EFFECTS OF NUTRITIONAL ERGOGENIC AIDS ON PHYSIOLOGICAL RESPONSES AND SKILLED PERFORMANCE AMONG FOOTBALL PLAYERS: A SCOPING REVIEW

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By

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LIST OF ABBREVIATIONS

AB = Alcoholic beer

BB = Berat badan

BMI = Body Mass Index

CAF/Caf = Caffeine

CB = Commercial beverages

CE = Carbohydrate electrolyte

CEPS = Carbohydrate-electrolyte-protein solution

CES = Carbohydrate-electrolyte solution

CHO = Carbohydrates

CMJ = Countermovement jump

DOM = Deep Ocean Mineral

FFA = Free fatty acid

FI = Fatigue Index

GI = Glycaemic index

HB = Hydroelectrolytic beverages

HR = Heart rate

HRmax = Maximum Heart Rate

HT = Half time

IL-6 = Interleukin-6

kg = Kilogram

kJ = Kilojoule

LIST = Loughborough Intermittent Shuttle Test

MDX = Maltodextrin

MJ = Megajoule

ml = Mililiter

NAB = Non-alcoholic beer

PL = Placebo electrolyte

PLA = Placebo

PRISMA = Preferred Reporting Items for Systematic reviews and Meta-Analyses

PSE = Palatinose

RAST = Running-based Anaerobic Sprint Test

RGC = Rhodiola-Ginkgo Capsule

RPE = Rating of Perceived Exertion

RVIPT = Rapid Visual Information Processing Test

SAFT90 = Soccer-specific Aerobic Field Test

SMS = Soccer Match Simulation

SRT = Simple reaction time

ST = Stroop Test

TCr = TeaCrine

TTE = Running time-to-exhaustion

USG = Urine specific gravity

VO_2max = Maximum oxygen consumption

VST = Visual Search Test

WA = Water intake

KESAN BANTUAN ERGOGENIK PEMAKANAN KEPADA TINDAK BALAS FISIOLOGI DAN PRESTASI KEMAHIRAN DALAM KALANGAN PEMAIN BOLA SEPAK: SEBUAH TINJAUAN SKOP

ABSTRAK

Pengenalan. – Bola sepak terkenal sebagai sukan paling popular di seluruh dunia. Keperluan makro-dan-mikronutrien dalam sukan bola sepak akan bertambah disebabkan oleh latihan dan pertandingan. Secara alternatif, pemain bola sepak boleh mendapatkan keperluan itu melalui pengambilan suplemen.

Objektif. - Tinjauan skop ini bertujuan untuk menjelaskan penemuan mengenai bantuan ergogenik pemakanan yang disarankan bagi meningkatkan tindak balas fisiologi dan prestasi kemahiran di kalangan pemain bola sepak.

Metodologi. – Sastera Penulisan dicari secara sistematik berdasarkan panduan *PRISMA*, menggunakan pangkalan data Scopus, ScienceDirect, PubMed dan ProQuest dari tahun 2016 sehingga 2021. Kesemua 11 kajian melibatkan manusia yang dikendalikan secara rawak – dimasukkan dalam analisis terakhir. Berdasarkan 11 kajian yang dikaji, empat kajian mengkaji tindak balas daripada minuman hidro-elektrolit manakala selebihnya menggunakan pelbagai minuman seperti minuman buah, alkohol, kafein, maltodextrin dan minuman probiotik.

Dapatan. – Terdapat sembilan kajian menggunakan suplemen jenis minuman dan dua kajian selebihnya menggunakan suplemen jenis kapsul. Dos pengambilan makanan

tambahan berbeza dalam semua kajian dengan julat antara 1 mg/kg BB dengan 4 mg/kg BB untuk suplemen jenis kapsul dan antara 0.48 ml/kg BB dengan 17.25 ml/kg BB untuk suplemen jenis minuman. Suplemen boleh diambil pada bila-bila masa dan mengikut dos yang tertentu berdasarkan tujuan dan matlamat yang diinginkan oleh subjek. Pengambilan campuran karbohidrat-elektrolit atau campuran karbohidrat-elektrolit-protein (2 - 5 ml/kg BW) meningkatkan beberapa aspek fungsi kognitif. Beberapa tindak balas fisiologi seperti urea plasma, *aspartate aminotransferase* dan *alanine aminotransferase* juga meningkat selepas pengambilan minuman resapan whey dengan ekstrak fenol kulit *jabuticaba*. Dua kajian terhadap minuman air mineral laut dalam dan elektrolit karbohidrat menunjukkan peningkatan prestasi kemahiran seperti keupayaan larian berintensiti tinggi, kelajuan menggelecek dan lain-lain kemahiran tertentu bola sepak. Walau bagaimanapun, tiada perubahan dicatatkan pada kepekatan glukosa dalam darah dan asid laktik dalam darah. Selain itu, pengambilan minuman probiotik secara harian (3 ml/kg BB) selama lapan minggu berserta rutin pemakanan biasa, latihan dan pertandingan dapat meningkatkan prestasi latihan, fungsi otak dan peningkatan fisiologi semasa senaman. Pengambilan bir tanpa alkohol yang diteruskan dengan senaman kadar-malar pada 65% HRmax selama 45 minit telah mengekalkan homeostasis elektrolit dalam darah semasa senaman. Seterusnya, minuman tembikai (7 – 10 ml/kg BW) yang digabungkan dengan protokol *Running-based Anaerobic Sprint Test (RAST)* mendapati penurunan pada indeks keletihan dan seterusnya mempercepatkan fasa pemulihan dalam kalangan pemain bola sepak. Pengambilan *isomaltulose* atau *maltodextrin* (4 – 6 ml/kg BB) menaikkan glukosa darah dan tiada penurunan ketara pada prestasi kemahiran. Tambahan pula, pengambilan karbohidrat (3 ml/kg BB) meningkatkan glukosa darah tetapi tidak memberi kesan kepada asid laktik dalam darah dan prestasi larian pilihan sendiri atau masa larian di kalangan pemain bola sepak. Kapsul kafein boleh-larut (1 mg/kg BB)

diambil dan disertakan dengan protokol senaman tanpa henti, ujian kekuatan dan kuasa serta tindak balas lompatan mampu meningkatkan prestasi pemanjangan otot fleksor lutut tetapi tiada kesan pada tindak balas fisiologi seperta kepekatan glukosa plasma, kepekatan insulin plasma, kepekatan asid lemak bebas dan *Urine Specific Gravity (USG).* Kemudian, pengambilan kombinasi *TeaCrine* dan kafein (TCr + Caf) sebanyak 4 mg/kg BB (jenis kapsul) digabungkan dengan simulasi 90-min *treadmill* perlawanan bola sepak selama empat sesi mendapati peningkatan dalam masa larian-sehingga-penat dan juga menambahkan fungsi kognitif.

Kesimpulan. - Kajian-kajian suplemen yang digabungkan dengan programme senaman dalam kajian skop ini menunjukkan kesan yang bermanfaat terhadap tindak balas fisiologi dan prestasi kemahiran di kalangan subjek pemain bola sepak. Suplemen dipercayai boleh diambil sebagai bantuan ergogenik sebelum, semasa dan selepas senaman serta jenis yang paling popular adalah jenis minuman.

EFFECTS OF NUTRITIONAL ERGOGENIC AIDS ON PHYSIOLOGICAL RESPONSES AND SKILLED PERFORMANCE AMONG FOOTBALL PLAYERS: A SCOPING REVIEW

ABSTRACT

Introduction. – Football is known as the most popular sports in the world. In football, the need for macro-and micronutrients can be greatly increased by training and competition. Alternatively, these needs could be fulfilled by the football players by consuming supplements.

Objective. - This review aimed to elucidate findings on recommended nutritional ergogenic aids to improve the physiological effects and sports performance among football players.

Methodology. – Literature was searched systematically based on PRISMA guidelines, using Scopus, ScienceDirect, PubMed and ProQuest databases from year 2016 up to 2021. All 11 on human randomized-controlled trials studies were included in the final analysis. From the 11 studies reviewed, four studies were conducted to determine the effects of hydro electrolytic beverages while the remaining six studies were conducted using variety of beverages such as fruit drink, alcohol, caffeine, maltodextrin and probiotic.

Results. – There were nine studies using drink types and the other two studies were using capsule types. The dosage of the supplements varies in all studies which ranges between 1 mg/kg BW to 4 mg/kg BW for capsuled supplement and between 0.48 ml/kg BW to 17.25 ml/kg BW for drink supplement. The supplements can be ingested at any time and at specific dosage depend on the purpose and aim of the participants. Carbohydrate-electrolyte solution or carbohydrate-electrolyte-protein solution ingestion (2 - 5 ml/kg BW) led to increase in some aspects of cognitive function. It is also found that some physiological responses such as plasma urea, aspartate aminotransferase and alanine aminotransferase improved after consumption of whey permeate with phenolic extract of jabuticaba peel. Another two studies using deep ocean mineral and CHO electrolyte increased in skilled performance such as high intensity running capacity, dribbling speed and other soccer specific performance. However, no differences in blood glucose and blood lactate concentration were observed. On the other hand, daily probiotic supplementation (3 ml/kg BW) in combination with regular food practice, training and competition for eight weeks resulted in better training, brain function, and physiological improvement to exercise. Non-alcoholic beer followed by steady-state exercise at 65% of HRmax for 45-min had maintained blood electrolyte homeostasis during exercise. Meanwhile, watermelon beverages (7 – 10 ml/kg BW) combined with Running-based Anaerobic Sprint Test (RAST) protocol resulted in reduction of fatigue index among football players and thus induced recovery phases. Isomaltulose or maltodextrin ingestion (4 – 6 ml/kg BW) led to increased blood glucose and no significant reduction in skilled performance. In addition, CHO intake (3 ml/kg BW) increased blood glucose, however it did not affect blood lactate and self-selected running performance or sprint times among football players. 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 had no effect on physiological responses such as plasma glucose concentration, plasma insulin concentration, FFA concentration and USG. Meanwhile a combination of TeaCrine and caffeine (TCr + Caf) ingestion (4 mg/kg BW, capsule type) combined with four sessions of 90-min simulated treadmill soccer match was found to increase in running time-to-exhaustion and improved cognitive function.

Conclusion. – The studies of supplementation in combination with exercise programme in this scoping review showed beneficial effects on some physiological responses and skilled performance among football players. It is believed that supplements could be taken as an ergogenic aid at pre, during and post exercise and the more popular form was drink types

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF THE REVIEW

Football is known as the most popular sports in the world. In certain countries, football is also called as association football or soccer (Giulianotti, 2012). Football is a competitive sport played by two teams of 11 players each. Players try to score the ball into the goal post of the opposing team using any part of their bodies, except their hands and arms. Only the goalkeeper is allowed to touch the ball and is only allowed to do so inside the penalty area around the goal area. The team which scores more goals will win. The game is played on a rectangular grass field, or occasionally an artificial turf with a target at either end of the field. Association football (soccer) is an invasive sport where it consists of stochastic interactions between teammates and opponents, resulting from a large pitch, and the various player tasks in the game (Silva et al., 2016).

Football players need to cover certain amount of distance in the big football pitch during attacking and defending. They also are 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 position of the player and match activities. 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 (Mohr et al., 2003a). Differences also occur within the same position because of the different tasks

that were 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 longest high-speed running distances (Dellal et al., 2011) while central attacking midfielders covered the most distance in high-speed running while their team was in possession of the ball (Bradley et al., 2013). Besides that, match activities like turns, accelerations, dribbles, tackles and jumps are also energy-consuming activities in football. FA Premier League players have been shown to make around 700 turns in a game, with about 600 of them being 0-90 degrees (Bloomfield et al., 2007) and the number of tackles and jumps in the top level teams varies from 3-27 and 1-36 respectively (Mohr et al., 2003a). From all these energy demands in football players, they must have enough energy intake from a proper nutritional intake to fulfil the demands.

With the competition level and with individual characteristics, the energy and physiological demands of soccer training and match-play differ over the season. Zurich (2006) stated that the typical energy expenditure of training or match-play in elite football players are about 6 MJ (6000kJ) per day for men and about 4 MJ (4000 kJ) per day for women. Football players need to eat a variety of foods that provide sufficient energy to fuel the training and competition, meet all the nutrition requirements and allow energy balance in the body. Lower energy intake causes disturbances to metabolic, hormonal and immune function, as well as bone health and thus inhibit performance. There are some studies that have stated that the energy intake of football players (from their nutrition) are not enough to meet the nutritional requirements which is the energy expenditure during training and competition (Braun et al., 2018; Brinkmans et al., 2019) with an average daily energy deficit of -3299 ± 729 kJ (Russell and Pennock, 2011).

In football, the need for macro-and micronutrients can be greatly increased by training and competition. This increase can be significant at a professional level, sometimes with prolonged periods of two matches per week and interspersed with training sessions (Hespel et al., 2006). This need must be fulfilled by the football players by consuming supplementation as a booster to provide them enough energy to fulfil the demands. Ergogenic aids would be helpful for the football players. Ergogenic aids can be simply defined as a technique or product used for performance enhancement purposes in the context of sports (Thein et al., 1995). Ergogenic aids have been classified as nutritional, mechanical, pharmacologic, physiologic, or psychologic. In this review, nutritional ergogenic aids will be focused in providing supplementation for football players. Most of the nutritional aids can be classified as a potential source of energy, an anabolic enhancer, a cellular component, or a recovery aid (Applegate, 1999). Types of nutritional ergogenic aids are carbohydrate loading, sports drinks, energy drinks and capsuled supplementation but for this review, we focused only on sports drinks, energy drinks and capsuled supplementation.

Nutritional ergogenic aids may be helpful for football players to meet the physiological demands as football is an intermittent sport which includes high-intensity exercise periods interspersed with lower-intensity exercise periods (Mohr et al., 2011). The physiological demands are varied between a single football player and another because of the changing intensities in football. The common physiological responses and demands which are used as physiological measurements in football are energy expenditure, maximal oxygen uptake and heart rate, where the latter is represented in

sampling of body fluids and tissues such as blood sample (Drust et al., 2007). These physiological responses are used by football players and coaching staff as guidance to improve football performances through practices and games. Next, nutritional ergogenic aids can also improve skilled performance in football. Skilled performance in football are sprints, changes in direction and pace of running, acceleration/deceleration, jumps and tackles, as well as technical activities such as kicking, dribbling, shooting and passing (Ndlec et al., 2012; Mohr et al., 2011). According to Russell et al. (2010), 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 consumed nutritional ergogenic aids (Krull et al., 2020; Stout et al., 1999; Kreider et al., 1998).

There were a number of studies on the effects of nutritional ergogenic aids on performance. As an example, a study by Hespel et al. (2006) had given a list of supplements selected that were relevant to football. The preferred supplements are amino acids/protein hydrolysate/protein, caffeine, carbohydrates, creatine, ephedra, antioxidants, Beta-hydroxy-β-methyl butyrate, glucosamine and vitamin C. To date, based on literature search the studies on the effects of nutritional ergogenic aids on physiological responses and skilled performance are mixed and not properly reviewed. Thus, the aim of this review is to investigate the recommended nutritional ergogenic aids intake for football players to improve their physiological effects and sport performance by using data obtained from Scopus, Science Direct, Pub Med and ProQuest. This would be the first scoping review to review the literature of the selected articles and suggesting the best amount, timing and type of nutritional ergogenic aids for football players.

1.2 PROBLEM STATEMENT

There are a number of reviews which have evaluated the effects of nutritional ergogenic aids on sports performance on running, cycling and swimming (Juhn, 2003; Lattavo et al., 2007). However, less attention has been paid on nutritional ergogenic aids and sports performance among team-sport including football (Bishop, 2010). Studies on proper dosage, timing, and type of nutritional ergogenic aids in football is also limited. The studies are still mixed and not properly reviewed. So, the aim of this review is to investigate the recommended nutritional ergogenic aids to improve physiological changes and sport performance among football players.

1.3 RESEARCH QUESTIONS OF THE REVIEW

1 What are the types, dosages and timing of nutritional ergogenic aids recommended for football players?

2 What are the effects of nutritional ergogenic aids on physiological changes among football players?

3 What are the effects of nutritional ergogenic aids on skilled performance among football players?

1.4 OBJECTIVES

1.4.1 General objective

The main objective of this review is to investigate the recommended nutritional ergogenic aids to improve the physiological effects and sports performance among football players.

1.4.2 Specific objectives

1 To determine the types, dosages and timing of nutritional ergogenic aids recommended for football players.

2 To determine the effects of nutritional ergogenic aids on physiological changes among football players.

3 To determine the effects of nutritional ergogenic aids on skilled performance among football players.

1.5 SIGNIFICANCE OF THE REVIEW

This review will suggest the types of nutritional ergogenic aids with proper dosage and timing that are suitable for football players. The effects on physiological responses and skilled performance of the nutritional ergogenic aids will also be reviewed properly and arrange neatly for better understanding for the readers. This review will be significant for football coaches or sports practitioners or doctors to suggest nutritional ergogenic aids for the players to boost their physiological responses and skilled performance during practices and matches. This review can provide beneficial information that can be implemented in educational, research or practical settings and serve as a reference or guidance in determining the guidelines of nutritional ergogenic products for football players.

CHAPTER 2

LITERATURE REVIEW

2.1 Types of nutritional ergogenic aids in the market

There are a few types of nutritional ergogenic aids in the market such as carbohydrate loading, energy bar, sports drink, energy drinks and capsuled supplements. For the literature in this review, we focused only on sports drinks, energy drinks and capsuled supplementation. Sports drinks, also referred to as isotonic beverages and fluid replacement beverages (Guo, 2009) are formulated to provide fast replacement of fluids, electrolytes and carbohydrate fuel for working muscles. This drink can be consumed before, during and after exercise. Sports drinks typically contain carbohydrates, electrolytes, minerals, vitamins and other nutrients and are advertised as products capable of enhancing athletic performance by providing hydration and replenishment of electrolytes lost during and after vigorous physical activity via sweat (Raizel et al., 2019).

Sports drinks normally contain 6–8 g/100 mL of carbohydrate and electrolytes such as sodium, potassium, calcium and magnesium (Silva et al., 2019). Sports drinks typically do not contain caffeine (Tomke and Rathod, 2019). Sports drinks are classified into three types based on the content of carbohydrate and electrolyte; isotonic sports drinks, hypotonic sports drinks and hypertonic sports drinks (Chatterjee and Abraham, 2019). Isotonic sports drinks are referred to drinks that contain same amount of carbohydrate and electrolyte in comparison with the amount of carbohydrate and electrolyte inside the human body. Hypotonic sports drinks are referred to drinks that

contain lower percentage of carbohydrate while hypertonic sports drinks are those which have the highest percentage of carbohydrate in them.

In contrast to sports drinks, energy drinks usually contain stimulants (e.g., caffeine and guarana) that are frequently mixed with amino acids, added sugars, B vitamins, minerals, and other nutrients to produce the so-called "energy blend," to increase energy, reduce exhaustion, and improve mental alertness. (Raizel et al., 2019). Energy drinks have become the fastest growing sector in the beverage industry (Smith, 2013) and also popular among young people over the last decade (İncedayı et al., 2019).

Energy drinks contain higher amounts of carbohydrate along with other nutrients such as riboflavin, niacin, vitamin B6 and B12, sodium, potassium, phosphorus, taurine (Silva et al., 2019) and also herbs (Suna et al., 2019). The most common herbal ingredients used in energy drinks can be listed as ginseng and ginkgo biloba. Other botanical ingredients can be summarised as bee pollen and guarana (Suna et al., 2019). Examples of energy drinks are Red Bull, 5-Hour ENERGY, and Monster. Most of the brands sold contain significant amounts of glucose, while some brands sell versions that are artificially sweetened. Sucrose, glucose, or high fructose corn syrup is the most popular type of added sugar (Raizel et al., 2019).

Nutritional ergogenic aids can also be in the form of capsules. Capsules are widely used in ergogenic aids because they can be swallowed easily and broken down quickly in the stomach. A capsule contains nutrients inside them. Nutrients are enclosed by an outer shell. This outer shell will be broken down in the digestive tract after ingestion. The nutrients will then be absorbed into the bloodstream and metabolised by

the body. The effects of the nutrients will occur inside the body. Childs and de Wit (2008) had conducted a study to compare the effects of a caffeine-containing (200 mg) supplement (CAF) or placebo in capsule form after prolonged wakefulness on 35 volunteers. The findings had indicated that the consumption of caffeine-containing capsule improves subjective state and cognitive performance in fatigued individual. This study shows that the content inside the capsule produces some ergogenic effects towards the body. Capsule is another way to consume nutritional ergogenic aids instead of drinks like sports drinks and energy drinks. There are many nutritional ergogenic aids in form of capsules such as vitamin A (Aremu et al., 2010), caffeine (Grgic et al., 2020), astaxanthin (Malmsten and Lignell, 2008), Rhodiola-Ginkgo Capsule (RGC) (Zhang et al., 2009) and chitosan (Mhurchu et al., 2004).

2.2 Functions of nutritional ergogenic aids for athletes

Active individuals or an athlete ingest sports drinks to replace water and electrolytes lost through sweating after doing an exercise. They are designed to be consumed before or during the workout to prevent possible dehydration (Tomke and Rathod, 2019). Sports drinks are also important to improve performance during exercise. There are a few studies that have determined the effects of sports drinks during exercise. These studies were grouped according to the exercise duration which are short term (less than one hour of exercise), prolonged (one to four hours of exercise), ultra-endurance (beyond 4 hours of exercise).

A study by Coombes and Hamilton (2000) aimed to investigate the effect of 7% carbohydrate-electrolyte (CE) drink (Gatorade) which is a sports drink on sprint capacity. The subjects were trained male cyclists who performed 50-min simulated time trials on a Monark stationary cycle ergometer. Subjects consumed either Gatorade or a flavoured water placebo during the exercise. As a result, from this study, sprint performance following a high intensity simulated time trial of only 50 min can be improved with periodic consumption of CE during the ride. Another study by Below et al. (1995) also ingested Gatorade to determine the effects of fluid and carbohydrate ingestion on performance, core temperature, and cardiovascular responses during intense exercise lasting 1 hour. Subjects cycled at 80% of VO_{2max} for 50 min followed by a performance test and the supplements were ingested during exercise. This study also resulted in improvement of cycling performance and the effects are additive.

According to a study from Davis et al. (1997), which consisted of repeated 1-min cycling bouts on a bicycle ergometer at 120-130% VO_{2max} separated by 3 min rest until fatigue. The subjects were given ingestion before and during exercise. The study had stated that sports drink can delay the time to fatigue and played a beneficial role in improvement of intermittent, high-intensity exercise in men and women. From the study, it shows the important role of sports drinks in delaying fatigue during exercise. In another study by Davis et al. (1988), it was reported that Gatorade intake every 20 minutes during 2 hours of cycling improved the efficiency of a subsequent 30-minute bout at 75% VO_{2max} after a 10-hour pre-exercise fast. In the same study, during a 3.5-mile sprint that followed 2 hours of cycling at 68% VO_{2max}, Gatorade was also shown to boost performance.

Long duration of exercise may contribute to muscle glycogen depletion, and thus it is not surprising that studies where subjects are supplied with sports drinks resulted in performance improvements compared to when only water was supplied. Brouns and Wagenmakers (1989) found that volunteers who consumed a 20% carbohydrate drink, ad libitum, conducted 126% more work during a 90% cumulative workload test during 48 hours of exhaustive intermittent cycling compared to a placebo drink. From this evidence, it shows the importance of sports drinks to improve the workload during exercise.

Meanwhile, energy drinks have a variety of benefits for their consumers during exercise. A study by Alford et al. (2001) analysed the effect on 36 people of a market leader in energy drinks. Psychomotor performance (reaction time, concentration and memory), subjective alertness and physical endurance were included in the tests. They showed that aerobic endurance (maintaining 65-75% heart $rate_{max}$) and aerobic performance (maintaining max. speed) on cycle ergometers were significantly improved

by the studied energy drink. Mental quality also significantly enhanced option response, concentration and memory which show increased in subjective alertness. Another study conducted by Forbes et al. (2007) found that in young physically active subjects, the same brand of energy drink significantly improved the upper body muscle endurance during repeated 'Wingate cycle performance.' However, no improvement in anaerobic peak or average power has been reported. From the evidence above, the benefits of energy drinks are increased aerobic endurance and aerobic performance, increased in subjective alertness (option response, concentration and memory) and improved upper body muscle endurance.

Furthermore, energy drinks can improve reaction performance as well as subjective feelings of focus and energy. Hoffman et al. (2009) carried out a study to examine the effect of a pre-exercise high energy drink on reaction time and anaerobic power in competitive strength/power athletes. Their results indicated a substantial increase in the efficiency of the reaction, with no effect on the performance of anaerobic power. In addition, the consumption of this supplement greatly increased male strength/power athletes' subjective feelings of concentration and energy. Besides, energy drinks can also delay fatigue during exercise. According to Walsh et al. (2010), there is a significant increase in time to exhaustion during a moderate intensity endurance run as well as improvement in perceived feelings of focus, energy and fatigue.

Duncan et al. (2012) conducted a study using resistance-trained male. The subjects drank caffeinated energy drink or placebo 60 minutes before completing a bout of resistance exercise comprising bench press, deadlift, prone row, and back squat

exercise to failure at an intensity of 60% 1-repetition maximum. The result of this study suggest that acute ingestion of a caffeine-containing energy drink can enhance resistance exercise performance to failure and positively enhance psychophysiological factors related to exertion in trained men. This study shows that energy drink (caffeinated) can boost resistance performance. Lastly, there are some data demonstrating that combining energy drink and exercise may enhance body fat reduction. A study by Ballard et al. (2010) have stated that there is conflicting evidence regarding the impact of energy drinks on weight loss.

Capsuled supplementation also has its importance according to its content. Capsuled supplementation can delay fatigue during exercise. Trexler et al. (2014) conducted a study to investigate the acute effects of pomegranate extract on blood flow, vessel diameter, and exercise performance on 19 active individuals. The extract and placebo were given in 2, 500mg capsules with 6 ounces of water. This study found that 1 g of pomegranate extract, ingested 30 minutes before exercise, improved fatigue time when running at 90% and 100% of VO_2max peak velocity, ~12% and ~8% respectively. Furthermore, capsuled supplements were found to increase aerobic and endurance performance. Zhang et al. (2009) had conducted a study to prove that. This study used combined herbal supplement, Rhodiola-Gingko Capsule (RGC). The results had shown that RGC improved endurance performance by increasing oxygen consumption and controlling against fatigue. Another study by Bridge and Jones (2006) also stated that as caffeine-containing capsule of 3mg/kg was proven to improve absolute 8 km run performance in their study.

Lastly, capsuled supplementation has been shown to improve power in athletes. A study (Cases et al., 2017) used PerfLoad which is principally obtained by alcohol and water extraction of grape (*Vitis vinifera* L.) and pomegranate (*Punica granatum* L.), and by water extraction of green tea (*Camellia sinensis* L. Kuntze). Both PerfLoad and the placebo were supplied in 500-mg capsules. Subjects consumed 3 capsules of supplement acutely 1 h before exercise increased total power output (5%), maximal peak power output (4%), and average power output (5%) during repeated cycle Wingate tests. As the result, a significant increase in total power output, maximum peak power output; oxidative homeostasis stabilised was associated with supplementation, without causing either more fatigue or greater heart rate.

2.3 Nutritional ergogenic aids consumed by football players

In the world of football, supplementation is used by some football players. Regarding the study by McGuine et al. (2001), of the1349 high school football players who participated in the study, only 30% of the respondents were reported to use creatine supplementation. Similar study by Greenwood and colleagues reported 41% of the respondents also were consuming creatine supplementation (Greenwood et al., 2000). Nutritional ergogenic aids used by each football player may not be the same. Different kind of nutritional aids will give different effects to human body.

There were many forms of nutritional ergogenic aids such as drinks, chocolate bars, powders and capsules. The nutritional ergogenic aids have their ergogenic effects on the body of a football player. A study by Kern and Robinson (2011) aimed to investigate the effects of β-alanine supplementation on performance and body composition. The subjects performed high-intensity interval, repeated sprint, and resistance training for 8 weeks. This study stated that β-alanine supplementation has improved performance (repeated sprint and resistance training) and increase the lean mass. Next, creatine supplementation are proven to increase sprint performance of a football player according to Mujika et al. (2000). There is another study of supplementation by Hoffman et al. (2008). The study also used β-alanine as the supplement to investigate its effects on training volume and subjective feelings of fatigue. As the results come out, β-alanine supplementation efficacy to increase training volume and lowered the subjective feelings of fatigue became apparent. All these evidence have shown that certain supplements are beneficial for footballers to consume to perform well during training and football matches.

CHAPTER 3

METHODOLOGY

3.1. Data sources

Related studies were searched electronically using the following databases: Scopus, ScienceDirect, PubMed and ProQuest. Briefly, the selected studies were searched using the same selection criteria as described below. In addition, cross-referencing on related previously published study was done to obtain additional information. Peer-reviewed articles in English language from January 2016 until January 2021 were used. No attempts were made to contact authors for additional information. Comparable searches were made for the other databases.

3.2. Study selection

The search was conducted according to the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines (Liberati et al., 2009). The following keywords were used during the search: #drink and (#soccer or #football). The selection criteria must be employing dietary supplementation as intervention and recruiting soccer or football players as participants. PRISMA flow has been produced based on a pre-determined stage which are identification, screening, eligibility and included. According to Figure 1, the initial search from the databases identified 415 potential articles while another 1 were found through cross referencing. After removing duplicates, 408 articles were assessed based on titles and abstracts against the selection criteria. A total of 394 articles were excluded because they did not meet the selection criteria. A total of 14

articles were selected for detailed analysis of the full-text articles. After detailed analysis of full-text articles, 3 articles were excluded for reasons such as Gaelic football as intervention (n=1) and no supplementation prescribed (n=2). 11 articles were included in this review for quantitative synthesis. Controlled trials and laboratory studies on human were included in this review. The intervention comprised: i) hydro electrolytic drinks, ii) fruit beverages, iii) alcohol, and iv) tea and caffeine capsule in combination with an exercise programme versus exercise alone. Exercise performance or physical activity described as: (1) Intermittent-running protocol on treadmill, (2) Intermittent Shuttle Run Test, (3) Running based anaerobic sprint test, (4) Modified version of Soccer Match Simulation, or (5) Soccer-specific aerobic field tests.

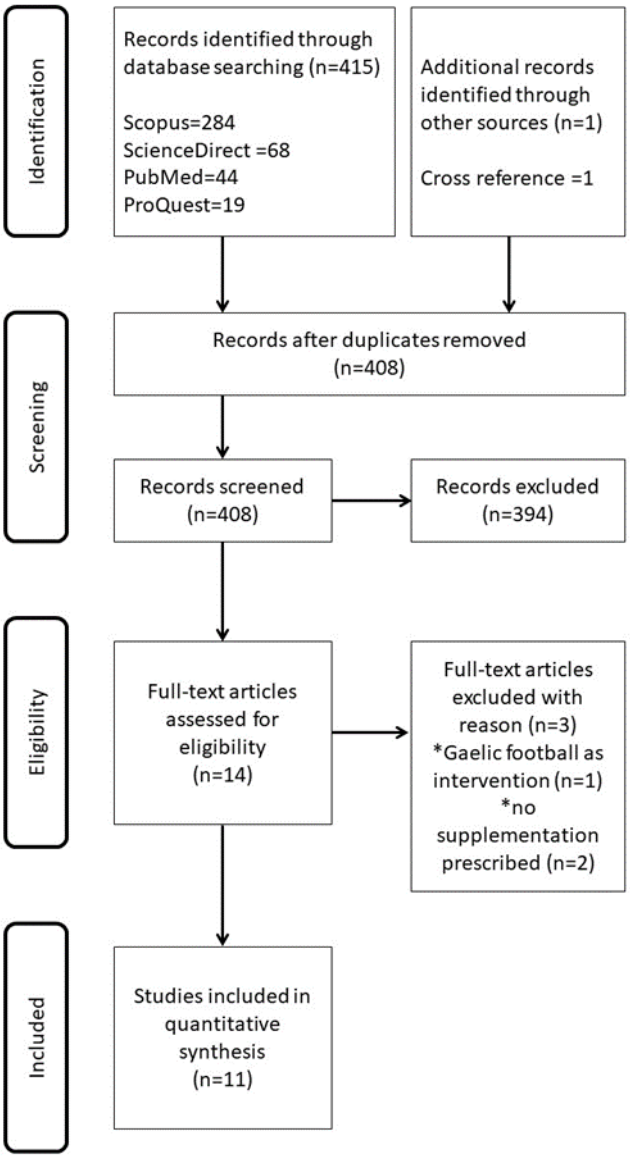

Figure 1. PRISMA flow for study selection.

3.3. 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, reanalysed or changed due to the nature of this scoping review.

CHAPTER 4

RESULTS

4.1. Search results

The initial search from the databases identified 415 potential articles while another 1 was found through cross-referencing. After removing duplicates, 408 articles were assessed based on titles and abstracts against the selection criteria. A total of 394 articles were excluded because they did not investigate on nutritional ergogenic aids on football or soccer players. After detailed analysis of the 14 full-text articles, only 11 were included in this scoping review. Three excluded articles were prescribed Gaelic football as intervention (n=1) and no supplementation prescribed (n=2). Figure 1 describes the PRISMA flow diagram for the study selection.

From the 11 studies reviewed, four studies were conducted using hydro electrolytic beverages while the remaining six studies were conducted using variety of beverages such as fruit drink, alcohol, caffeine, maltodextrin and probiotic. The scope of the study for those retrieved articles was primarily on combination of exercise programmes 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, maltodextrin and probiotic in combination with exercise programmes on physiological responses and skilled performance among football players. Four of these studies investigated in both physiological responses and skilled performance.

There were nine studies using drink type and the other two studies were using capsule type. The dosage of the supplements varies in all studies which ranges between 1 mg/kg BW to 4 mg/kg BW (capsuled supplement) and 0.48 ml/kg BW to 17.25 ml/kg BW (drink supplement). The timing of beverages consumption prescribed pre exercise (Adikari et al., 2020; Bello et al., 2019; Rizal et al., 2019; Ali et al., 2016; Castro-Sepulveda et al., 2016) pre and during exercise (Sun et al., 2020; Ferreira et al., 2020; Harper et al., 2017; Stevenson et al., 2017; Funnell et al., 2017) and post exercise (Higgins et al., 2019).

4.2. Combination of exercise programmes and hydro electrolytic drinks on physiological responses and skilled performance

Table 1 summarises the effects of combination of exercise programmes and hydro electrolyte 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 increase in some aspects of cognitive function by using electrophysiological devices (Sun et al., 2020). Study by Ferreira et al. (2020) found improvement in some physiological responses such as plasma urea, aspartate

aminotransferase and alanine aminotransferase after consumption of whey permeate with phenolic extract of jabuticaba peel. Another two studies reported increase in skilled performance such as high intensity running capacity, dribbling speed and other soccer specific performance (Higgins et al., 2019; Harper et al., 2017). No differences in blood glucose and blood lactate concentration reported in three studies (Sun et al., 2020; Higgins et al., 2019; Harper et al., 2017).

4.3. Effects of fruit beverages, alcohol, caffeine, maltodextrin and probiotic in combination with exercise programmes

Table 2 summarises the effects of fruit beverages, alcohol, caffeine, maltodextrin and probiotic in combination with exercise programmes on physiological responses and skilled performance. Three studies reported in physiological changes only; all studies were conducted on male subjects. In these three studies different supplementations were used. The study by Adikari et al. (2020)was been given of daily probiotic supplementation (3.22 ml/kg BW) in combination with regular food practice, training and competition for eight weeks resulted in better training, brain function, and physiological improvement to exercise. The second study was been given of non-alcoholic beer followed by steady-state exercise at 65% of HRmax for 45-min had maintained blood electrolyte homeostasis during exercise (Castro-Sepulveda et al., 2016). The third study by Rizal et al. (2019) prescribed watermelon beverages as intervention (7.00 – 10.00 ml/kg BW) and combined with Running-based Anaerobic Sprint Test (RAST) protocol resulted in reduction of fatigue index among football players thus induced recovery phases.