Physical Exercise and Performance in Esports Players: An Initial Systematic Review

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Background: Participation in esports (excluding active video games) has raised concerns due to its sedentary nature and the potential negative effects this may have on player health. As well, research suggests that physical activity (PA)/exercise improves specific cognitive skills that have been identified as positive contributors to esports performance. The aim of this systematic review was to assess whether evidence supports that PA/exercise positively impacts esports player performance. Methods: The systematic literature search comprised PubMed, SPORTDiscus, PsycINFO, and Web of Science up until March 31, 2022. An additional search included reference list searching, citation searching, and hand searching. Results: Emerging evidence suggests that PA/exercise as an intervention may have a positive effect on esports performance. While it appears that the majority of esports players believe PA/exercise to be beneficial to esports performance, only a minority currently undertake PA/exercise for the purpose of improving esports performance. Conclusion: Although further controlled experimental research is necessary, results highlight that PA/exercise may positively correlate with esports performance. These effects are consistent with the majority of player perceptions that PA/exercise is beneficial to esports performance. Qualified fitness and health professionals should be utilized to implement training to enhance esports performance, improve health, and extend player career length.

Keywords: physical activity, video games, e-athlete, cognitive function, cognition, console gaming, PC gaming

The most popular form of esports, or organized competitive video gaming competitions (Jenny et al., 2017), has raised concerns regarding players’ health due to its sedentary nature (e.g., Yin et al., 2020). Long periods of daily relative inactivity (i.e., sitting in front of a computer or console playing esports) reported by esports players are varied, with reports ranging from 5.5 to 11 hr/day (Bayrakdar et al., 2020; DiFrancisco-Donoghue et al., 2019; Rudolf et al., 2020). Currently, there is little consistency of names and the number of in-game rankings across esports game titles. Collectively, studies highlight the need for more research and specific health promotion strategies for esports players (e.g., Schary et al., 2022; Watanapisit et al., 2020; Yin et al., 2020). Likewise, evidence suggests that exercise might be an effective intervention strategy to improve esports player performance (e.g., Dykstra et al., 2021; Toth et al., 2020) as it relates to broad physiological benefits, as well as cognitive improvements.

Benefits of Physical Activity and Exercise

While physical activity (PA) refers to bodily movement, exercise encompasses PA and is a structured or goal-driven form of PA aimed at improving the body’s physical condition. While clearly distinguishing PA from exercise is important, for the purpose of this study they will be mentioned together. The benefits of regular exercise are varied and well known, including improved respiratory and cardiovascular functioning, improved muscular fitness (i.e., muscular strength, endurance, and power), reduced risk factors for cardiovascular disease, decreased morbidity (i.e., illness or disease), and mortality (i.e., death), as well as a plethora of other benefits (e.g., decreased depression and anxiety, enhanced quality of life, and improved cognitive function and sleep; American College of Sports Medicine, 2022). Currently, research in PA or exercise in esports is in an early phase, with practice often drawing from established research from sport (Leis et al., 2021). Despite existing similarities, McGee and Ho (2021) indicated that esports gameplay requires approximately triple the physicality of office workers in terms of actions per minute. Grushko et al. (2021) also showed improved hand-to-eye coordination compared with athletes in the domains of visual search and hand-to-eye coordination. Playing esports in competitive settings has been associated with stress responses (see review by Leis & Lautenbach, 2020). For example, (Leis, Pedraza-Ramirez, et al., 2022) reported increased heart rate in professional League of Legends players during competition, while Mendoza et al. (2021) found increased cortisol responses in elite players. However, research on the stress–performance relationship in esports as well as the moderating effect of PA and exercise is missing.

Evidence demonstrates that exercise improves multiple domains of cognitive function (Ludyga et al., 2020; Wilke et al., 2019) and mental well-being (Lubans et al., 2016; Schuch et al., 2016). However, there is minimal research investigating the effect of exercise on mental well-being or cognitive function within...
esports performance. Preliminary findings of a recent study have shown that higher cardiorespiratory fitness and reaction time are significantly correlated within esports players (Dykstra et al., 2021), which also suggests that players with greater cardiorespiratory fitness had quicker and more accurate responses. In a dual-systematic review, Toth et al. (2020) suggest that specific cognitive abilities, such as task-switching ability, information processing and attention, and memory, are the least to most important for action video gaming. This also showed that attention, memory, information processing, and task switching significantly improved after exercise interventions in 65.38%, 28.57%, 37.50%, and 25% of them, respectively. Sharpe et al. (2023) mentioned that esports players believe that a healthy lifestyle and appropriate scheduling could improve their performance. This highlights the demand for future research to investigate the effect of exercise on not only cognitive function but more specifically esports performance specific to individual games (e.g., outcome performance indicators as mentioned by Sharpe et al., 2023). Results from such studies will help inform team training schedules to maximize player performance while also promoting the health and well-being of players.

Esports Performance

In general, there is a consensus that esports performance is reliant on players’ cognitive abilities (e.g., anticipation and decision making) and motor skills (e.g., keyboard and mouse movements). In addition, performance is argued to be dependent on game title and associated demands (e.g., Himmelstein et al., 2017; Nagorsky & Wiemeyer, 2020), and players’ abilities to manage the demands of the competitive environment (e.g., Smith et al., 2019; Leis, Franziska et al., 2022). However, there are numerous options to measure performance (Sharpe et al., 2023). Sharpe et al. (2023) emphasized differentiating between outcome performance and action performance. While outcome performance addresses variables such as game score, action performance includes both task performance (i.e., reaction time and mouse control) and contextual performance (i.e., sportsmanship and personal initiative). Currently, there is a lack of evidence investigating indirect variables (e.g., mental well-being and cognitive function) that contribute to specific action performance indicators (e.g., reaction time, response time, keyboard proficiency, and mouse control) which could influence esports performance. Overall, increased empirical evidence shows a positive relationship between improved cognition and esports performance (e.g., Campbell et al., 2018; Nagorsky & Wiemeyer, 2020; Pedraza-Ramirez et al., 2020; Toth et al., 2020), with regular exercise known to improve cognitive functioning (American College of Sports Medicine, 2022).

Study Purpose

Although elite esports teams and organizations are beginning to engage with exercise training, along with good nutritional and mental health practices, to maintain the physical health of their players (Leporati, 2022), there are no current guidelines to support exercise for improving player performance as well as health. While it has been suggested that the inclusion of exercise programs as part of a holistic approach to improving esports player performance and health, this culture is not prominent in both amateur and professional esports environments (Schary et al., 2022). Despite evidence suggesting positive effects of exercise on cognitive aspects of esports performance (e.g., attention, memory, and task switching; Toth et al., 2020), many esports players of varying genres do not perceive that PA/exercise benefits esports performance (Nagorsky & Wiemeyer, 2020). In other words, while esports players’ performance might benefit from PA/exercise, little is known regarding the impact of PA or exercise on esports performance.

Therefore, the purpose of this systematic review was to provide an overview of the literature on whether PA/exercise can improve esports performance. In addition, a secondary aim of the paper is to summarize player attitudes and perceptions of PA/exercise in terms of its effect on esports player performance. Thus, the overarching question guiding this research was the following: Does PA/exercise improve esports performance? This review will highlight all existing primary research that investigates PA or exercise on esports player performance. This review primarily aimed to examine the literature regarding whether there is a relationship between PA/exercise and increased in-game esports performance, while also assessing player perceptions of PA/exercise regarding whether esports players believe PA/exercise impacts performance.

Methods

Protocol and Eligibility Criteria

A systematic search followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines for systematic reviews and meta-analysis (Page et al., 2021). Studies were selected based on the Population, Intervention, Comparison, Outcomes, and Study Design criteria as shown in Table 1. Search results were excluded if participants were taking prescription, nonprescription, and/or regionally illicit medications/substances that may interfere with gameplay (this does not include caffeine), or if participants had any health-related conditions that may interfere with gameplay or PA exercise. The study was preregistered through the National Institute of Health and Care Research: CRD42021276799.

Search Strategy

The search was conducted on March 31, 2022, by C. McNulty and P. Sondergeld using PubMed, SPORTDiscus, PsycINFO, and Web of Science databases with no restriction on publication date. The search terms for each database are presented in the Supplementary Material (available online) (link blinded for publication; Excel file).

<table>
<thead>
<tr>
<th>Table 1</th>
<th>PICOS Model of the Systematic Review</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PICO elements</strong></td>
<td><strong>Description</strong></td>
</tr>
<tr>
<td>Population</td>
<td>Healthy individuals over 12 years of age</td>
</tr>
<tr>
<td>Intervention</td>
<td>The competitive or noncompetitive sedentary activity of playing esports on console and/or computer at different performance levels and any structured form of physical activity or reported participation variables of exercise training (e.g., intensity and volume)</td>
</tr>
<tr>
<td>Comparison</td>
<td>Baseline measurements</td>
</tr>
<tr>
<td>Outcome</td>
<td>In-game performance such as Kill–Death–Assists, target accuracy, minions killed, and victory/defeat</td>
</tr>
<tr>
<td>Study design</td>
<td>Studies published in peer-reviewed journals and written in English or certified English translation</td>
</tr>
</tbody>
</table>

*Note. PICO = Population, Intervention, Comparison, Outcomes, and Study Design.*
For example, the following keywords were used for the database Web of Science: (TS = [esport * OR e-sport * OR eathlete * OR e-athlete * OR “competitive gaming” OR cybersport * OR cyber-sport * OR “first-person shoot*” OR “real-time strategy” OR “battle arena” OR moba]) OR (TS = [(computer * OR electronic OR virtual OR video OR multiplier * OR multi-player*) NEAR/2 game*] AND TS = [competit * OR sport * OR profession * OR elite]) AND (TS = [exercis * OR train * OR conditioning OR fitness OR “physical activit*”]).

In addition, the search comprised reference list searching, citation searching, and hand searching. Although unpublished research (e.g., conference proceedings and theses) was not included in this review, the references from those studies were checked for additional potentially relevant papers. A final search was conducted on October 14, 2022, using the above criteria in an effort to identify additional publications prior to journal submission. A total of 1,142 articles were found (after removal of duplicates from the initial search) using PubMed, SPORTDiscus, PsycINFO, and Web of Science. No additional articles were identified for inclusion in the review following this second screening.

Data Analysis

At first, all studies (i.e., titles and abstracts) were checked for duplicates by (blinded) and (blinded). Next, full-text articles were independently screened for eligibility by (blinded) and (blinded) using the Rayyan (rayyan.ai) online tool. All disagreements were resolved by discussion between both researchers; interrater reliability was ? = .97. While the first author extracted data from the selected full texts to an Excel spreadsheet including information on general data (e.g., year and author), participants (e.g., age, gender, and experience), and outcome measures (e.g., exercise and PA type, and in-game performance), (blinded) controlled the accuracy of data extraction. The analysis primarily focused on the outcomes of exercise on in-game performance. In addition, a narrative synthesis was performed around study characteristics, intervention type, and in-game performance. Furthermore, results were divided into “exercise and PA and esports performance” and “esports player exercise and PA attitudes and participation.” While research discussed numerous options to measure performance (Sharpe et al., 2023), in-game performance focused on outcome performance variables (e.g., game score and in-game ranking) and action performance indicators (e.g., reaction time and executive function).

Moreover, the risk of bias within selected studies was independently assessed by two researchers and validated by a blinded third researcher using 14-question quantitative assessment tool from the Standard Quality Assessment Criteria for Evaluating Primary Research Papers from a Variety of Fields (Kmet et al., 2004). Using this tool, studies were assessed across 14 queries, particularly focusing on strengths and limitations of each study.

Results

Study Selection

The literature identification, screening, checking eligibility, and included studies are displayed in Figure 1 as a Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram. In total, 3,843 studies were identified using the predetermined search criteria to utilize the selected databases. After removing 358 duplicates, 3,485 titles and abstracts were screened resulting in 18 full-text articles. No additional studies were found using reference list searching, citation searching, and hand searching. Of these, six articles were eligible to be included in this systematic review.

Characteristics of Included Studies

The included study characteristics are outlined in Table 2, along with strengths and limitations identified using the Standard Quality Assessment Criteria for Evaluating Primary Research (Kmet et al., 2004). Regarding the quality of the studies, criteria relating to study design (Criteria [C] 2) and the reporting of detailed results (C13) were met in full (score of 2) by all studies. Criteria relating to the participant group (C4 and C5) and statistical analysis (C8, C9, C10,

![Figure 1 — PRISMA flowchart of records screened and included in the systematic review. Note. Studies were excluded if participants were taking medications or substances that may interfere with gameplay (not including caffeine) or if participants had any health-related conditions that may interfere with gameplay or PA. PRISMA = Preferred Reporting Items for Systematic Reviews and Meta-Analyses; PA = physical activity.](image-url)
Table 2 Summary of Included Studies

<table>
<thead>
<tr>
<th>Authors</th>
<th>Sample size</th>
<th>Gender</th>
<th>Mean age ± SD (years)</th>
<th>Exercise/physical activity type</th>
<th>Volume</th>
<th>Intensity</th>
<th>Esport(s) or genre</th>
</tr>
</thead>
<tbody>
<tr>
<td>de Las Heras et al. (2020)</td>
<td>18</td>
<td>Female = 11%; male = 89%</td>
<td>22 ± 3.0</td>
<td>HIIT on cycle ergometer</td>
<td>5 × 1:1 min (80%–85%: 40% peak watts)</td>
<td>80%–85% peak watts</td>
<td>LoL</td>
</tr>
<tr>
<td>Design</td>
<td>Randomized counterbalanced experimental design</td>
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<tr>
<td>Purpose</td>
<td>Investigate short-term effects of a single session of cardiovascular exercise compared to resting condition on esports performance (i.e., customized LoL task tracking total eliminated targets and accuracy)</td>
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<tr>
<td>Findings</td>
<td>15 min of HIIT, performed 20 min before playing, and enhanced game performance; exercise improved capacity to eliminate targets by 9% and increased accuracy of attacks by 75%</td>
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<tr>
<td>Strengths</td>
<td>Randomized counterbalanced experimental design; controlled laboratory environment limiting extraneous variables</td>
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<tr>
<td>Limitations</td>
<td>Small sample size and only 11% female; generalizability of customized task to regular LoL gameplay and other esports</td>
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<tr>
<td>Did exercise improve esports performance?</td>
<td>Yes</td>
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<tr>
<td>DiFrancisco-Donoghue et al. (2021)</td>
<td>21</td>
<td>Female = 43%; male = 57%</td>
<td>20.76 ± 2.61</td>
<td>Walking</td>
<td>6 min</td>
<td>“Brisk but comfortable”</td>
<td>Competitive FPS games</td>
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<tr>
<td>Design</td>
<td>Randomized repeated-measures experimental design with exit survey</td>
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<tr>
<td>Purpose</td>
<td>Evaluate executive function and esports performance across three conditions—continuous 2-hr gameplay, 6-min walk break midplay, and 6-min rest break midplay</td>
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<tr>
<td>Findings</td>
<td>Walk condition produced significantly faster mean solution (7,613.6 ± 3,060.5 min, p = .02) and planning times (5,369.0 ± 2,802.09, p = .04) compared with rest (9,477 ± 3,547.4; 6,924 ± 3,247.7) and continuous play (8,200.0 ± 3,031.6; 5,862.7 ± 2,860.7) conditions for a color–word Stroop and Tower of London executive function tasks; no impact on game performance (i.e., kill–death ratio; wins/losses) across conditions. About 74% of participants felt walk break improved esports performance; 52% perceived walk condition was “most effective” to help gaming performance compared to rest and continuous play conditions</td>
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<tr>
<td>Strengths</td>
<td>Randomized repeated-measures experimental design; objective executive function measures; qualitative participant perceptions also reported; nearly half of sample was female; improved external validity due to participants playing on home gaming setup</td>
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<tr>
<td>Limitations</td>
<td>Small sample size; effect sizes not reported; game performance measures not well controlled due to team-based esports gameplay and other uncontrolled factors (e.g., varying game maps)</td>
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<tr>
<td>Did exercise improve esports performance?</td>
<td>Quantitatively—No (however, exercise did increase executive functioning); subjective perceptions—Weak positive evidence</td>
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<tr>
<td>Kari and Karhułahti (2016)</td>
<td>115</td>
<td>Female = 3%; male = 97%</td>
<td>20.8 ± 4.4</td>
<td>“Physical training”</td>
<td>Hours per day</td>
<td>Not reported</td>
<td>CS: GO; SCII; DOTA2; LoL; others</td>
</tr>
<tr>
<td>Design</td>
<td>Cross-sectional survey</td>
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<tr>
<td>Purpose</td>
<td>Investigate physical exercise routines of “elite” esports players. Note. Kari et al. (2019) published an extended version of this study with seven additional qualitative interviews</td>
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<tr>
<td>Findings</td>
<td>Overall, sample averaged 1.08 hr/day of physical exercise; only 8.7% of all respondents considered the main purpose of physical exercise was to improve esports performance/success, while 47.0% reported it is to maintain or improve overall physical health; 55.6% reported physical training “somewhat positively” (39.1%) or “significantly positively” (16.5%) influences esports performance; 11.3% reported not doing any physical exercise (i.e., 88.7% perform physical exercise); 81.7% claimed to have a physical exercise program; 70.4% reported planning their own physical exercise themselves, with only 5.2% having a personal coach and 4.4% having a team coach plan the training program</td>
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<tr>
<td>Strengths</td>
<td>Portion of sample included professional esports players (n = 31); study included further analysis comparing professional versus “high-level” elite esports players</td>
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<tr>
<td>Limitations</td>
<td>Nonexperimental; self-report data; possible response bias; was 97.4% male, only 1.8% from Asia, and may include respondents who exaggerated their elite esports status as “high-level”; “physical training” not operationalized; subjective perceptions of exercise impact on esports performance</td>
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<td></td>
</tr>
<tr>
<td>Did exercise improve esports performance?</td>
<td>Weak positive evidence (self-report perceptions)</td>
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</tr>
<tr>
<td>Pereira et al. (2021)</td>
<td>926</td>
<td>Female = 1%; male = 99%</td>
<td>22 (median)</td>
<td>Physical activity</td>
<td>Minutes per week</td>
<td>Vigorous, moderate, or walking</td>
<td>Virtual football</td>
</tr>
<tr>
<td>Design</td>
<td>Cross-sectional survey</td>
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</tr>
<tr>
<td>Purpose</td>
<td>As measured by custom survey and IPAQ, examine PA, sedentarism, and physical training motivations and habits of virtual football (i.e., soccer) players in Portugal</td>
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</tbody>
</table>

(continued)
Table 2 (continued)

<table>
<thead>
<tr>
<th>Authors</th>
<th>Sample size</th>
<th>Gender</th>
<th>Mean age ± SD (years)</th>
<th>Exercise/physical activity type</th>
<th>Volume</th>
<th>Intensity</th>
<th>Esport(s) or genre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trotter et al. (2020)</td>
<td>1,772</td>
<td>Female = 9.4%; male = 87.2%; other = 3.4% (n = 851)</td>
<td>Not reported</td>
<td>Not reported</td>
<td>Days per week</td>
<td>Not reported</td>
<td>Any competitive video game</td>
</tr>
<tr>
<td>Rudolf et al. (2020)</td>
<td>1,066</td>
<td>Male = 91.9%</td>
<td>22.9 ± 5.9</td>
<td>Physical activity</td>
<td>Hours per week (four Likert options)</td>
<td>Moderate to vigorous</td>
<td>Varied esports titles; mostly CS: GO</td>
</tr>
</tbody>
</table>

Did exercise improve esports performance? Very weak negative evidence (self-report perception)

Findings
Participants reported spending median 1,080 min/week (154 min/day) on physical activities; total energy expenditure on physical activities included 5,625 MET-min per week, including expending 2,880 vigorous, 1,080 moderate, and 1,155 walking MET-min per week; participants reported spending on average 320 min/day sitting and 150 min/day practicing virtual football; according to IPAQ scores, 84.5% reported high PA levels, with the remaining being moderate (12.9%) or low (2.5%) levels; 87.1% considered physically active according to World Health Organization (2020a) guidelines; 76.1% reported performing “regular physical training,” with 60.0% of these participants reporting they planning their own physical training; maintaining or improving overall physical health was most frequent reason for doing physical training (66.7%), with only 6.1% responding being active to improve virtual football performance; only 38.7% perceived physical exercise improves esports performance (45.1% perceived no effect and 4.8% negative effect).

Strengths
Large sample size; objective IPAQ instrument used for participant PA levels; data also analyzed cross-sectional by age group

Limitations
Nonexperimental; self-report data; possible response bias; sample limited to Portuguese Football Federation Esports listserv members (who may also not be active members); sample almost entirely male; results may be impacted by sample who may already have positive notions toward PA or already perform high amounts of PA due to liking football; subjective perceptions of exercise impact on esports performance

Did exercise improve esports performance? Inconclusive

Findings
Across the entire sample, 66.9% reported partaking in moderate-to-vigorous PA for more than 2.5 hr/week and on average 7.7 ± 3.6 hr/day of sedentary behavior; no statistically significant difference between all player types regarding reported hours per week of PA or hours per day of sedentary behavior; majority perceived “good physical fitness” brings very positive (n = 343; 32.2%) or quite positive (n = 513; 48.1%) effects to esports performance

Strengths
Large sample size; data also analyzed cross-sectional by type of player

Limitations
Nonexperimental; self-report data; possible response bias; sample limited to Germany and strong majority male; sample size of professional esports players (n = 14) significantly smaller than rest of cross-sectional categories limiting statistical power; classification of participants not objectively clear; nonvalidated survey instrument used; “moderate-to-vigorous” PA behavior measure was subjective

Did exercise improve esports performance? Weak positive evidence (self-report small correlation)

Note: CS: GO = Counter-Strike Global Offensive; DOTA2 = Defense of the Ancients 2; FPS = first-person shooter; IPAQ = International Physical Activity Questionnaire; HIIT = high-intensity interval training; LoL = League of Legends; MET = metabolic equivalents; PA = physical activity; SCII = StarCraft II.
and C11) were met in full by most studies (majority score of 2 and remainder score of 1).

While five of the six studies were published in either 2020 or 2021, one study was published in 2016. Of these studies, four collected data on esports performance and PA via online questionnaires (Kari & Karhulahti, 2016; Pereira et al., 2021; Rudolf et al., 2020; Trotter et al., 2020) and two studies used a randomized single-group experimental exercise intervention (De Las Heras et al., 2020; DiFrancisco-Donoghue et al., 2021). DiFrancisco-Donoghue et al. (2021) also utilized an exit questionnaire following participant completion of the intervention.

Within the included studies, the sample size varied considerably. As illustrated in Table 2, studies had a combined total of 3,918 participants, with a range between 18 and 1,772 participants. Across all studies, participants included 92.7% male ($n = 2,778$), 6.3% female ($n = 190$), and 1.0% other ($n = 29$; $n = 2,997$ as 921 of Trotter et al.’s [2020] participants did not report gender), with the average age of participants being 21.69 years ($n = 2,146$ as Trotter et al. [2020] did not collect this demographic). Study participants ranged from casual/recreational (De Las Heras et al., 2020; Rudolf et al., 2020; Trotter et al., 2020) to amateur/experienced/professional (De Las Heras et al., 2020; DiFrancisco-Donoghue et al., 2021; Kari & Karhulahti, 2016; Pereira et al., 2021; Rudolf et al., 2020), to professional esports players (Kari & Karhulahti, 2016; Pereira et al., 2021; Rudolf et al., 2020; Trotter et al., 2020).

### PA or Exercise and Esports Performance

Across the included studies, the impact of PA or exercise on esports performance was evaluated in three primary ways: (a) experimental exercise intervention, (b) correlations between PA/exercise frequency and player level (i.e., in-game ranking and esports professional player status), and (c) player perceptions of PA/exercise impact on esports performance. Results will now be presented across these three areas, from strongest to weakest evidence. Of note, several studies utilized more than one of these methods.

#### Experimental Intervention Evidence

Two experimental studies compared an exercise intervention with measures of esports performance (De Las Heras et al., 2020; DiFrancisco-Donoghue et al., 2021). First, De Las Heras et al. (2020) compared 18 esports player’s accuracy and the capacity to eliminate targets within a single group in a League of Legends modified game scenario task following an acute 15-min high-intensity interval training (HIIT) cycling session performed 20 min prior to the gaming tasks, compared to a rested condition. In this counterbalanced experimental design, results indicated an improvement in esports performance of 9% for the capacity to eliminate targets and a 75% increased accuracy of attacks following the HIIT exercise condition compared with the resting condition. Of note, the Positive and Negative Affect Schedule was also used to assess subjects’ perceptions of—and emotions (positive or negative) aligned with—the HIIT (i.e., PA) and resting conditions and a potential relationship with esports performance. However, positive and negative affects did not correlate with esports performance (measured by the number of targets eliminated or mistakes made) for either condition.

In a randomized repeated-measures experimental design, DiFrancisco-Donoghue et al. (2021) assessed esports performance using game win or loss data (i.e., win percentage) and kill-to-death ratio for 21 competitive first-person shooter (FPS) esports players who each participated in three conditions: continuous 2 hr of FPS gameplay, a 6-min walk amid 2 hr of FPS gameplay, and a 6-min rest break (i.e., supine with eyes open) amid 2 hr of FPS gameplay. Results revealed no statistically significant impact on either gaming performance metric across conditions. However, pre/postexecutive functioning testing (i.e., color–word Stroop and Tower of London executive function tests) across each condition showed that the walking (i.e., PA) condition produced significantly faster mean solution and planning times compared to the rest and continuous play conditions.

#### Correlation Evidence

Two cross-sectional survey studies investigated a potential statistical relationship between esports player level (i.e., in-game ranking or “professional” esports player status) and PA/exercise frequency. First, survey responses collected and analyzed by Trotter et al. (2020) from 1,772 international esports players revealed that players ranked in the top 10% of their esports participated in statistically significantly more PA/exercise (i.e., on average 2.79 days/week of PA/exercise) compared with players ranked in the bottom 69% (i.e., on average 2.24 days/week of PA/exercise), reported as a small effect correlation. Conversely, Rudolf et al. (2020) surveyed 1,066 esports players located in Germany and found no statistically significant difference between five different esports player types (i.e., professional, former professional, amateur, regular, and occasional players) and their self-reported amount of PA (including structured exercise) or sedentary behavior (both reported as hours per week).

#### Player Perception and Motivation Evidence

Three of the questionnaire studies also report esports player perceptions of and motivations for PA/exercise. For instance, Kari and Karhulahti (2016) investigated exercise routines and motivators (e.g., “What is your main reason for doing physical training?”) and esports performance (e.g., “How do you perceive that doing physical training has affected your performance level in esports?”) across 115 players (31 professional and 84 “high-level”). As a result, while only 8.7% of players reported to engage in exercise for the “primary purpose” of increasing esports success, 55.6% of respondents perceived PA to be either “somewhat” or “significantly” positively correlated to esports success. Similarly, Rudolf et al. (2020) found that 80.3% of respondents ($n = 1,066$ players in Germany) believe “good physical fitness” brings “very positive” (32.2%) or “quite positive” (48.1%) effects to esports performance on a 5-point Likert scale. Likewise, Pereira et al. (2021) used the International PA Questionnaire (Craig et al., 2003) to assess Portuguese Football Federation virtual football players’ ($n = 926$) motivations for exercise and found that 38.66% reported that they believe exercise improves esports performance, while 4.77% perceived that exercise has a negative effect on esports performance. Finally, DiFrancisco-Donoghue et al.’s (2021) experimental study also reported participant perceptions via an exit survey. After experiencing all three conditions (i.e., continuous play, walk break, and rest break) and being blinded of the results, 73.9% of the FPS players perceived the walking condition to be beneficial to performance, with 52.2% stating that the walking break was the most effective to enhance esports performance.

### Discussion

The aim of this systematic literature review was to evaluate whether PA/exercise can improve esports performance, while also assessing player perceptions of PA/exercise regarding whether they believe...
PA/exercise impacts performance. Although the empirical assessment of the impact of PA/exercise as it relates to in-game esports performance is limited, these initial findings will be discussed.

**Experimental Exercise Intervention Evidence**

Only two studies were found that experimentally investigated exercise and esports performance. In detail, De Las Heras et al. (2020) and DiFrancisco-Donoghue et al. (2021) measured in-game performance following an acute exercise bout. The results indicated an improvement in custom esports performance-related tasks following the acute exercise condition in De Las Heras et al.’s (2020) study but not by DiFrancisco-Donoghue et al. (2021). Overall, De Las Heras et al. (2020) found that 15 min of HIIT exercise completed 20 min prior enhanced participants’ capacity to eliminate targets by 9% and increased accuracy of attacks by 75%. DiFrancisco-Donoghue et al. (2021) tracked exercise’s (i.e., 6-min walk) impact on individuals' performance through team game win percentage and individual player kill-to-death ratio. Given the limitation of team-based esports gameplay and lack of control for confounding variables (e.g., varying teammates and game maps), the findings of DiFrancisco-Donoghue et al.’s (2021) study should be interpreted with caution (see limitations within Table 2). Extraneous teammate and between-game factors may have impacted differences in results as it is difficult to measure objective individual metrics that contribute to individual performance in team-based esports. In a randomized counterbalanced experimental design, De Las Heras et al. (2020) employed a closed esports task that tracked number of targets eliminated and mistakes made. While the generalizability of findings may be better with DiFrancisco-Donoghue et al.’s (2021) study as actual esports games were played, De Las Heras et al. (2020) used in a controlled laboratory environment where in-game performance measures were better controlled. The difficulty of collecting cognitive data without interfering with gameplay and performance often requires such studies to use a constrained or modified game, which does not entirely represent performance requirements during an authentic competitive match.

While more replication studies are needed for validation, De Las Heras et al. (2020) findings suggest that partaking in a short bout of intense cardiovascular exercise prior to esports gameplay may positively impact performance. Meta-analysis research supports these results that HIIT training can increase cognitive functioning in youth (Leahy et al., 2020) as well as in healthy adults (Moreau & Chou, 2019). Moreover, in a quasi-experimental feasibility study with older adults, HIIT exercise stimulated through exergaming was found to be enjoyable, safe, and feasible in eliciting moderate-to-vigorous exercise intensities with significant effects on participant power output (Rebsamen et al., 2019). Thus, motion-based video games (i.e., exergames utilizing sensors and software that requires whole-body movements to play the game; Jenny et al., 2021) might be an attractive avenue for esports players to perform HIIT training, but research must confirm this efficacy.

Importantly, Sousa et al. (2020) found that regardless of prior PA levels, esports players decrease in executive functioning following an acute 2.5-hr session of esports gameplay. Due to DiFrancisco-Donoghue et al.’s (2021) findings that taking a short activity break does not necessarily decrease subsequent esports performance and some esports players perceive taking breaks midgame decreases performance, these findings should be considered, where possible, when planning practice and competition matches, and training. Taking breaks during extended gaming sessions may actually improve player cognition and overall health through reducing long sedentary stints, stimulating blood flow, and reducing chances for deep vein thrombosis (Carter et al., 2018; Lippi et al., 2018). Overall, while PA/exercise increases blood flow to the brain which subsequently can increase cognitive skills, this may be best achieved by breaking up large blocks of sedentary time compared with simply performing exercise. More research is needed regarding midgame breaks on performance.

**Correlation Between PA or Exercise Frequency and Player Level**

Two identified cross-sectional survey studies attempted to assess a potential relationship between exercise and PA frequency and level of esports players. With an extremely large sample size of 1,772 esports players, Trotter et al. (2020) found significant differences ($p < .001$) for esports playing frequency and days physically active per week. Trotter et al. (2020) found a small effect size ($r_p^2 = 0.01$) between self-reported exercise and PA frequency and players ranked in the top 10% (2.79 days/week) compared with players ranked in the bottom 69% (2.24 days/week) of their esports. Conversely, Rudolf et al.'s (2020) report no significant differences between self-reported exercise and PA hours per week across five different levels of esports player, ranging from “professional” to “occasional” (recreational) players (described in Table 2). While Rudolf et al.’s (2020) findings did not corroborate that self-proclaimed “professional” esports players perform significantly more self-reported moderate-to-vigorous PA than lower levels of players, it is important to note this was a small self-reported sample limited to Germany with unclear player classifications. Thus, the research is mixed in this area.

With all cross-sectional survey research, it is important to remember that correlation does not equal causation. In other words, causal relationship assertions cannot be made based solely on this type of evidence (i.e., increased PA per week causes a higher in-game esports ranking). This important point strengthens the argument for more experimental research needed in this area.

**Player Perceptions of Exercise Impact on Esports Performance**

Results of esports player perceptions of exercise as a potential catalyst for improvement in esports performance indicated that the majority (73.9%) of participants perceived exercise to be beneficial for esports performance, following a structured walking break during gameplay (DiFrancisco-Donoghue et al., 2021). However, despite participants’ perceived benefits of exercise, statistically significant performance gains were not found based on the acute light walking performed (DiFrancisco-Donoghue et al., 2021).

Perception findings are evidenced further in two survey-based studies by Kari and Karhulahti (2016) and Rudolf et al. (2020), which reported 55.6% and 80.3% of responders believing exercise had a positive impact on esports performance, respectively. However, only 8.7% (Kari & Karhulahti, 2016) completed physical training primarily for improvement of esports performance. This suggests that although most responders believe exercise to be positively impactful to esports performance, this may have been perceived as a secondary outcome of physical training. In contrast, only 38.66% of responders in Pereira et al.’s (2021) survey-based study perceived exercise to positively effect esports performance.

This calls for more experimental research and education in this domain to inform and provide consistency in stakeholder
perceptions with more objective evidence. Perceiving a specific behavior (e.g., performing PA) is beneficial (e.g., improving esports performance) and does not always result in that behavior being consistently performed as many factors are involved (Sharma, 2017). Future studies might investigate the effectiveness of utilizing tenants of a specific theory of health behavior (e.g., health belief model, social cognitive theory, and theory of reasoned action; Hayden, 2019) and its potential impact on improving PA in esports players.

Interestingly, Pereira et al. (2021) utilized virtual football (i.e., soccer) players. Despite virtual football games being developed to mimic a physically active and well-recognized sport, results indicated these participants’ perceived benefit of exercise for esports performance was lower in comparison with results presented by Kari and Karhulahti (2016) and Rudolf et al. (2020) that included esports titles not directly representative of a traditional sport. More research is needed in this area.

While the results of included studies indicate that many players perceive a benefit from engaging in exercise, sampled players varied in reported PA/exercise considerably. Rudolf et al. (2020) found that only former professional and occasional players indicated completing more than 5 hr of PA/exercise per week—with professional players reporting the second lowest mean sedentary activity time (7.3±3.3 hr) behind occasional players (7.0±2.3 hr). Trotter et al. (2020) found that only 19.7% of esports players met the World Health Organization (2020b) weekly guidelines for PA, while Pereira et al. (2021) reported 84.5% of virtual football players having high PA levels, with the remaining being moderate (12.9%) or low (2.5%) as measured by International PA Questionnaire scores. Of note, players reporting that they include exercise to attempt to specifically improve esports performance was only 8.7% (Kari & Karhulahti, 2016) and 6.05% (Pereira et al., 2021) within included studies. This might be due to these players primarily participating in exercise to improve general health, not simply esports performance; however, this could be an unintended tertiary result.

Again, the importance of exercise training as part of an esports player’s scheduled training may extend further than improvements in short- and long-term performance, but this is not certain. While professional players highlight perceived benefits of PA/exercise (e.g., Leis, Franziska et al., 2022), empirical evidence also reported positive effects on an individual’s response to stressors and ability to cope at the physiological, psychological, and behavioral levels (Greenwood & Fleschner, 2011). A player’s ability to effectively cope with stress has been linked to better in-game performance and mental health outcomes (Poulus et al., 2020). In response to stress, stress hormone (i.e., cortisol), sympathetic nervous system activation, and immunosuppression can be downregulated through exercise (Fleschner, 2005, Greenwood & Fleschner, 2011). Exercise might indirectly influence performance and psychological well-being in esports players by helping downregulate stress responses and supporting players to employ more effective coping strategies. That said, more experimental research must be performed on the effects of exercise and esports performance, with intentional collaboration and dissemination of results to varying esports stakeholders.

Limitations

Several limitations were identified by the authors of this systematic review (see Table 2). Only six studies were identified to be included in the review, participants were almost entirely those who identify as male (92.7%), player levels (i.e., amateur to professional) were mixed across studies, clarity on the type of exercise performed (e.g., strength training, cardiovascular training, and flexibility training) was not consistent or reported across studies, and only one study collected data during actual esports competition (DiFrancisco-Donoghue et al., 2021). As a result, the findings have to be interpreted with caution. For example, it is unclear how the results apply to female samples or different player levels. In addition, esports exercise science literature sometimes lacks a precise differentiation between PA and exercise. While PA is included in exercise, findings do provide information on whether esports players should be more physically active or incorporate structured exercise training into their training to improve their performance. Furthermore, identified studies do not differentiate which individual metrics contribute to individual performance, for example, the role of individual kills, deaths, in-game communication, or psychological skill (i.e., stress coping) involved in individual and team performance (e.g., Sharpe et al., 2023). Finally, the review was limited to peer-reviewed articles published in English, particularly limiting potential studies from Asia—a major esports market. Non-English studies, as well as unpublished research, may lead to additional findings.

Future Research

As noted previously, future research should more clearly distinguish PA from exercise when investigating its impact on esports performance. Similarly, a clearer delineation between esports and recreational video game players is needed across study samples. In doing so, research should begin to investigate specific esports (e.g., game titles), rather than investigating game genres, as each esport is unique and poses different cognitive demands. Since studies highlight negative effects of sitting such as obesity and cardiovascular disease (e.g., Stamatakis et al., 2011; Wilmot et al., 2012), future studies could investigate potential health ramifications of esports participation in more detail. To extend current knowledge provided by this review, more controlled longitudinal and acute experimental research of exercise interventions and esports performance is necessary to begin to draw reliable conclusions. For instance, long-term exercise interventions, targeting the improvement of game-specific cognitive skills, to investigate performance changes could inform criteria for exercise in esports training. Exercise may have an important role in improving aspects such as player career longevity, injury prevention and rehabilitation, reducing stress, improving coping, and mitigating burnout in esports. For example, since players are required to cope effectively with the demands of the competitive environment, more research on additional aspects such as group dynamics (e.g., Freeman & Wohlen, 2019; Leis, Franziska et al., 2022) and the stress–performance relationship is needed (e.g., Leis & Lautenbach, 2020). This, in turn, could benefit evidence-based intervention strategies at a more holistic understanding of esports. Without this research, there will be difficulties in player/management adherence to exercise as part of esports player training, where the outcomes of such interventions are still unknown. Overall, collaborations with stakeholders (e.g., esports researchers, players, coaches, health professionals, and organizations) are vital for future research to be performed, disseminated, and put into action.
and its effect on esports performance. In terms of esports player attitudes and motivation for exercise, results indicated that a majority of players perceive benefits from exercise on performance, but many players only perform low to moderate levels of PA/exercise. The limited results of this systematic review suggest that PA/exercise may positively correlate with esports performance. However, more controlled experimental evidence is needed to investigate short- and long-term effects of exercise on in-game performance. While the inclusion of exercise as a mechanism for esports player training may have a positive outcome in player performance, the limited research on this topic currently warrants caution in proclaiming a cause-and-effect relationship. Esports organizations, teams, coaches, managers, and players must continue to be made aware of the potential benefit of exercise on esports performance, as well as the promotion of overall player health. More research is required to further understand the importance of promoting the potential positive effects of exercise on esports performance, as emphasis is needed by all to prioritize esports players’ health.

References


