)	Drink 3 ml/kg BW Pre- and during exercise	up. After that, the subjects drank 250 mL of the test drink for over 5 minutes before resting for 5 minutes. Subjects then began a modified version of the LIST.	Blood glucose Blood lactate Heart rate RPE 15-min sprint time Total distance covered or mean speed	was affected. There is no difference in 15 m sprint times. No difference in distance covered. Consumption of a 12% carbohydrate solution before and at half-time of a A simulated soccer match does not affect self-selected running performance or sprint times in a fed state.	
Abreu et al., (2023) (30)	Placebo-controlled Intervention 19 professional soccer players (age: 24±4.20 years old)	210 mg of caffeine, placebo Capsule 2.6 mg/kg BW 30 minutes before the game, during the game, and after the game.	Play an official Mineiro Championship	Blood creatine kinase (CK), Heart rate variability (HRV), Rate of Perceived recuperation and exertion, time spent on the field	No significant differences were found in CK, HRV, RPR, RPE, or minutes on the field when comparing caffeine supplementation with the placebo. Caffeine supplementation throughout the championship appears to have had no ergogenic effect on athlete performance and recovery	10
Mor et al., (2022) (31)	Pre-post test 24 active male amateur football players between 18-26 years old	5000 mg of BCAA 2000 mg of creatine Placebo (bran) Capsule ~71mg/kg/BW for BCAA ~28mg/kg/BW for creatine Pre and post-exercise	Players performed consecutively; rested ball kicking speed test, RAST, and repeated ball kicking speed test one more time. Hence, ball kicking speed with peak power, kicking the ball, and shooting on the athletes' target without rest was determined immediately after high-intensity training test protocol. Football players were given supplements before and after exercise, whereas the placebo group ingested bran 30–40 minutes before training and 1 hour after training.	Running anaerobic sprint test (RAST), Ball speed measurement, Blood lactate test, Heart rate, Body composition	BCAA and creatine consumption do not affect recovery rates in football players, according to the obtained data. However, regarding other findings of this study, BCAA and creatine supplementation improves anaerobic capacity, provides strength endurance against fatigue, and prevents the decrement of ball-kicking speed in exhaustion.	9

Authors and year	Study target/ target population	Types/dosage/timing	Intervention/ exercise program	Outcome measures	Main finding	Quality assessment score
Macuh et al., (2023) (32)	Randomized Controlled Trial, Cross over study 15 highly trained football players from Slovenian football's First Division, aged between 19 to 31 years old	400 mg nitrate, placebo Drink ~5 mg/kg BW Pre-test	12 min Cooper test	3 days food diaries, Body composition, Rating of perceived exertion, Distance cover on Cooper test.	Nitrate supplementation had a statistically significant positive effect on performance if baseline dietary nitrate intake was below 300 mg (p=0.0104) in both the placebo and intervention groups. There were no effects of nitrate supplementation when baseline dietary nitrate intake was higher than 300 mg. Nitrate supplementation did not significantly affect perceived exertion. The daily nitrate intake of the participants was measured at 165 mg, with most nitrates coming from nitrate-rich vegetables.	10
Mancin et al., (2024) (33)	Randomized controlled trial 38 elite male soccer players (age: 27±4 years old) Dark chocolate group (n=19) White chocolate group (n=19)	30 g of dark chocolate or 30 g of white chocolate for 30 days Solid bar 0.37/kg/BW Pre-exercise (before 9:00 a.m.)	120 min training, 6 times/week, and 90 min match/week	Anthropometry assessment, Lipid profiles, Plasma polyphenol extraction and quantification, Plasma fatty acid, Microbiome taxonomic profiling, DNA extraction and sequencing	daily ingestion of 30 g of dark chocolate for 4 weeks significantly improved blood lipid profiles, reducing the total cholesterol, LDL cholesterol, triglycerides, and the AA: EPA ratio. After 4 weeks of cocoa supplementation, high-density lipoprotein cholesterol improved slightly in the dark chocolate group but without a significant difference compared with controls (no significant Time × Treatment interaction).	10

DISCUSSION

The main findings of this study were that drink supplement was the most preferred form during exercise among football players, with a dose ranging from 2 ml/kg up to 17 ml/kg. In contrast, capsule supplementation in the studies was the second highest at 4 mg/kg BW and 71 mg/kg BW. The least form was the solid bar of 30g or 0.37g/kg BW. The supplements are varied from hydroelectrolytic beverages, fruit beverages, alcohol, caffeine, maltodextrin (carbohydrate solution), probiotic supplementation, bran chain amino acid (BCAA), creatine, cocoa, and nitrate. Overall, supplements were taken pre-exercise except for deep ocean water, BCAA, creatine, watermelon juice, and caffeine, which were consumed during recovery.

The study by Sun et al. (24) assessed the effects of carbohydrate-electrolyte solution (CES) and carbohydrate-electrolyte-protein solution (CEPS) on cognitive function in football players. Compared to PLA, CES could improve response time in numerous tests, including VST (complex level), ST (complex level), and RVIPT. Carbohydrate-electrolyte solutions improve perception, executive function, and sustained attention, all of which are essential aspects of cognition that can help players with better football performance. The insulin responses after CHO ingestion may be responsible for the improved effects of glucose on memory (34). Previous studies showed that CHO consumption enhances several cognitive domains, such as executive function, as measured by the Trail Making Test (35) and short-term memory (36). Protein may help with cognitive performance in addition to the benefits of CHO on cognition. CEPS ingestion may help with sustained focus and attentiveness, which might boost football performance but does not affect perception (24).

Carbohydrate ingestion (12% carbohydrate-electrolyte beverage) improved sprinting, dribbling speed, and self-paced exercise performance versus equivalent volumes of water and placebo (26). Other than that, CHO ingestion also contributed to better physiological responses, such as increased blood glucose concentration (26). The higher blood glucose concentrations at 60th and 75th minute may explain the improvement of dribbling speed because the brain largely depends on blood glucose concentrations as a fuel source for cognition (37).

During 120 minutes of simulated football match play, consuming CHO at a rate of 20 g per hour did not significantly reduce physical performance (i.e., sprinting and jumping) or skilled (i.e., soccer shooting and dribbling) performance (27). This study compared high glycaemic index (GI) CHO and low-GI carbohydrates. When low-GI CHO was consumed at the start of the second half of soccer-specific exercise, blood glucose concentrations appeared to be better sustained than high-GI CHO in a study aimed to elicit rebound hypoglycemia (defined as glucose concentrations <3.8 mmol per liter (38) consuming low-GI carbohydrates lowered the proportion of individuals who had blood glucose values of less than 3.5 mmol per liter resulting from pre-exercise carbohydrate ingestion (39). Indeed, when compared to maltodextrin (MDX; high-GI), the change in glycemia from HT was similarly smaller in isomaltulose (PSE; low-GI) at 60th min (27).

Funnell et al. (28) found that consuming 3.25 ml/kg BW of a 12% CHO solution before and during a simulated soccer match did not improve self-selected running performance or sprint speed. The finding contrasts with several similar studies investigating the effect of CHO intake on simulated soccer performance. Nicholas et al. (40) conducted a study in which participants drank a 6.9% CHO solution before (5 ml/kg BW) and every 15 minutes during the activity (2 ml/kg BW) following 75 minutes of the LIST, which resulted in a 33% improvement in running time to exhaustion (alternating between 20 m shuttles of jogging and cruising). When a 6% carbohydrate solution was consumed before (5 ml/kg BW) and every 15 minutes throughout the LIST (2 ml/kg BW), there was a 32% increase in intermittent running time to exhaustion (41). Thus, carbohydrate intake has been proven to improve intermittent running performance.

On the other hand, athletes, in general, tend to have deficiencies in a wide range of nutrients. The nutrients are lost because of exercise and are not always appropriately replenished. As a result, their insufficiency can harm sports performance. Thus, the study by Ferreira et al. (25) presents a new alternative beverage for hydroelectrolytic replacement in athletes, which uses a co-product of the cheese industry and derivatives called whey permeate. It is a good natural source of potassium, calcium, sodium, phosphorus, and magnesium, important minerals for replacing the loss of salts in athletes. The administration of these substances appears to be helpful against oxidative stress caused by exercise in clinical trials (42). Furthermore, this beverage's consumption may also increase antioxidant defense.

Other than that, consuming deep ocean mineral water (DOM) enhanced high-intensity intermittent running capacity in soccer players by 25% after a short period of recovery following an initial bout of prolonged exercise (29). However, it was stated that the mechanism underlying this effect was unclear, and further research was needed to determine the mechanism(s) behind DOM's ergogenic effects to enhance its potential performance and health advantages in the general population. Magnesium (Mg) is involved in various fundamental biological functions, including energy production, electrolyte control, and oxygen absorption (43). In fact, DOM is found to have a high amount of Mg (29).

The study by Adikari et al. (19) demonstrated that the participants who consumed 3.22 ml/kg BW probiotic supplementation had shown a significantly high level of absolute theta oscillation among the football players in the probiotic group compared to the placebo group at week 4, which was similar to the study conducted by Wang et al. (44). This suggested that the football players in the probiotic group were more relaxed, with less tension and anxiety. This is good for decision-making in football players during training or competition. In the same study, delta oscillation was significantly higher in the probiotic group compared to the placebo at week 4. The cognitive processes of attention, problem-solving, perception, and signal tracking were all linked to high delta responses (45). Daily probiotic supplementation was able to increase the attention of football players (19).

According to Bello et al. (20), running time-to-exhaustion (TTE) for TeaCrine, TCr + Caffeine, Caffeine (Caf) alone supplementation gave a larger effect than TeaCrine alone, Caf alone and placebo supplementation. Increased TTE across all situations implied that Caf and TCr intake can help players maintain a better level of performance later in a game. Even though TCr and Caf alone showed equal magnitudes of positive effects on TTE compared to PL, the combination appears to have been much more effective, as seen by the 38 % rise in TTE. A previous study to support these improvements found that Caf has an ergogenic effect, increasing endurance performance in trained cyclists and distance runners after ingesting 2 and 3 mg/kg BW, respectively (46). In terms of increasing and sustaining energy, attention, and performance level, the combination of TCr + Caf appears to be the most helpful when considering overall cognitive and endurance benefits.

Ali et al. (22) found that 6 mg/kg per body weight of capsuled caffeine ingestion had significantly enhanced eccentric muscle strength and power (predominantly observed in the knee flexors) in female team-sport players, including football during and following intermittent running exercise. In team sports like football, leg strength, and power are critical components of performance. Football's dynamic and intermittent nature requires much sprinting, which puts much strain on the knee flexors' eccentric capabilities (47). Furthermore, another study by Stuart et al. (48) found that caffeine improved several elements of team-sport performance in male rugby players during a simulated game, including sprint timing, sprint agility, and drive power. The recent study by Abreu et al. (30) found that a low dose of caffeine (2.6 mg/kg BW) had no significant differences in creatine kinase, heart rate variability, or minutes on the field when comparing caffeine supplementation with the placebo. Caffeine supplementation throughout the championship appears to have had no ergogenic effect on athlete performance and recovery.

Non-alcoholic beer drinks are also recommended to boost performance. According to a study by Castro-Sepulveda et al. (23), consumption of 0.48 ml/kg BW non-alcoholic beer before exercise could help maintain blood electrolyte homeostasis during exercise. Fluid and blood electrolyte balance are well-known to be important for good performance and, more importantly, for health maintenance (49). Plasma sodium regulation is necessary for sports performance and athlete’s health (50), and when non-alcoholic beer was consumed before exercise, plasma sodium was maintained (23). Plasma potassium levels rise during exercise (51), which may be linked to muscle fatigue (52) and decreased muscular strength (53). Plasma potassium was higher in the last minutes of exercise in the alcoholic beer trial, while no significant alterations in plasma potassium were observed after the non-alcoholic beer and water trials (23). It shows that non-alcoholic beer may be an effective supplementation before exercise.

Based on Rizal et al. (21), ingestion of 7–10 ml/kg BW watermelon beverage can reduce muscle fatigue. Muscle fatigue occurs when a muscle's ability to produce power decreases in response to activities that require contraction (54). Football is a high-intensity game that requires a lot of muscle contraction, especially on the lower limb. Besides reducing muscle fatigue, watermelon beverage was also found to increase VO_2max in football players aged between 15 to 17 years old (55) and reduce the recovery of heart rate and muscle soreness after 24 hours of exercise (56).

In terms of amino acid supplement classification such as BCAA, creatine (31), and nitrate (32), it is found that BCAA and creatine consumption showed significant effects on anaerobic capacity, provides strength endurance against fatigue, and prevents the decrement of ball-kicking speed in exhaustion but do not affect recovery rates in football players. However, nitrate supplementation had a statistically significant positive effect on performance if baseline dietary nitrate intake was below 300 mg (p=0.0104) in both the placebo and intervention groups—no effects of nitrate supplementation when baseline dietary nitrate intake was higher than 300 mg. Therefore, a daily 400mg nitrate intake is recommended for the participants with low daily nitrate (with most nitrates coming from nitrate-rich vegetables). Lastly, a recent study by Mancin et al. (33) showed that daily ingestion of solid bars of dark chocolate for 4 weeks significantly improved lipid profiles compared with controls.

This scoping review examined publications from 2016 up to 2024; only those in English were considered. Hence, there is a possibility that a few related publications in other languages may have been missed when searching in database journals.

CONCLUSION

A total of 15 articles have been selected in this review. Four studies investigated using capsule supplementation, while the remaining ten used drink supplementation, and only one prescribed solid bar to the football player. The supplements are varied from hydroelectrolytic beverages, fruit beverages, alcohol, caffeine, maltodextrin (carbohydrate solution), probiotic supplementation, BCAA, creatine, cocoa, and nitrate. The capsule supplementation in the studies was taken at a dosage of 4 mg/kg BW to 71 mg/kg BW, while the range for drink supplementation is from 2 ml/kg up to 17 ml/kg and only 30g (0.37 g/kg BW) for the solid bar. The supplements could be consumed as pre-exercise, during exercise, or as recovery intake.

The studies of supplementation in combination with an exercise program in this review showed benefits on sports performance, including isokinetic muscle performance, endurance, sprint, self-paced, and anaerobic power; some studies also showed positive effects on blood markers (cholesterol level, antioxidant markers, glucose and lactate level and) and skilled performance (shooting and dribbling) among football player subjects. Every supplement is believed to have different physiological effects on football players, including cognitive function and skilled performance. The supplements can be ingested at any time, and specific dosages can be made depending on the purpose and aim of the subjects.

APPLICABLE REMARKS

- Current study showed support that drink type of supplementation was the preferred form among the players during the competition compared to the capsule or solid bar.
- Interestingly, the most chosen supplements were from carbohydrates, amino acid groups, electrolyte drinks, and caffeine. Among all, deep ocean water, carbohydrate-electrolyte, caffeine, nitrate, BCAA, and creatine were used to improve sports performance, while probiotic was focused on brain function and others to alter blood markers to the optimum level compared to baseline.
- Therefore, we claim that the supplement dosage should be based on body weight to give maximum effects to football players.

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AUTHORS' CONTRIBUTIONS

Study concept and design: Muhammad Luqman Jariah, Nur Syamsina Ahmad. Acquisition of data: Muhammad Luqman Jariah, Nur Syamsina Ahmad. Analysis and interpretation

of data: Muhammad Luqman Jariah, Nur Syamsina Ahmad. Drafting the manuscript: Muhammad Luqman Jariah. Critical revision of the manuscript for important intellectual content: Nur Syamsina Ahmad, Rosniwati Ghafar. Administrative, technical, and material support: Erie Zuraidee Zulkifli, Rosniwati Ghafar. Study supervision: Nur Syamsina Ahmad.

CONFLICT OF INTEREST

The authors declare that they have no competing interests.

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ETHICAL CONSIDERATION

The study was conducted under the Declaration of Helsinki and approved by the ethical researcher committee of the Universiti Sains Malaysia, which granted approval to the study (USM/JEPeM/19100617) for studies involving humans. Informed consent was obtained from all subjects involved in the study. Written informed consent has been obtained from the participants to publish this paper. This review was registered with the International Prospective Register of Systematic Reviews (registration number: CRD42024598883).

ROLE OF THE SPONSOR

The funding organizations are in the government sector and have no role in the design and conduct of the study, collection, management, and analysis of the data or preparation, review, and approval of the manuscript.

ARTIFICIAL INTELLIGENCE (AI) USE

The authors disclosed that they do not use AI and AI-assisted technologies in this manuscript.

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