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Time to 'Power-Up' Esports Performance Nutrition: A Scoping Review

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Abstract

Objective: The aim of this scoping review was to explore existing evidence on the nutritional intake and performance of esport athletes

Methods: The JBI Guidance for Scoping Reviews was followed to conduct a systematic search of MEDLINE and EBSCOHost for peer-reviewed original research articles. Articles were required to classify participants as esport athletes and consider nutritional intake, including the use of dietary supplements, in the context of training and competition.

Results: 14 records were identified, and key findings charted. Seven studies aimed to record habitual dietary intake and links to health and performance in esport athletes. The remaining 7 studies were nutritional supplement interventions with 5/7 using caffeine alone or in combination with other ingredients. On analysis two main themes were identified: 1) Sub-optimal dietary habits; and 2) Impact of supplements on cognitive and gaming performance.

Conclusion: Current research suggests that esport athletes believe a healthy diet is important for performance. However, emerging evidence suggests they have sub-optimal dietary habits that may negatively influence their health and performance. Whilst energy drinks are widely used, nutritional supplements have shown equivocal results on performance to date.

Keywords: Esports, Diet, Supplements, Performance

Highlights

- Early evidence suggests that esport players may have sub-optimal dietary habits that are detrimental to their health, despite believing that diet is important for performance.
- Caffeine may be an effective ergogenic aid in some circumstances but evidence on the benefits of other nutritional supplements is limited.
- More research is needed to understand the optimum diet and use of supplements to aid performance – and whether this varies according to game type.

Introduction:

Esports (electronic sports) involves playing video games, such as first-person shooter (FPS), real time strategy (RTS) and multi-player online battle arena (MOBA), in competitive tournaments (1). Tournaments run year-round and are huge commercial and popular events. The International 10 (a Dota 2 tournament) was watched by over 2.74million people (2). Interest in esports is predicted to continue to grow, with the industry expected to be worth $1.87bn by 2025 (3). With this growth has come increased professionalisation of the sport and interest in what drives success (4).

Performance in esports is linked to aspects of cognitive skills such as reaction times, motor skills and visual processing speed (5). Being able to focus for prolonged periods, recover from setbacks and find 'flow' (a state of focussed concentration) are also seen as important determinants of success (6). Competitive matches are believed to trigger a sympathetic nervous system response in players, leading to a rise in heart and respiratory rates (7). Maintaining performance over tournaments that can last 8hrs or more requires extensive practice, with esports athletes playing from 5.5hrs-10+hrs a day according to competitive level (4). However, such intense training has also been linked to negative health impacts, such as low bone mineral density, musculoskeletal injuries, sleep disturbances, eye strain and cardiovascular sequalae (8–10). Recognition of these issues, alongside the high rewards for success in esports, has driven an increasing role for the sports sciences in training and competition – including for sports nutrition (11).

It is well documented that overall diet, and some specific nutrients or ergogenic aids (a technique or substance used for the purpose of enhancing performance, i.e. caffeine (12)), may have a role in protecting and enhancing cognitive performance (13, 14). This has been demonstrated in various subgroups of the general population (15,16), including technical and skill-based athletes, military personnel, and pilots (17,18). Moreover, several narrative reviews have highlighted the potential for applying these performance nutrition learnings to esports (19,20). However, relatively little is known about the dietary intake of esports players. There is some evidence that increased duration of recreational videogame playing is linked to higher consumption of sugar-sweetened beverages and snacking, but it is unclear whether this applies to competitive esport athletes (1). A systematic review of health behaviours in esport suggested that players are aware of the benefits of a healthy lifestyle and avoid many of the deleterious behaviours linked to videogaming but did not look at dietary intake and performance (21).

Therefore, there is a need to establish what is known about the diet and nutritional intake of esports athletes and how it may relate to performance. As this is a relatively new area of research, a systematic scoping review is the most appropriate methodology. Systematic scoping reviews are used to methodically map the existing literature in an emerging area, recording the types and range of research, highlighting common themes and identifying potential gaps (23). The results of this review will help guide evidence-based practice and highlight avenues for future research.

Review objective:

The aim of this scoping review is to map the existing evidence on the nutritional intake of esports athletes and how it relates to performance. The secondary objectives are to: i) characterise research in the area to date; ii) highlight research themes, and; iii) identify gaps and potential priorities for future research.

Methods

This review will follow the protocol of the Joanna Briggs Institute (JBI) methodology for scoping reviews (23), based on Arksey and O'Malley's framework (24). Items will be reported in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRIMSA-ScR) (22).

Eligibility criteria:

Population

The scoping review included studies where the participants were characterised as esport or competitive video game players of any level (ie. participating in official matches or tournaments). This included athletes of any gender, age, and nationality. 'Active' (ie. motion-based) gaming was excluded due to it not currently being used in any popular esports tournament and the different physiological demands.

Concept

Studies that explored dietary habits, nutritional intake and interventions were considered. This included the use of supplements and ergogenic aids.

Context

The review considered studies in any setting or country that reflect training or competition scenarios.

Types of studies

Original peer reviewed research of any methodology was included. Studies were in English or had translations available. No date limits were set.

Search strategy

An initial limited search was conducted in MEDLINE to identify studies in this area. This was then used to establish a search strategy for MEDLINE (Ovid; 1950- present) and SPORTSDISCUS (EBSCO; 1892-present) using appropriate keywords, wildcards and Boolean operators. The searches were conducted in August 2023.

The following keywords were used: 'Esports' OR 'Electronic Sports' OR 'competitive video gaming' OR 'gamers' AND 'nutrition*' OR 'intake' OR 'diet*' OR 'supplements' OR 'ergogenic'.

Selection of sources of evidence

Following the search all identified citations were collated and uploaded to 'REFWORKS V' (ProQuest) and duplicates removed. Titles and abstracts were screened to determine eligibility. Full texts of the remaining papers were read to determine inclusion. Reasons for exclusion of any full text studies were recorded for reporting. The reference lists of those studies that met the review criteria were then combed to identify any other eligible studies.

Data charting and items

Data was extracted from the included papers into a data extraction tool developed and tested by the author. Data on authors, year, country of study, aim of study, participants (including age, sex, body mass index (BMI), level of esports player, and hours played per week), methodology, outcome measures and key findings were extracted.

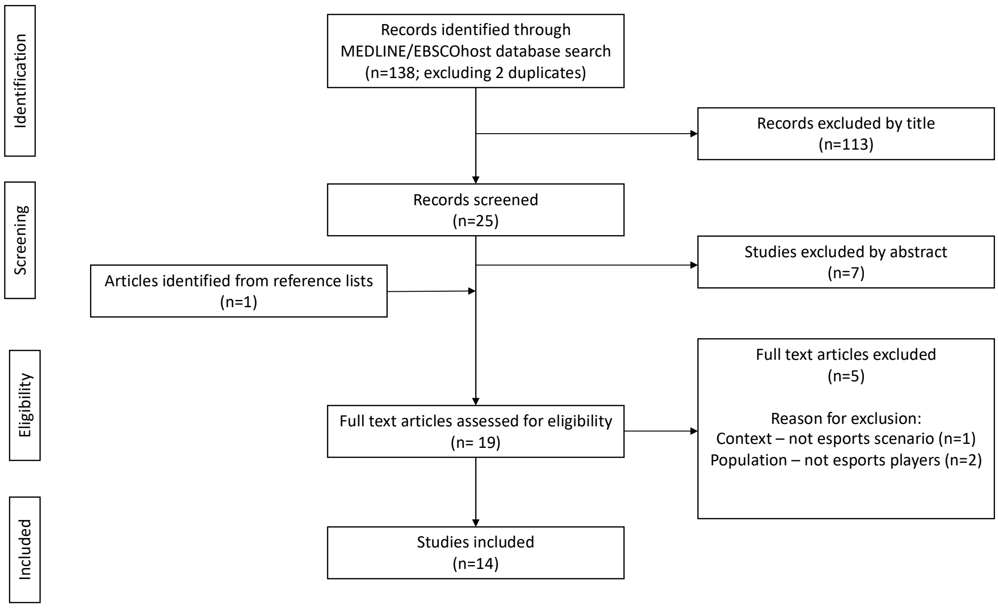
Data presentation

Results were summarised in tables (see Tables 1 and 2). These included author, year of publication, study design and key findings.

Results

138 studies were found through the initial searches. 113 of these were excluded based on title. A further 7 were excluded by abstract. 3 were excluded based on the eligibility criteria. The reasons for exclusion are as follows: participants not characterised as esport players or 'competitive' gamers (n=2); methodology not in line with scoping review context (doesn't reflect any esports training or competition scenarios(n=1). 14 studies remained for review. The studies were all published between 2019 and the present day.

Figure 1 - Review Process



Study Characteristics

Participants

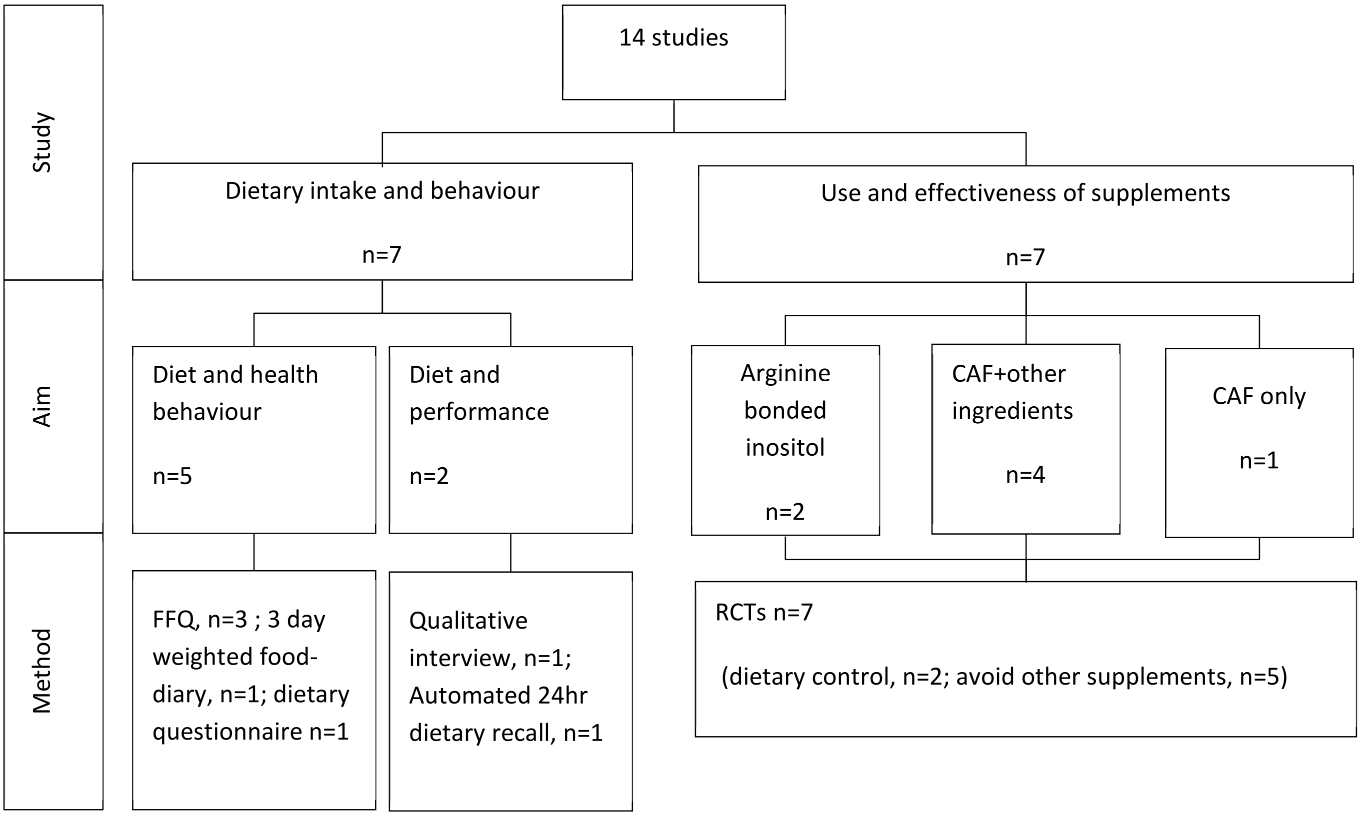
Overall, 3154 esports players were included in the studies reviewed with a mean age of 22.7 ± 3.5 years. 92% of participants were male (n=2914) and 8% female (n=290). 6/14 studies only included male participants (27,31,34, 37,38).

There was no common definition of esport player level, however all studies gave an estimate of the number of hours participants spent playing esports per day or week which ranged from >5hrs to 70hrs per week. Four studies (27, 31, 34, 38) defined the level of participants by whether they were a member of a competitive esports team or were receiving regular coaching. One study used a questionnaire developed and trialled by the research team to classify esport player level (26). Three studies asked participants themselves to categorise their playing level via an online questionnaire (28-30). In all other studies the level of esport player was defined by the authors themselves based on their interpretation of hours spent gaming per day/week.

Themes

Following charting of the study data, the following themes were identified: 1) Suboptimal dietary intake; and 2) Impact of nutritional supplements on esports performance. Results relating to these themes are presented below.

Figure 2 – Study characteristics



1. *Suboptimal dietary intake*

There were 7 studies which focussed on dietary intake in esports players (25-31) with varying aims. Four studies aimed to describe the diet or health behaviours of participants (28-31); one study sought to compare the gut microbiota, lifestyle and health behaviours of esport athletes with other types of athletes (27); and two explored the link between diet and performance(25,26).

Dietary intake was assessed using a variety of methods: Goulart et al. (26) used an automated 24hr dietary recall software programme to record food intake over 10 days. Kulecka et al. (27) assessed food intake over 3 days using a weighted food diary and remote food photography. Three studies used previously validated questionnaires with two using a food frequency questionnaire (FFQ)(29,30) and one using the PREDIMED questionnaire assessing adherence to a Mediterranean dietary pattern (28). The remaining two studies used self-designed questionnaires with Baumann et al (25) choosing a semi-structured qualitative interview, Rudolf et al. (29) using an ordinal scale for pre-selected food groups.

1.1 Energy and macronutrient intake

Two studies reported on the habitual energy and macronutrient intake of participants. An average total daily energy intake (TDEI) of 1852±698 kcal 2.5g/kg/BM CHO; 0.9g/kg/BM PRO; and 0.9g/kg/BM FAT was reported in a sample of elite esports athletes (n=119), with 66% of participants consumed >10% TDEI from saturated fat (26). Whilst a TEDI of 2155±637kcal was recorded in professional and semi-professional esports athletes with their macronutrient intake reported as 3.37g/kg/BM CHO; 1.34±0.5g/kg/BM PRO; and 1.25±0.48g/kg/BM FAT. The esport athletes in the study also consumed 12% TDEI from saturated fat vs 9.97% in student controls ($p<0.05$) (27).

The impact of macronutrient profile on performance was considered in three studies (25, 26, 29). Esport athletes who consumed >0.8g/kg/BM/day of protein demonstrated higher gaming-related cognitive performance (as measured using specialised software) (26). Baumann et al.'s (25) qualitative interviews noted that a diet high in refined carbohydrates and fatty foods was considered detrimental to performance. Finally, Rudolf et al. (29) reported that most participants in their survey believed that 'balanced nutrition' had a positive impact on performance ("very positive": *n* = 231; 21.7%; "quite positive": *n* = 521; 48.9%).

1.2 Fruit and vegetable consumption

Fruit and vegetable consumption was reported in 5 studies (26, 28- 31); Goulart et al's (26) US based study found that participants consumed an average of 1.1±0.6 portions of vegetables per day and 0.4±0.6 of fruit. Szot et al. (31) meanwhile reported that 67.8% of participants consumed vegetables once a day or less and similarly 66.9% ate fruit once a day or less. Both German studies (29, 30) reported slightly higher average intakes with gamers and esports athletes in their samples consuming 1.7±1.6 servings of vegetables with 0.9±1 fruit per day, and 2.7±1.8 portions fruit and vegetables combined respectively. All 5 studies noted that mean intake by participants failed to meet the relevant national guidelines in their country for consumption with Rudolf et al (29) and Ribeiro et al (28) noting that only 11% and 15.5% of their samples respectively met the 5-a-day recommendation.

Goulart et al. (2023) found that fruit and vegetable intake was significantly correlated with better cognitive performance ($r=0.272$; $p=0.003$). Rudolf et al. (29) also noted a non-significant trend for professional esports players to consume more fruit and vegetable portions per day than non-professionals (3.5+2.2 vs. 2.7±1.8 portions a day; $p=0.46$) but this wasn't replicated in a similar group-wise comparison by Soffner et al. (30). Soffner et al. (30) noted that both fruit and vegetable consumption were positively associated with self-reported health status (rho=0.19 and 0.14 respectively; both $p<0.01$)

1.3 Dairy consumption

Three studies reported dairy consumption. Goulart et al. (26) reported an average consumption of 1.4±0.8 cup equivalents of dairy products a day and noted that 95.7% of esport athletes failed to meet the recommended intake of magnesium and 97.4% consumed vitamin D (26). Soffner et al. (30) noted that that esport athletes consumed significantly fewer portions of dairy foods per day than video gamers (0.4±0.6 portions of milk and 0.7±0.4 portions of cheese in esport athletes vs 0.6±0.9 and 0.8±0.4 in video gamers; $p<0.01$). Intake was also low in Szot et al.'s (31) study with only 36% of participants consuming milk more than once-a-day.

1.4 Fast food consumption

Fast food consumption was reported in three studies (25,30, 31). Szot et al. (31) reported that fast food was consumed once a day or more by 28.3% of their sample. Whilst a comparison between esport athletes and video gamers (30) found that esport athletes consumed significantly more portions per day than video gamers (0.3+0.4 vs 0.2+0.4 portions per day; $p<0.01$). Intake of fast food was negatively correlated with self-reported health status (rho -

0.12; $p<0.01$). Fast food consumption was also negatively associated with performance for many of the participants interviewed in the qualitative study (25), with consumption being cited as causing tiredness and poor focus.

1.6 Energy drinks

Four studies reported regular use of energy drinks by esports athletes (25, 28, 30, 31). Energy drinks were reported as being consumed at least once -per day by 26.6% (31) and 40.9% (28) of participants. Soffner et al. (30) noted a mean weekly intake of 0.4±0.9l in their respondents which was positively correlated with video game playing time (rho=0.14; $p<0.01$) and negatively associated with health status (rho=0.11; $p<0.01$). Baumann et al. (25) meanwhile reported that 75% of their sample used energy drinks regularly, drinking at least one 500ml bottle at a time. Whilst energy drinks were cited in their study as being useful for 'staying awake' they were ultimately believed to harm performance and mood.

Table 1 - Studies investigating the dietary intake of esport athletes.

Study	Aim	Participants	Methodology	Key findings
Baumann et al., 2022 (25)	To explore Norwegian esports students' lifestyle perspectives and habits concerning health and esports performance	Students studying esports (15-20hrs/week) n=20; 17m, 3f 19±1.4 BMI = 22.7±3.7	Semi-structured qualitative interview	Unhealthy food items were often felt to negative impact on performance, specifically 'pizza', 'fatty food'. 75% participants mentioned using energy drinks regularly. Some mentioned that sugary foods had negative impact on in-game stamina
Goulart et al., 2023 (26)	To characterise the lifestyle of high level esports athletes and the relationship to gaming-related cognitive performance	Elite esports athletes (4.8±2hrs/day) n=119; 103m, 16f 23.3±5yrs BMI = 27.3±8.2	Participants completed diet (automated self-administered 24hr dietary recall), physical activity and sleep tracking over 10 days. They also took part in 8 days of cognitive training with testing on days 1 and 8 using NTx	Average EI: 1852 ±698 kcal. 79.6 g (0.9g/kg/BM) PRO; 76.2 (0.9g/kg/bm) FAT; and 210.8g (2.5g/kg/bm) CHO. Average fruit and veg intake of 1.5±0.6 cups a day Sig + correlation (p=0.003) (r=0.272) between total fruit and veg intake and NTx performance Those who consumed >0.8g/kg/BM PRO had ↑ NTx scores (p=0.018)

Kulecka et al., 2023 (27)	To investigate the composition of the gut microbiota, physical activity and nutrition measures in esports players compared to two reference groups (endurance athletes and physical activity students)	Esports players (13% professional; 87% semi-professional; 4±1.25hrs/day) n=109m 20.88±2.37yrs BMI=23.52+3.75 Vs controls n= 36 22.98±2.35 BMI= 23.87 ± 2.3	Nutritional intake assessed by 3-day weighted food diary and remote photography. Physical activity assessed via questionnaire. Fecal samples to assess gut microbiome	Esport ↓ EI: than controls (2154.91±637.01 vs 2555.07±594.36kcal; p<0.01) and lower PRO and CHO per g/kg/BM (p<0.05) Esport 97.95±30.36g (1.34±0.5g/kg/BM) PRO; 246.97±77.52g (3.37+1.25g/kg/BM) CHO; and, 83.95g± 36,43g (1.25g±0.48g/kg/BM) FAT No differences in gut bacterial diversity but significant difference between esport players vs controls for 9 bacteria species (p<0.05)
Ribiero et al., 2023 (28)	To characterise the dietary and gaming habits of Portuguese and Brazilian esports players	Esports players (12.4% professional; 25.4% semi-professional; 62.3% amateur; 3.5hrs/day; IQR 2.0-6.0) n= 579; 529m, 50f 24yrs; IQR 20-30 BMI=24.6; IQR22.3-28.5	Open online questionnaire incorporating PREDIMED component	53.7% (n=311) of sample reported poor adherence to Mediterranean diet pattern. 84.5% respondents ate <5 portions fruit or veg per day. 2/3rds respondents are sweets or fast food > once a week. 23% respondents drank energy drinks > once per week

Rudolf et al., 2019 (29)	To examine the demographics and health behaviour of video game and esport players	Professional esport players, former professionals, and amateur gamers (88.5% sample esport players; 24.4±15.9hrs/week) n=1066; 980m, 86f 22±5.9yrs BMI = 24.6±4.8	Cross-sectional online survey	Mean fruit and veg consumption of 2.7±1.8 portions/day No significant differences between categories of player but trend for professional players (n=14) to consume more fruit and veg (3.2±2.2) than all other groups
Soffner et al., 2023 (30)	To investigate the dietary behaviour of video game and esport players in Germany	Professional esport players, former professionals, and amateur gamers (20.3±15.6hrs/ week) n=808; 703m, 105f 24.2±6.9 BMI=24.7±5.1	Cross-sectional online survey	Mean weekly intake of energy drinks was 0.4±0.9L Participants ate 7.5±10.4 servings of fast food and 1.7±1.6 servings veg and 0.9±1.0 servings of fruit a day. Fruit and veg consumption correlated with ↑ health status ($p<0.01$) Energy and soft drink consumption assoc with playing time (rho=0.14; $p<0.01$) Esport players ↑ intake of fast food than gamers ($p<0.01$)
Szot et al., 2022 (31)	Quantify the dietary patterns of Polish esports athletes aged 18-26 yrs	Well trained esports players (4-6hr/day) n=233m BMI=23.4±4.5	Modified FFQ (based on Harvard, NHANES and international FFQs)	67.8% eat vegetables and 66.9% eat fruit once per day or less 26.6% drink energy drinks at least once a day 28.3% consume fast food at least once a day

	41.7% described no regular mealtimes

CAF=caffeine; PLA=placebo; BP=blood pressure; HR= heart rate; PEBL= Psychology Experiment Building Language cognitive test battery; POMS = Profile of Mood States; PREDIMED = Prevención de Dieta Meditteránea; TMT-A,B = Trail Making Test A and B; PVT=psychomotor vigilance test; LRT = light reaction test

2. Impact of supplements of performance

Seven studies looked at the possible effect of dietary supplements on performance in esports athletes (31-37). A variety of supplements were studied (see table 2): five of which contained caffeine, either alone (33) or in combination with other ingredients (31, 32, 36, 37). Amounts ranged from 40-44mg per dose (equivalent to ~0.6/g/KG/BM) (32) to 270mg (equivalent to ~3.3g/kg/BM) (31). The remaining studies tested a proprietary blend of 1600mg inositol bonded arginine with inositol. Supplement protocols varied in length from 1 to 30 days (33,32 respectively). Only two of the studies attempted to standardise diet preceding the intervention (32,34), the other studies asked participants to either avoid certain foods, dietary supplements or stimulants. One study (32) asked participants to have fasted for 12hours (overnight) prior to testing and one study provided the athletes with a protein bar in addition to the supplement (31).

Table 2 - Studies investigating the effects of supplements on esports performance.

Study	Aim	Participants	Method	Outcome measures	Key findings
Bloomer et al., 2022 (32)	To evaluate the impact of AmaTea Max on physiological and gaming performance	Active gamers (>4hrs/d on >4d/week) n=49; 47m, 2f 22±3yrs	Double blind, crossover with subjects consuming AmaTea (proprietary blend 270mg CAF and polyphenols), CAF (270mg) or PLA, 5 mins before 4hr Fortnite gaming session. Repeated 3x, 1 week apart	Gaming: total kills, squad performance and ranking Cognitive: Brunel Mood Test; Go/NO-GO Test, digit/symbol test; AX-CPT Physical: BP,HR; blood cortisol	No sig effect of CAF or AmaTea on gaming or cognitive performance Trend for ↑ kills/match for AmaTea condition effect (p=0.075):21%↑vsPLA; 12%↑vs CAF ↓ systolic BP and cortisol in PLA vs CAF or AmaTea (p<0.05)
Leonard et al., 2023 (33)	To evaluate whether 30 day supplementation of microalgae extract with guarana improves cognitive and gaming performance	Experienced gamers (>5hr/week) n=61;51m,10f 21.7±4.1yrs	Double blind RCT. Participants allocated to high dose (HD) 880mg microalgae plus 500mg guarana (containing 40-44mg CAF) (HD); low dose(LD) 440mg microalgae plus 500mg CAF; or PLA for 30 days. Testing day 1 and 30, testing pre-ingestion; 15 mins post and after 60mins gaming No CAF control	Gaming: normalised 'round performance" score Cognitive: POMS; PEBL; LRT Physical: self-reported side effects and sleep quality	←→ game performance Some within group improvements in aspects of LRT and PEBL for LD and HD. ↑ after 30 days, but some learning effect.

Sainz et al. 2020 (34)	Determine the effect of ingestion of acute caffeine intake on accuracy and reaction time	Professional gamers (10±2hrs/week) n= 15m 22±3yrs	Double blind, randomised crossover. 2 trials, 3 days apart with 3/mg/kg/BM CAF or PLA 45 mins pre-testing	Gaming: FPS game with score for accuracy and hits Cognitive: simple reaction time test	CAF↓ reaction times in repeated simple test (0.19±0.01 vs 0.20±0.01s in PLA; p<0.01) CAF ↓ time to hit target (0.88±0.07vs. 0.92±0.07s in PLA; p<0.05 CAF ↑ hit accuracy (99.8±0.92 vs 98.8±0.35s in PLA p<0.01)
Sowinski et al., 2021 (35)	To examine the effects of inositol-enhanced bonded arginine silicate ingestion (ASI+I) on cognitive function in esport players	Experienced gamers (>5hr/week) n=26; 18m, 8f 23±5yrs	Double-blind crossover RCT Participants undertake testing pre ingestion of 1600mg of ASI+I or PLA, 15mins post and 1hr after playing favourite video game. 7-14 day washout period and then repeat	No game performance tests Cognitive: PEBL, LRT; Cambridge Brain Sciences Reasoning and Concentration Test	No significant differences between conditions in CBSRCT and LRT – some significant within group differences but these are inconsistent. Significant improvement in PEBL:Sternberg Mean Present Reaction Time for ASI+I vs PLA (p<0.05)
Tartar et al., 2019 (36)	To examine the effects of ASI+I on cognitive performance and energy in esports athletes	Experienced gamers (>5hr/week) n=60; 50m,10f 28.6±5.4yrs	Double blind, controlled study. On day 1 and 7 participants were tested before and 15 mins after taking 1600mg ASI+I or PLA. Tests repeated after 60 mins of gaming.	Game performance: difference from baseline in score/rank/time Cognitive performance: TMT-A,B; Stroop Test; POMS	←→ game performance ↑ self-reported vigour and ↓ TMT-B test errors vs PLA (p<0.05) Post gaming ↓ in Stroop Test error and TMT-A time vs baseline for SUP (p<0.05) but not PLA

Tartar et al., 2021 (37)	To compare the effects of caffeine, caffeine combined with non-adjunctive supplements, and placebo on cognitive performance in e-gamers	Amateur gamers (>10hrs per week) n=50m 20.52±2.03	Randomised, crossover study. Participants took tests pre and 60min post taking 125mg CAF supplement, 125mg CAF + methylliberine + theacrine (CDT) or PLA on three separate occasions a week apart.	No game performance measures Cognitive: Flanker task Psychomotor vigilance task (PVT), pattern comparison processing speed test, dimensional card sort test Physical: Mood alertness and Physical sensations scale (MAPSS)	Compared to baseline CDT and CAF ↑ Flanker performance (p<0.005) but not PLA ↑ PVT reaction time performance with CDT pre to post-dose [t (244) = 2.46; p = 0.044] but not for the CAF or PLA (p < 0.05)
Thomas et al., 2019 (38)	To examine the cognitive and physical changes associated with consuming an energy drink on elite e-sport players	Professional esport players (>10hrs/d) n=9m 21±2yrs	Double blind RCT. Participants took tests pre and ingestion of energy drink (150mg CAF plus other additives) and then waiting 30 mins before playing 3 rounds of LoL with testing after each game	No game performance measures Cognitive: Flanker Test (attention); Go-No Go test (reaction time); n-back test (working memory) Physical: Fatigue and finger tap strength	↓ reaction time on working memory test for treatment condition pretest to post (668.9±2.13 vs.497.5±105.1ms, p=0.004). No other significant differences across treatments or times.

ASI+I = arginine-bonded inositol; CAF=caffeine; PLA=placebo; BP=blood pressure; HR= heart rate; PEBL= Psychology Experiment Building Language cognitive test battery; POMS = Profile of Mood States; TMT-A,B = Trail Making Test A and B; PVT=psychomotor vigilance test; LRT = light reaction test

2.1 Cognitive performance

The studies reviewed used a variety of cognitive tests to measure performance. Reaction time was measured specifically by all studies except one (36) with most using the Go-No Go Test either in isolation or as part of the PEBL. Two studies also utilised the Light Reaction Test (33,35) and one an online tool (34). Other cognitive tests varied (see table 2).

The studies trialling arginine-bonded inositol demonstrated limited results. Tartar et al. (35) found a reduction in TMT-B errors (visual scanning and psychomotor speed) 15 minutes post supplementation compared to placebo, but these results weren't replicated by Sowinski et al. (35).

For the supplements containing caffeine, Sainz et al. (34) found that participants taking 3mg/kg/BM caffeine had faster reaction times than PLA (0.19+0.01 vs 0.20+0.01s; p<0.01). Bloomer et al (32); Leonard et al (33), Tartar et al., (37) and Thomas et al. (38). All other studies testing caffeine in combination with other ingredients failed to show significant improvement versus placebo on cognitive performance (32,33,37,38). Some limited within group differences were noted by three of the studies but these were not consistent across time or type of cognitive test (33, 27,38).

2.2 Game-specific performance

This scoping review examined the existing evidence on nutritional intake and performance in esport athletes. Early findings suggest that, whilst esport athletes consider nutrition important for success and wellbeing, they have some sub-optimal dietary habits. These may have a potentially deleterious effect on performance and long-term health. Moreover, whilst the use of energy drinks is widespread, ergogenic supplements in general have failed to demonstrate performance enhancing effects.

The British Esports Federation recommends that players eat a diet that meets the UK EatWell guidelines (39). However, this review found that they are failing to meet guidelines – consuming more fast food and energy drinks than their peers, too much saturated fat and insufficient fruit, vegetables and dairy. This is concerning because these sub-optimal dietary characteristics are linked to an increased risk of adverse health outcomes, including those prevalent in this population, such as mood disturbance, cardiovascular disease, and reduced bone mineral density (9,11). Indeed, although findings were limited to one study, esport athletes who report these sub-optimal habits also have lower self-reported health status (30)). The low intakes of dairy products, vitamin D and magnesium reported are of particular concern. Prolonged periods of sitting and lack of sunlight exposure due to training and competition have been linked to the high prevalence of reduced bone mineral density found in esport athletes (9, 40). Combined dietary and physical activity-based interventions that support athletes to consume a diet that meets their nutritional needs, including the key micronutrients required for bone health, should be considered. This is particularly pressing given bone mass density typically peaks in the early to mid-20s (41) meaning poor habits in current esport athletes may have lifelong consequences.

Conversely, this review found some evidence that esports players believe a balanced diet, low in refined carbohydrates and 'fatty foods', may be beneficial to wellbeing and performance (25, 29). More research is needed to substantiate this but the only empirical study to explore this found that esport athletes consuming adequate protein (>0.8g/kg/BM) and higher vegetable intakes perform better in cognitive tests (26). These findings have some support from studies in the general population: both acute and long-term adequate protein intakes have been linked to better working memory function under high task demands (14). This cognitive domain has been shown to relate to performance in certain types of esport games such as RTS (42). More generally, a 'Mediterranean' diet (high in fruit, vegetables, lean protein, complex carbohydrates, and healthy fats) is associated with improved cognitive performance in older adults (43). However, evidence on the extent diet could improve game-specific performance in this population is lacking and more work is needed to explore this.

Whilst there is too little research to draw conclusions on the best dietary composition for performance, there is a notable mismatch between what esports athletes are reported to consume and what may be most beneficial for their health and performance. Further research is therefore needed to explore the barriers to healthy eating in this population. None of the studies reviewed directly explored barriers to healthy eating but irregular mealtimes, lack of time and tiredness were described in several of the studies (25;31) These are all factors that have been identified as barriers to healthy eating in young adult men (44). Whilst some elite esports athletes may live in catered facilities with well-planned diets (45), for those at more junior levels there is a need to understand and develop interventions to help them establish healthy eating behaviours that will support their career development.

Research to date suggests that the benefits of supplements on esports performance are uncertain. Arginine-bonded inositol only showed significant results in one of the two studies where acute supplementation reduced errors compared to placebo in the visual scanning element of the TMT (36). Whilst both studies highlighted some within-group results these were inconsistent and, arguably, not meaningful. More research, sufficiently powered, is needed to examine these findings and their applicability to esports game performance.

Most studies tested caffeine, either alone or compounded with other ingredients. Whilst caffeine and energy drinks have been shown to have a positive impact on cognitive skills (46, 47), the studies reviewed reported mixed findings. The four studies that used caffeine in conjunction with other ingredients demonstrated equivocal results. Significant findings were mainly small, within-group effects and in inconsistent cognitive domains. This may be partly due to methodological and conceptual issues.

Doses of caffeine varied from 40mg to 270mg (with no adjustment for body weight) and 2/4 studies did not control for habitual caffeine intake. Participants may have therefore received ineffective doses or already have some degree of tolerance to the ergogenic effects of caffeine.

The only study that reported a clear benefit to game performance used a well-researched dose of caffeine with a clearly defined population and game-specific performance test. Sainz et al. (34) reported that 3mg/kg/BM improved both hit accuracy and reaction times in professional esport athletes playing a FPS under conditions described as 'stressful'. Caffeine has been found to have most ergogenic benefit during cognitive tasks that involve attention and vigilance, such as FPS-type games where target identification is essential, and in sleep-deprived individuals or stressful conditions (46). Esport games that focus on different skills, such as RTS, may not see the same performance benefits and further research is needed to explore this.

Half of the studies (7/14) in this scoping review were focussed on trialling supplements to improve esports performance. Despite mixed evidence on the efficacy of supplements, there is evidence that esports players not only already use them or know peers who take them (48)) but feel pressure to take them (49).).This study found that energy drinks are habitually consumed by esports players despite some feeling that they were detrimental to wellbeing. This may partly reflect the ubiquity of sports supplements sponsorship and marketing in esports (50). However, it also highlights that the initial reticence of sports science to engage with esports (51) has created a vacuum in which the supplements agenda has flourished whilst performance nutrition foundations have been overlooked.

Limitations

The findings of this scoping review are limited due to several factors. There is a lack of clarity in the literature on what defines an esport athlete and their competitive level. This blurring of descriptors has been noted in previous reviews in this area (1) (and may have confounded results. Work between researchers to establish a consensus on terminology is needed. Secondly, the wide variety of cognitive tests used haven't been shown to relate to esports performance (52). Game performance measures may be more useful but these need to be title/game specific and what constitutes a meaningful improvement in a competitive setting needs to be established.

Findings from the diet studies will be limited by the methodological and practical difficulties in accurately recording food intake in study populations – it is difficult to control for confounding factors such as participants activity levels, supplement use or behaviour change in response to taking part in a study (53). The study results reported were mainly based on food frequency questionnaires which may be flawed due to participants inability to recall past behaviour accurately (54). One study used a 3-day weighted food diary which is potentially more accurate but is more expensive and burdensome for both participants and researchers. Moreover, only two studies were able to compare intake in esport athletes to that of similar age peers (26,27). The majority of participants in the studies are 'emerging adults' (i.e., those between ages 18-25) and previous studies on those in this age group have found similar attitudes and behaviours around food (55) – therefore it is unclear to what extent esport players' dietary behaviour is distinct compared to others their age.

Conclusions

This scoping review provides an outline of current research into the nutritional intake and performance of esport players. Esports athletes may be failing to consume a diet that meets their nutritional needs, and this has potential consequences for their health and performance. Whilst, ergogenic aids and supplements have been of keen interest, this review found that, to-date, these have failed to show significant game-related performance benefits.

Implications for research

Further research is needed into the optimum diet for esports athletes and strategies for helping them achieve this given the potential barriers to healthy eating and the demands of training. Future study designs should be careful to clearly delineate the level and type of participants and incorporate performance measures that are game-specific and relevant to competitive scenarios.

Implications for practice

Supplements may be popular and promoted to athletes, but it is important to stress that, to date, there is little evidence to support their use. Caffeine may be appropriate for some game-types but should be carefully considered and trialled on an individual basis. Improving the basic diet of esport athletes may not only be beneficial to performance but can also help secure their health, wellbeing and careers for the future.

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