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**Narrative Review**

# Evidence Relevant to the Classification of Esports as Sport: A Narrative Review from a Psychological and Neuroscientific Perspective

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**ABSTRACT**

**Background:** Competitive video gaming (esports) is now professionalized and institutionalized, yet whether it should be classified as sport remains disputed.

**Purpose:** Written from a psychological and neuroscientific perspective, this narrative review evaluates evidence relevant to five dimensions commonly used to characterize sport (competition, rule-governance, institutionalization, skill, and physicality) and distinguishes evidence of competitive expertise from the stronger claim of sport status.

**Methods:** PubMed, Scopus, PsycINFO, Web of Science, and Google Scholar were searched (January 2000 to September 2026) and supplemented by citation tracing and dated governance documents. Evidence was graded by design and by population (professional or high-ranked esports players vs. general or action-video-game players); reporting followed SANRA.

**Results:** Esports-specific studies document sport-like stress, coping, and mental-toughness processes, and meta-analytic expert–amateur differences in spatial cognition and attention. Predominantly cross-sectional neuroimaging studies report expertise-associated neural differences, but pre-existing characteristics also predict skill acquisition. Gameplay produces modest autonomic changes and energy expenditure only slightly above rest. Institutionalization is extensive, although governance remains fragmented and Olympic integration is paused.

**Conclusion:** The evidence supports esports as a domain of competitive cognitive-motor expertise, but expertise alone does not establish sport status; the verdict depends on the weight given to physicality, and a graded (polymorphic) conceptualization fits the evidence best.

**WHAT IS ALREADY KNOWN ON THIS TOPIC**

Esports is a professionalized competitive activity whose status as sport is contested. Recent reviews and meta-analyses synthesize esports cognition, stress, and mental health separately, but rarely relate this evidence to the dimensions used to define sport.

**WHAT THIS STUDY ADDS**

This review maps evidence from five domains onto five classification dimensions, grades it by design and population, and separates evidence of competitive expertise from evidence of sport status. Esports meets competition, rules, and skill well, and physicality weakly.

**HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY**

Researchers should prioritize longitudinal, esports-specific, and direct athlete-comparison designs. Practitioners should treat sport-psychology interventions for esports players as hypotheses requiring testing. Governing bodies' decisions hinge on the weight given to physicality.

## 1. Introduction

Esports, defined as organized competitive video-game play between individuals or teams under established rules and tournament structures, has developed from a niche gaming activity into a global professional and spectator industry over the past two decades. Games such as *League of Legends*, *Counter-Strike*, *Dota 2*, and *Valorant* now feature professional players, coaching and support staff, organized training environments, and tournaments that attract large in-person and online audiences (Bányai et al., 2019; Wollesen et al., 2025). Research on esports spectatorship also demonstrates the importance of social and affective experiences at competitive events (Jang et al., 2020). This rapid development raises a question that is both conceptual and empirical: Should esports be classified as a sport, or is it better understood as a distinct form of skilled competition that shares certain features with established sports?

The debate depends substantially on how sport is defined. Arguments for inclusion emphasize organized competition, codified rules, institutionalization, and demonstrable skill development (Jenny et al., 2017). Arguments against inclusion give greater weight to the physical skills required for an activity to qualify as sport, particularly the role of gross-motor athletic performance rather than fine-motor control of a mouse, keyboard, or controller (Hallmann & Giel, 2018; Parry, 2019). Esports competition places considerable demands on perception, attention, decision-making, sensorimotor coordination, and emotional regulation. Nevertheless, the presence of these demands does not by itself resolve the definitional question, which also depends on how physicality and embodiment are understood (Wollesen et al., 2025).

Two propositions must therefore be distinguished. The first is that esports requires genuine, trainable competitive expertise. The second, stronger proposition is that esports qualifies as sport. Evidence supporting the former does not necessarily establish the latter. Expertise, rule-governed competition, institutional organization, and spectatorship are also found in activities, such as chess and competitive music performance, that are not consistently classified as sports (Parry, 2019; Pluss et al., 2019). A defensible classification argument must consequently distinguish features that are merely shared with established sports from those considered necessary for sporting status.

Recent evidence syntheses have examined several relevant domains, including esports psychology (Bányai et al., 2019; Pedraza-Ramirez et al., 2025), competitive stress and stress responses (Leis & Lautenbach, 2020; Leis et al., 2024), mental health and well-being (Poulus et al., 2026), cognitive expertise (Miao et al., 2024), eye-movement characteristics (Luo et al., 2025), and autonomic responses during gameplay (Lyu et al., 2026). A recent rapid review identified 13 evidence syntheses and 125 empirical publications relevant to sport and exercise psychology in esports (Pedraza-Ramirez et al., 2025). However, an integrated assessment of how evidence across these domains maps onto sport-defining criteria remains underdeveloped. In particular, there is a need to distinguish the strength and applicability of evidence across study designs and populations, and to assess whether similarities between esports and established sports could be explained by features common to other skilled competitive activities. Addressing these issues constitutes the principal contribution of the present review.

Accordingly, this review asks: What do psychological, cognitive, neuroscientific, physiological, and social findings reveal about esports in relation to commonly proposed criteria for sport, and what conclusions about its classification can reasonably be drawn from that evidence? The aim is not to impose a binary verdict but to identify where the evidence is informative, where it remains inconclusive, and which questions depend on conceptual rather than empirical judgments. The review adopts a psychological and neuroscientific perspective while giving particular attention to the criterion of physicality, which represents a central challenge to the classification of esports as sport (Sections 3.4 and 4.3; Table 3). Section 2 describes the review methods, terminology, and analytical framework; Section 3 synthesizes the evidence by domain; Section 4 evaluates this evidence against proposed criteria for sport, considers alternative explanations and the physicality question, and develops evidence-graded implications; and Section 5 presents the conclusions.

## 2. Methods

### *2.1. Review Design and Reporting Standard*

This article is a narrative (non-systematic) review that integrates empirical and conceptual evidence relevant to the classification of esports as sport. No review protocol was prospectively registered, and the review was not conducted or reported as a systematic review under PRISMA. To improve transparency, reporting was guided by the six domains of the Scale for the Assessment of Narrative Review Articles (SANRA; Baethge et al., 2019): justification of the review's importance (Section 1), explicit aims (Section 1), description of the literature search (Sections 2.2 and 2.3), appropriate referencing, scientific reasoning and critical appraisal of the evidence (Sections 2.4 and 4), and presentation of relevant outcome data, including effect estimates and confidence intervals when available (Section 3; Table 2). SANRA informed the reporting structure; it was not used as a study-level risk-of-bias tool or a formal system for grading evidence certainty.

### *2.2. Literature Search*

PubMed/MEDLINE, Scopus, PsycINFO, Web of Science Core Collection, and Google Scholar were searched for publications dated from January 2000 to the final search update on September 24, 2026. The core Boolean search expression combined esports-related terms with psychological, cognitive, neuroscientific, physiological, and institutional terms:
(esport* OR "e-sport*" OR "electronic sport*" OR "competitive video gam*" OR "professional gam*") AND (psycholog* OR cognit* OR neur* OR brain OR EEG OR MRI OR physiolog* OR "heart rate" OR "energy expenditure" OR stress OR coping OR "mental toughness" OR governance OR institutionali* OR definition OR "sport status").

Two supplementary search approaches targeted (a) meta-analyses and training studies involving action-video-game play and (b) comparator evidence from the traditional-sport expertise literature, using terms such as "perceptual-cognitive expertise," "cognitive function" AND athlete*, and "precision sport" AND physiolog*. For Google Scholar, the first 200 records returned for each search string were screened. Backward and forward citation tracing was undertaken for each included systematic review and meta-analysis.

Because institutional recognition of esports continues to

evolve, governance information was drawn preferentially from dated statements issued by relevant bodies, including the International Olympic Committee and the Olympic Council of Asia. Dated specialist reporting was considered when an official statement was unavailable. Foundational works in sport philosophy and sociology, including the works of Guttmann (1978) and Suits (1988), were eligible irrespective of the publication-date limit.

Searching was concluded when additional targeted searches and citation tracing no longer identified material expected to change the interpretation of an evidence domain. This was a pragmatic stopping rule rather than a formally validated saturation criterion. Accordingly, the search was intended to identify and critically integrate relevant literature, not to claim exhaustive retrieval of all eligible studies.

### *2.3. Eligibility and Selection*

Eligible material comprised four categories: (a) peer-reviewed empirical studies of competitive esports players at any skill level, together with systematic reviews and meta-analyses of those studies; (b) studies involving action-video-game players or general gaming populations, included only when they addressed questions for which esports-specific evidence was insufficient and explicitly labelled as indirect; (c) conceptual and philosophical publications addressing the definition of sport; and (d) dated, authoritative governance documents. Clinical studies of gaming disorder in noncompetitive samples, exergame and active-video-game studies unrelated to the physicality question, conference abstracts, and non-English publications were excluded.

When several sources addressed a comparable question, interpretive priority was generally given to systematic reviews and meta-analyses, followed by experimental, longitudinal, or training studies; cross-sectional studies with verifiable competitive expertise (e.g., professional status or objective ranking); and qualitative studies. This ordering was used to organize interpretation, not to assume that research design alone determined methodological quality. Contradictory evidence and important design limitations were considered in the narrative synthesis. The first author performed screening and selection, which were checked by the second author; disagreements were resolved through discussion. A complete record-level screening log was not maintained, and no PRISMA flow diagram or exhaustive screening count is claimed. The final synthesis comprises 72 sources, grouped by their principal contribution: conceptual, definitional, and methodological (n = 11); psychological (n = 12); cognitive (n = 14); neuroscientific (n = 11); physiological and physical-demand (n = 14); intervention-related (n = 4); and social and governance (n = 6). These counts describe the composition of the narrative evidence base rather than the yield of a systematic selection process.

### *2.4. Appraisal of Evidential Strength*

To make the basis for interpretation explicit, empirical evidence was classified by design and population relevance. *Level 1* comprised esports-specific systematic reviews and meta-analyses; *Level 2*, esports-specific randomized, longitudinal, or training studies; *Level 3*, esports-specific cross-sectional expert–novice comparisons or correlational studies; and *Level 4*, qualitative studies, case series, or uncontrolled pilots. Evidence from action-video-game or general gaming populations and from traditional-sport research was categorized separately as *Indirect*. These labels indicate the type and directness of evidence; they are not validated risk-of-bias ratings or formal certainty grades.

Interpretation also considered sample size, how competitive expertise was verified, outcome relevance, potential confounding, correction for multiple comparisons, and whether the study design supported temporal or causal inference. Randomized studies can provide stronger evidence of intervention effects when adequately conducted; longitudinal associations establish temporal ordering more directly than cross-sectional comparisons but do not, by themselves, prove causation. Cross-sectional group differences are therefore described as expertise-associated rather than as effects of esports training. Findings from systematic reviews and meta-analyses were considered alongside the quality, heterogeneity, and relevance of the studies they synthesized, rather than being given automatic precedence in every comparison.

Qualitative domain-level strength judgments are presented in Table 1 using the decision rules specified in its note. These judgments summarize the convergence, directness, and limitations of the available literature; they do not represent numerical scores or pooled effects. Table 2 reports study-level characteristics and relevant outcome estimates for influential empirical sources, including effect sizes and confidence intervals where available.

### *2.5. Terminology*

Terminology is consequential in this debate because labels can implicitly presume an answer to the sport-classification question (Bubna et al., 2023). For this review, *esports* refers to organized competitive video-game play under codified rules within a structured competitive setting, consistent with established esports-psychology definitions (Pedraza-Ramirez et al., 2020). The spelling *esports* is used throughout; alternative spellings are retained only when reproducing the titles of cited works.

*Professional esports players* are individuals competing under professional contracts or in established top-tier leagues. *High-ranked competitive players* are those occupying the upper tiers of a game's ranking system (often approximately the top 1–10%, depending on the title and ranking structure). *Ranked competitive players* participate regularly in ranked modes without necessarily attaining high ranks. *Action-video-game players* (AVGPs) are categorized primarily by their history or frequency of play in action-game genres, rather than verified competitive achievement. *General gamers* are described principally by gaming participation or frequency without documented competitive expertise. These categories are operational distinctions for evaluating source relevance, not a claim that ranking systems are equivalent across games. In the authors' own prose, the neutral term *esports player* is preferred. The terms *esports athlete* and *e'athlete* are retained only when accurately describing terminology used by cited authors. By contrast, *athlete* is used for participants in conventional sport. This convention avoids assuming the conclusion of the classification debate.

### *2.6. Analytic Framework: Dimensions of Sport*

The review uses several influential accounts of sport as conceptual comparators rather than treating any one account as a universally accepted definition. Guttmann (1978)

characterizes modern sport sociologically through secularism, equality, specialization, rationalization, bureaucratic organization, quantification, and record keeping. These characteristics describe the historical and institutional form of modern sport; they should not be interpreted as an exhaustive set of necessary and sufficient conditions. Suits (1988) places physical human skill at the centre of his revised analysis of sport, distinguishing sporting games and judged performances. His earlier emphasis on broad and stable public participation should not be conflated with the revised 1988 formulation. Parry (2019) defines *Olympic* sport more narrowly as an institutionalized, rule-governed contest of human physical skill. Under that particular account, the decisive question for esports is not whether it involves human skill or organized competition, but whether the physical-skill requirement is met.

Other contributions complicate a strictly binary classification. Jenny et al. (2017) examine how esports aligns with established definitional attributes, including competition, skill, physicality, broad following, and institutionalization, and question how consistently these attributes are applied across recognized sports. Hallmann and Giel (2018) evaluate esports against sport-related characteristics and conclude that, at the time of their analysis, the evidence did not justify its classification as sport, while acknowledging the possibility of future change. Heere (2018) approaches esports through on the philosophical definition being applied.

For the purposes of this review, five recurring dimensions organize the comparison: (a) organized competition, (b) rule-governance, (c) institutionalization, (d) demonstrable and trainable skill, and (e) physicality. This five-dimensional framework is the authors' analytical synthesis of the cited perspectives, not a single definition endorsed by all of them. The dimensions are neither assumed to be equally important nor treated as necessary or sufficient conditions in every account. No composite score is calculated, and statements implying that esports qualifies by satisfying a given number of criteria are avoided.

Two interpretive principles follow. First, organized competition, rules, institutions, and skill are not uniquely diagnostic of sport, since they are also found in other structured competitive activities. Physicality therefore carries particular discriminating weight within definitions that require physical skill, although its meaning and threshold remain contested. Second, empirical evidence can establish the extent and nature of competitive expertise, bodily demands, and institutional organization, but cannot by itself determine which criteria ought to define sport. Accordingly, psychological, cognitive, and neuroscientific studies are interpreted mainly in relation to skill and expertise; physiological studies inform the nature of physical demands; and social and governance evidence informs competition, rule-governance, and institutionalization (Figure 1). Claims about overall sport status remain explicitly dependent on the philosophical definition being applied.

**Table 1**. Mapping of Evidence Domains onto Classification Dimensions, with Strength of Evidence

| Evidence domain | Principal findings (design level) | Key sources | Dimension(s) informed | Strength of evidence | Main uncertainty |
|---|---|---|---|---|---|
| **Psychological** | Stress, coping, and mental-toughness processes measurable with sport-psychology constructs; sport-coping taxonomy applies; some esports-specific stressors (L1, L3, L4). | Leis, Sharpe, et al. (2026); Poulus et al. (2020); Drew et al. (2025); Behnke et al. (2023) | Skill; Competition (secondary) | Moderate | Mostly cross-sectional or qualitative; one direct athlete comparison shows differences |
| **Cognitive** | Expert–amateur advantage in attention and spatial cognition (g = 0.37); shorter fixations in experts; AVG training effects are indirect (L1, L3, Indirect). | Miao et al. (2024); Luo et al. (2025); Bediou et al. (2018) | Skill | Moderate | Wide CI; causality; no identical-battery comparison with athletes |
| **Neuroscientific** | Expertise-associated structural, functional, and ERP differences; pre-existing volume predicts learning (L3, L2 small). | Kowalczyk-Grębska et al. (2021); Kim et al. (2015); Gan et al. (2020); Coronel-Oliveros et al. (2024) | Skill | Low | Small cross-sectional samples; predisposition vs. practice unresolved |
| **Physiological** | Modest vagal withdrawal during play; energy use ~13% above rest; localized overuse complaints; physical training does not improve gaming (L1, L2, L3). | Lyu et al. (2026); Nicholson et al. (2024); Wachholz et al. (2025); Holland et al. (2025) | Physicality; Competition (secondary) | Moderate | Autonomic change not sport-specific; small laboratory samples |
| **Social / institutional** | Codified rules, leagues, spectatorship; 11 esports medal events at the 2026 Asian Games; IOC Olympic Esports Games paused | Hallmann & Giel (2018); Olympic Council of Asia (2025b); International Olympic Committee (2025) | Competition; Rule-governance; Institutionalization | Moderate | Publisher-owned rules; governance fragmented and changing |

*Note*. Design levels: L1 = esports-specific systematic review or meta-analysis; L2 = esports-specific randomized, longitudinal, or training study; L3 = esports-specific cross-sectional study; L4 = qualitative or uncontrolled pilot; Indirect = action-video-game, general gamer, or traditional-sport evidence. Strength of evidence: *High* = at least one esports-specific meta-analysis with precise, consistent estimates plus supporting experimental evidence; *Moderate* = esports-specific Level 1 syntheses or convergent Level 2–3 studies, with imprecision or predominantly cross-sectional designs; *Low* = few, small, or mainly cross-sectional esports-specific studies, or reliance on indirect evidence; *Very low* = conflicting or anecdotal evidence. For the social domain, strength refers to documentary rather than empirical evidence. Ratings are qualitative judgements, not a meta-analytic estimate or a classification score.

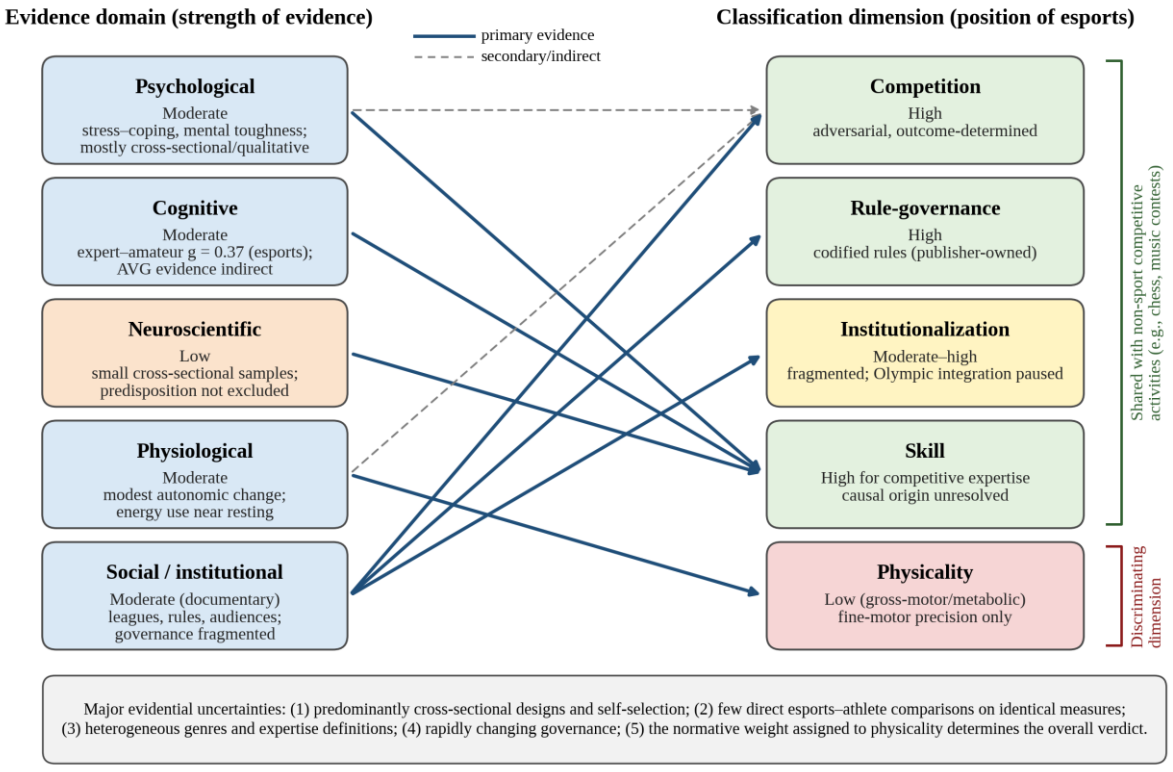



**Figure 1**. Conceptual Map Linking Evidence Domains to Classification Dimensions, with Strength of Evidence and Major Uncertainties

*Note*. Solid arrows show primary evidential links and dashed arrows secondary or indirect links. Evidence strength follows the definitions in Table 1. Competition, rule-governance, institutionalization, and skill are shared with non-sport competitive activities; physicality is the dimension that discriminates sport from them on most definitions. Positions are not summed into a score.

## 3. Results

Each subsection first reports esports-specific evidence and then, where relevant, indirect evidence, which is labelled as such. Design levels (Section 2.4) are indicated for key studies, and study characteristics, effect sizes, and major limitations of the most influential empirical sources are listed in Table 2.

**Table 2**. Characteristics of the Most Influential Empirical Sources

| Authors (year) | Sample and expertise level | Genre / title | Design (level) | n | Primary outcome | Principal finding | Major limitation |
|---|---|---|---|---|---|---|---|
| ***Psychological*** | | | | | | | |
| **Poulus et al. (2020)** | Ranked players, top 40% | MOBA, FPS (5 titles) | Cross-sectional survey (L3) | 316 | Mental toughness; appraisal; coping | Mental toughness associated with perceived control and more problem-/emotion-focused, less avoidance coping | Self-report; no athlete comparison |
| **Drew et al. (2025)** | Elite team (LoL Circuit Oceania) | LoL (MOBA) | Diary, 71 days (L2) | 5 | Stressors; coping effectiveness | Performance + teammate stressors = 72.3%; coping less effective in competition than training | Very small; single team |
| **Behnke et al. (2023)** | Esports players vs. athletes | Mixed | Cross-sectional comparison (L3) | 416 vs. 452 | Big Five personality | Esports players less extroverted and conscientious | Self-report; personality rather than skill |
| ***Cognitive*** | | | | | | | |
| **Bediou et al. (2018)** | Habitual action-video-game players (hours-based) | Action games | Meta-analysis (Indirect) | 2000–2015 literature | Perception, attention, cognition | Cross-sectional g = 0.55; intervention g = 0.34; strongest for top-down attention and spatial cognition | Not esports expertise; possible publication bias |
| **Miao et al. (2024)** | Professional or top-1% vs. amateurs | Mixed | Three-level meta-analysis (L1) | 15 studies; 1,085 | Cognitive abilities | g = 0.373, 95% CI [0.055, 0.691]; mainly spatial cognition and attention | Few studies; wide CI; cross-sectional primaries |
| **Luo et al. (2025)** | Expert vs. non-expert players | Mixed | Meta-analysis (L1) | 7 studies; 165 | Eye movements | Shorter fixation duration, SMD = −0.66 [−1.01, −0.30]; fixation count n.s. | Small k and n; task heterogeneity |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Valls-Serrano et al. (2022)** | Experts, regular players, non-players | LoL (MOBA) | Cross-sectional (L3) | 80 | WM, attention, flexibility, inhibition | Experts > others in working memory; players > non-players in attention | Cross-sectional; single title |
| ***Neuroscientific*** | | | | | | | |
| **Kowalczyk-Grębska et al. (2021)** | Ranked players (Gold–Grandmaster) vs. non-players; naive trainees | StarCraft II (RTS) | VBM cross-sectional (L3) + 30-h training (L2) | 31 vs. 31; 16 | Grey-matter volume; learning rate | Larger lenticular nucleus (d = 1.06), unrelated to hours played; baseline volume predicted learning; no training-related change | Training correlations uncorrected; small |
| **Coronel-Oliveros et al. (2024)** | Players vs. non-players | StarCraft II (RTS) | Whole-brain modelling (L3) | 31 vs. 31 | Simulated functional connectivity | Greater meso-scale integration in frontal, parietal, occipital regions; structural graph measures n.s. | Model-derived, not measured |
| **Gan et al. (2020)** | Top-7% vs. low-ranked players | LoL (MOBA) | Cross-sectional EEG/ERP (L3) | 19 vs. 19 | Attentional blink; P3 | Better second-target detection; earlier, larger P3 | Male students; correlational |
| **S. Wu et al. (2012)** | Non-gamers | FPS vs. 3-D puzzle | Training experiment, 10 h (Indirect) | 16 vs. 9 | Attentional visual field; ERPs | ERP changes only in FPS trainees with largest behavioral gains | Small; novices, not esports players |
| ***Physiological and physical demand*** | | | | | | | |
| **Leis & Lautenbach (2020)** | Mixed competitive levels | Mixed | Systematic review (L1) | 17 studies | Psychological and physiological stress | Non-competitive play unrelated to stress; 3 of 5 competitive studies found no hormonal response | Few competitive-setting studies |
| **Lyu et al. (2026)** | Mixed, including non-esports samples | Mostly MOBA | Meta-analysis (L1) | 12 studies; 489 | HRV during play vs. rest | RMSSD SMD = 0.24 [0.10, 0.38]; HF SMD = 0.47 [0.14, 0.81] (decreases); SDNN, LF, LF/HF n.s. | Heterogeneous samples; GRADE moderate–low |
| **Nicholson et al. (2024)** | Top-10% players (male) | MOBA, FPS, sports | Within-subject laboratory (L3) | 13 | Energy expenditure; HR; HRV | Energy 1.28→1.45 kcal·min⁻¹; HR 84.5→87.1 bpm; HRV n.s. | Small; laboratory, not tournament |
| **Forman et al. (2025)** | Gamers and non-gamers | Aim trainer (FPS-type) | Laboratory protocol (Indirect) | 20 | Forearm sEMG; aiming | Wrist extensors ≤ 9.3% MVC; no performance decline | Not professional; 30-min protocol |
| **Holland et al. (2025)** | Professional GT drivers | Motorsport vs. simulator | Within-subject field vs. laboratory | 5 | HR; core temperature; strain | HR 159 vs. 112 bpm (authentic vs. simulated racing) | Very small; simulator lacked competition |
| ***Interventions*** | | | | | | | |
| **Wachholz et al. (2025)** | Gamers (≈12 h/week) | Aim and reaction tasks | RCT, 8 weeks, 3 arms (L2) | 28 | Coordination; grip; gaming tasks | Physical outcomes improved; no effect on gaming performance | Small; non-professional |
| **Poulus et al. (2023)** | Elite team | LoL (MOBA) | Pre–post pilot, no control (L4) | 5 | Coping; performance; mental health | ↑ coping effectiveness and subjective performance; no change in distress, well-being, resilience | No control; very small |
| **Behnke et al. (2024)** | Competitive players | Counter-Strike (FPS) | Randomized registered report (L2) | 300 | Affect; physiology; tournament performance | Synergistic-mindsets intervention did not improve tournament performance | Single title and intervention |

*Note*. L1–L4 and Indirect are defined in Section 2.4 and Table 1. AVG = action video game; BMC = bone mineral content; CI = confidence interval; ERP = event-related potential; FPS = first-person shooter; HR = heart rate; HRV = heart-rate variability; LoL = *League of Legends*; MOBA = multiplayer online battle arena; MVC = maximal voluntary contraction; n.s. = not significant; RCT = randomized controlled trial; RTS = real-time strategy; sEMG = surface electromyography; SMD = standardized mean difference; VBM = voxel-based morphometry; WM = working memory. Sample sizes for meta-analyses are numbers of studies and total participants.

### *3.1. Psychological Evidence*

Esports-specific reviews suggest that constructs commonly studied in sport psychology can also be meaningfully examined among competitive esports players. A systematic review of esports psychology identified motivational and psychosocial features that resemble those observed in conventional sport, including achievement orientation, structured practice, and team coordination. It also highlighted concerns such as problematic gaming and disrupted sleep (Bányai et al., 2019). A subsequent systematic review of 19 studies identified performance stressors (e.g., defeat and pressure to win), alongside team-related, social, organizational, and personal stressors. The authors organized reported coping strategies using a sport-specific coping taxonomy and also identified context-specific stressors, including social-media exposure and equipment failure (Leis, Sharpe, et al., 2026; Nicholls et al., 2016). A scoping review has extended this work to mental health and well-being (Poulus et al., 2026). Nevertheless, much of the underlying evidence is cross-sectional or qualitative and is based on relatively small samples.

At the study level, 316 players ranked in the top 40% of five titles completed mental-toughness, stress-appraisal, and coping measures; mental toughness was associated with greater perceived control and with more problem- and emotion-focused and less avoidance coping (Poulus et al., 2020). Small longitudinal diary studies have examined how stress and coping unfold across competitive periods in elite *League of Legends* teams. In six players followed for 87 days, problem-focused coping was used most often and was rated more effective than avoidance coping (Poulus et al., 2022), In another study

involving five players followed for 71 days, performance- and teammate-related stressors accounted for 72.3% of reported stressors, and coping effectiveness was lower in competition than in training (Drew et al., 2025; Level 2, very small samples). Interviews with five high-level *League of Legends* players described self-initiated goal-setting, mental rehearsal, and emotional-control strategies alongside obstacles such as competitive pressure and negative team communication (Himmelstein et al., 2017). Laboratory work links players' emotional states to in-game performance (Behnke et al., 2022), and an expert–non-expert comparison of esports teams has examined how verbal communication and coordinated effort relate to team performance (Eldadi et al., 2025).

Direct comparisons with conventional athletes are uncommon and do not support a straightforward assumption of psychological equivalence. In a large direct comparison identified in this review, 416 esports players were less extroverted and less conscientious than 452 athletes (Behnke et al., 2023). The proposal to adopt the term *esports athlete* (Bubna et al., 2023) is a normative argument about terminology rather than an empirical finding. Taken together, the psychological evidence shows that competitive esports involves performance stress and self-regulatory processes that can be measured with sport-psychology constructs, and that these processes are conceptually similar to findings reported in the separate sport literature. Because similar constructs also apply to other high-stakes performance domains (e.g., music, surgery, and examinations), these findings provide stronger evidence of competitive expertise than of sport status.

### 3.2. Cognitive Evidence

#### *3.2.1. Esports-specific evidence*

The most direct esports-specific synthesis compared professional or top-1% players with amateurs across 15 studies (142 effect sizes, 1,085 participants) and found a small overall expert advantage (Hedges' g = 0.373, 95% CI [0.055, 0.691]), expressed mainly in spatial cognition and attention (Miao et al., 2024). The relatively wide confidence interval, small number of primary studies, and predominance of cross-sectional designs limit the precision and causal interpretation of this estimate. A meta-analysis of eye-tracking studies (seven studies; 165 participants) found that expert players had shorter mean fixation durations than non-experts (SMD = −0.66, 95% CI [−1.01, −0.30]) with no difference in the number of fixations (Luo et al., 2025). Among individual studies, experts in *League of Legends* outperformed regular players and non-players in working memory, whereas attention differed only between players and non-players (Valls-Serrano et al., 2022; n = 80). In *Counter-Strike*, the colour–word Stroop task did not differentiate players of different ranks, although elite players performed better when speed and accuracy were considered jointly (Toth et al., 2019). Experienced first-person-shooter and multiplayer online battle arena (MOBA) players responded faster than non-gamers on the Stroop task but made more errors, and were faster on the Trail-Making Test without an accuracy cost—a pattern more consistent with a speed–accuracy trade-off than with superior inhibitory control (Kowal et al., 2018). Intervention evidence specific to esports remains limited: in 40 physical-education students without esports experience, eight weeks of *FIFA* play was followed by improvements in attention and working memory, and in cognitive flexibility only in the co-player condition. Nevertheless, the absence of a non-gaming control group precludes attributing these changes to gaming (Imanian et al., 2026).

#### *3.2.2. Indirect evidence from action-video-game research*

The largest body of cognitive evidence concerns habitual action-video-game players rather than esports players. A meta-analysis covering 2000–2015 found an advantage of about half a standard deviation in cross-sectional comparisons (g = 0.55) and a smaller effect of about a third of a standard deviation in intervention studies with active video-game controls (g = 0.34), with the most robust effects in top-down attention and spatial cognition (Bediou et al., 2018). Early training studies established that action-game play can alter visual selective attention and processing speed in novices (Dye et al., 2009; Green & Bavelier, 2003), although subsequent analyses suggest that training effects may be inflated by publication bias and redundant reporting (Hilgard et al., 2019). These findings support the possibility that some forms of gaming can improve selected attentional skills under certain training conditions; it does not show that the expertise of professional esports players arises from the same mechanisms, because these populations are defined by hours of play rather than competitive skill. A dual systematic review proposed that principles from exercise–cognition research may transfer to esports performance (Toth et al., 2020); this remains a hypothesis.

#### *3.2.3. Relation to the sport-expertise literature*

Separate meta-analyses of traditional sport report expert advantages of broadly similar magnitude on general cognitive tests (r = 0.22 across 19 studies; Scharfen & Memmert, 2019; see also Voss et al., 2010). The two literatures do not, however, show identical visual-search patterns: expert athletes typically use fewer fixations of longer duration (Mann et al., 2007), whereas expert esports players show *shorter* fixations (Luo et al., 2025). Esports cognitive expertise therefore appears domain-specific rather than a replica of sport expertise. No study identified in the present review directly compared esports players and conventional athletes using an identical cognitive test battery. Accordingly, similarities and differences reported here are descriptive comparisons across separate literatures, not evidence of statistically tested between-domain differences.

### *3.3. Neuroscientific Evidence*

Neuroscientific research on gaming spans structural and functional imaging and electrophysiology (Bavelier et al., 2011), and esports has been proposed as a window on neurocognitive expertise (Campbell et al., 2018). Within esports and closely related gaming populations, this literature reports associations between expertise and structural or functional brain measures. Because nearly all of it is cross-sectional, it cannot determine whether gaming produced these characteristics or whether people with particular neural characteristics are more likely to become skilled players; the few training studies bear directly on this question.

In a structural study, 31 ranked *StarCraft II* players (Gold to Grandmaster leagues) had larger right lenticular-nucleus grey-matter volume than 31 non-players (d = 1.06), but volume was not correlated with hours played. In an independent sample of 16 game-naive participants trained for 30 hours, pre-training volume of the same regions correlated with the rate of skill

acquisition, although these correlations did not survive correction for multiple comparisons, and no training-related volume change was detected (Kowalczyk-Grębska et al., 2021). A preliminary study likewise linked pre-training white-matter structure to subsequent real-time-strategy learning (Lewandowska et al., 2022). These findings are more consistent with pre-existing neural characteristics contributing to expertise—possibly interacting with practice—than with a simple training-induced adaptation. Functional and diffusion imaging showed greater task-related activity in the right inferior frontal gyrus and anterior cingulate cortex and stronger visual–frontal white-matter connectivity in real-time-strategy players than in non-players, differences that correlated with gaming experience and accompanied faster early perceptual learning (Kim et al., 2015). A computational study that combined structural connectomes of 31 *StarCraft II* players and 31 non-players with a whole-brain model found greater simulated meso-scale integration, with increased local connectivity in frontal, parietal, and occipital regions, although graph measures of structural connectivity itself did not differ (Coronel-Oliveros et al., 2024); These functional differences were generated by computational modelling rather than directly measured as functional connectivity.

Electrophysiological studies add temporal resolution. Nineteen *League of Legends* players ranked in the top 7% detected second targets more accurately than 19 low-ranked players during an attentional-blink task and showed earlier and larger P3 responses (Gan et al., 2020); the authors note that the design is correlational and that P3 amplitude has more than one interpretation. Professional *Counter-Strike* players showed earlier (by 20–70 ms) and larger P300 responses and faster reaction times than novices, but no difference in visual search (Gostilovich et al., 2023). Experimental evidence of training-induced neural change exists only for novices and action games: after 10 hours of first-person-shooter play, event-related potential changes occurred only in the trainees who improved most behaviorally, whereas controls who played a puzzle game showed none (S. Wu et al., 2012; n = 16 vs. 9).

Structural and functional differences between experts and novices are also described in the separate sport-expertise literature, which faces the same predisposition-versus-practice problem (Debarnot et al., 2014; Yarrow et al., 2009). No study identified in this review compared esports players and athletes with the same imaging protocol. Overall, the neuroscientific literature identifies neural correlates of high-level gaming expertise, but its predominantly cross-sectional nature and lack of directly matched athlete comparisons prevent strong claims about training-induced adaptation or equivalence with conventional sport. Its principal relevance to the classification debate is therefore the skill dimension.

### *3.4. Physiological Evidence*

#### *3.4.1. Competitive psychophysiological stress*

A systematic review of 17 studies found that non-competitive play appeared unrelated to psychophysiological stress responses; of five studies in competitive settings, three found no hormonal response, and sympathetic activation was reported in two (Leis & Lautenbach, 2020). In seven professional *League of Legends* players, motivation, perceived match importance, and psychological and physiological stress responses were greater in competition than in training (Leis, Praisan, et al., 2024). A meta-analysis of 12 studies involving 489 participants found that heart-rate variability indices of vagal activity decreased during gameplay relative to rest (RMSSD: SMD = 0.24, 95% CI [0.10, 0.38]; high-frequency power: SMD = 0.47, 95% CI [0.14, 0.81]), whereas SDNN, LF, and LF/HF did not change; certainty was rated moderate for RMSSD and low for high-frequency power, and the pooled samples included non-competitive and non-expert players (Lyu et al., 2026). In 13 players ranked in the top 10% of their titles, heart rate rose only from 84.5 to 87.1 beats·min$^{-1}$ during competitive gameplay, and heart-rate variability did not change significantly (Nicholson et al., 2024), whereas 40 male college students showed clear autonomic changes across roughly 90 minutes of play (T. Wu et al., 2025).

Taken together, these findings suggest that competitive esports can produce psychophysiological stress responses, although their magnitude and consistency vary by sample and competitive context. They are not, however, evidence of sport status: comparable reductions in heart-rate variability occur during mental stress in non-sport settings such as demanding computer work (Hjortskov et al., 2004). The autonomic evidence is therefore interpreted here as evidence of competitive psychophysiological stress, which is relevant to the competition dimension, and is kept distinct from evidence of physical athletic demand.

#### *3.4.2. Metabolic and physical demand*

Measured with indirect calorimetry, energy expenditure during competitive gameplay increased from 1.28 to 1.45 kcal·min$^{-1}$ (medians), and oxygen uptake from 0.27 to 0.29 L·min$^{-1}$, relative to rest (Nicholson et al., 2024; n = 13). In this small sample, the median increase in energy expenditure was approximately 13% above the resting value, indicating a relatively low metabolic demand compared with many conventional sports. A within-discipline comparison is especially informative: in five professional racing drivers, heart rate during the final 50 minutes of an authentic race was 159 beats·min$^{-1}$, compared with 112 beats·min$^{-1}$ in a matched simulated race, and core temperature, breathing rate, and physiological strain were also higher in the authentic race (Holland et al., 2025). Although the simulator reproduced central aspects of the driving task, it did not reproduce the G-loading and physiological demands of authentic racing.

#### *3.4.3. Musculoskeletal demands, conditioning, and training interventions*

Musculoskeletal demands are present but are concentrated in particular body regions and repetitive movement patterns. In a laboratory aiming protocol with 20 gamers and non-gamers, wrist extensors reached up to 9.3% of maximal voluntary contraction, and performance did not deteriorate over 30 minutes (Forman et al., 2025); this sample was not professional. Survey and review evidence documents wrist, hand, neck, and back complaints in competitive players (DiFrancisco-Donoghue et al., 2025; Seffah et al., 2023). Collegiate esports players took fewer daily steps than matched controls (about 6,040 vs. 12,844) and had higher body-fat percentage and lower lean mass and bone mineral content (DiFrancisco-Donoghue et al., 2022; n = 24), These group differences are compatible with a less physically active lifestyle among the sampled players, although the observational comparison cannot establish that

esports participation caused them. In a randomized controlled trial with 28 gamers, eight weeks of specific or general physical training improved overall coordination and grip strength but had no significant effect on gaming-performance variables (Wachholz et al., 2025). Randomized trials of ergogenic aids report performance effects of caffeine and γ-aminobutyric acid (Hara et al., 2025; Rogers et al., 2024), showing that esports performance is sensitive to psychophysiological state, but not that it imposes physical load. Overall, available physiological evidence suggests that esports may combine competitive psychophysiological stress with comparatively low whole-body metabolic demands and localized repetitive musculoskeletal loading. Such demands share important features with sustained computer-based work and should not be equated automatically with the physical requirements of conventional athletic competition.

### *3.5. Social and Institutional Evidence*

The institutionalization of esports has advanced rapidly, although it remains uneven across titles and governing contexts. Esports features standardized competitive rulesets, publisher- and third-party-run leagues, salaried rosters, and talent pathways—the organizational markers Guttmann (1978) associated with modern sport (Hallmann & Giel, 2018; Jenny et al., 2017). Its commercial and spectator infrastructure mirrors that of traditional sport (Jang et al., 2020), and university scholarships and athletic self-descriptions indicate that the category of sport is being socially renegotiated (Bubna et al., 2023; Wollesen et al., 2025). Sociological work has also begun to theorize the social role of the body in competitive gaming (Riatti & Thiel, 2024), indicating that even sociological accounts do not treat esports as disembodied. Governance remains fragmented because competitive titles are controlled by their publishers and there is no single international governing authority with jurisdiction comparable to the sport-specific federations associated with many established Olympic sports.

Recognition within multisport governance remains partial and time-sensitive. To remain consistent with the review's final search date, the following account refers to information available as of 24 September 2026. The Olympic Council of Asia approved 11 esports medal events for Aichi-Nagoya 2026, held from 19 September to 4 October 2026 (Olympic Council of Asia, 2025b). The same council required the Asian regional esports federation to amend its constitution for good governance or lose recognition (Olympic Council of Asia, 2025a). The International Olympic Committee approved the creation of Olympic Esports Games in 2024 in partnership with the Saudi Olympic and Paralympic Committee, but the two parties ended that cooperation on 30 October 2025 (International Olympic Committee, 2025). In May 2026, the IOC President confirmed that the Esports Commission had been disbanded and that esports now sits within her Executive Office, with no timeline for the Games (Livingstone, 2026). These developments indicate significant institutional engagement without uniform or irreversible agreement about how esports should be integrated into established sport-governance structures.

## 4. Discussion

### *4.1. Mapping the Evidence onto the Classification Dimensions*

Table 1 and Figure 1 summarize how each evidence domain maps onto the five dimensions and where the major uncertainties lie. *Competition* and *rule-governance* are strongly represented: esports matches are adversarial, outcome-determined, and governed by explicit rules, although those rules are owned by publishers rather than by independent federations. *Institutionalization* is substantial but fragmented, and its recognition by multisport bodies is partial and reversible (Section 3.5). *Skill* is well supported as far as competitive expertise is concerned: esports-specific meta-analytic evidence shows expert–amateur differences in attention, spatial cognition, and gaze behavior, and psychological studies document sport-like stress and coping processes. The causal origin of this expertise, however, is unresolved, because most studies are cross-sectional and training studies suggest a role for pre-existing characteristics. *Physicality* is less strongly represented when defined primarily by substantial gross-motor performance and physiological loading (Section 3.4). These positions are not summed: consistent with the framework in Section 2.6, they describe where esports lies on each dimension, and the overall verdict depends on how the dimensions are weighted.

### *4.2. Expertise Is Not the Same as Sport: Alternative Explanations*

The central inferential risk in this debate is to move from evidence that esports involves genuine expertise to the conclusion that it is a sport. The properties most often cited in favor of classification—competitive stress, cognitive specialization, institutional organization, spectatorship, and professional identity—are also properties of chess, competitive bridge, music competitions, and other skilled competitive activities that most definitions do not classify as sport (Parry, 2019; Pluss et al., 2019). An alternative explanation for the evidence reviewed is therefore that esports is a highly developed competitive activity whose resemblance to sport reflects properties shared by skilled competition in general, not properties that define sport. On this explanation, the psychological, cognitive, and neuroscientific findings are exactly what one would expect of any demanding competitive domain, and they carry little weight for the classification question.

Two considerations prevent this alternative from settling the matter. First, unlike chess, esports performance requires rapid, precisely timed motor execution under time pressure, and motor speed and accuracy contribute to expertise (Kowalczyk-Grębska et al., 2021; Gostilovich et al., 2023). Esports may therefore be compared with both mind sports and precision sports, but this analogy does not itself settle the definitional question. Second, whether this fine-motor component counts as "physical" is precisely the normative question on which definitions diverge. The evidence reviewed here thus supports two conclusions of different strength: a well-supported conclusion that esports is a domain of competitive cognitive-motor expertise, and a conditional conclusion that esports is a sport only under definitions that do not require gross-motor exertion or substantial physiological load.

### *4.3. The Physicality Question and the Precision-Sport Analogy*

Comparisons with shooting, archery, and motorsport (Jenny et al., 2017) challenge simplistic assumptions that a sport must

involve high metabolic expenditure, but they do not eliminate the need to define the physical skill required for sport status. Table 3 compares the type and magnitude of motor demands across esports and several low-metabolic-demand traditional sports. Rifle and pistol shooting require whole-body postural stabilization, and postural stability distinguishes top-level from naive shooters (Era et al., 1996). Archery requires repeated high-force isometric drawing and holding in a standing posture, with performance-relevant autonomic regulation (Carrillo et al., 2011). Motorsport imposes sustained G-loading and heat strain, with heart rates far above those of the same drivers in a simulator (Holland et al., 2025). Esports, by contrast, involves distal, low-force, high-frequency inputs in a seated, externally supported posture, with a near-resting metabolic cost (Forman et al., 2025; Nicholson et al., 2024). The precision-sport analogy therefore identifies commonality in the type of motor control rewarded (precision and timing) while highlighting differences in the magnitude and nature of postural, force, and physiological demands. Heere's (2018) account of *sportification* offers an alternative to forcing a binary classification: esports can acquire increasingly sport-like organizational features without its status being settled by a single empirical test. Under the five-dimensional framework applied here, esports is strongly characterized by competition, rules, and trainable expertise; institutionalization is substantial but uneven, while the magnitude of whole-body physical demand is generally low in the studied formats. Whether this combination warrants classification as sport remains a normative question.

**Table 3** .Type and Magnitude of Motor and Physiological Demands in Esports and Selected Low-Metabolic-Demand Activities

| Activity | Principal motor task and effectors | Force and postural demand | Cardiovascular or metabolic load in performance | Illustrative evidence |
|---|---|---|---|---|
| **PC esports (MOBA, FPS, RTS)** | High-frequency, precisely timed fine-motor inputs (mouse, keyboard); bimanual distal coordination | Low force (wrist extensors ≤ 9.3% MVC while aiming); seated, externally supported posture | Near resting: energy 1.45 vs. 1.28 kcal·min⁻¹ at rest; HR +2–3 bpm; modest vagal withdrawal | Forman et al. (2025); Nicholson et al. (2024); Lyu et al. (2026) |
| **Simulated racing (esports)** | Steering, pedal, and gear inputs in a simulator | Low to moderate; no sustained G-loading | HR ≈ 112 bpm in professional drivers (hot-cockpit simulation) | Holland et al. (2025) |
| **Motorsport (authentic)** | Whole-vehicle control with neck and trunk stabilization | High: sustained G-forces; heat stress | HR ≈ 159 bpm in the same drivers; higher core temperature and physiological strain | Holland et al. (2025) |
| **Rifle and pistol shooting** | Whole-body postural stabilization with fine trigger control | Standing, load-bearing posture; postural stability distinguishes top-level from naive shooters | Low; not a principal performance determinant | Era et al. (1996) |
| **Archery** | Repeated isometric bow draw, hold, and release | Repeated high-force isometric upper-body effort in a standing posture | Low to moderate; experienced archers show greater parasympathetic modulation in competition | Carrillo et al. (2011) |
| **Chess (mind-sport reference)** | Piece movement only; motor execution incidental to outcome | Negligible | Not a performance determinant | Parry (2019); Pluss et al. (2019) |

*Note.* Values come from different studies with different protocols and are illustrative rather than directly comparable. The comparison shows that precision sports resemble esports in the *type* of skill rewarded (precision and timing) but exceed it in the *magnitude* of postural, force, or physiological demand. HR = heart rate; MVC = maximal voluntary contraction.

### *4.4. Implications for Research, Practice, and Governance*

For researchers, esports offers an opportunity to examine aspects of competitive expertise in settings with comparatively limited whole-body physical exertion; this advantage should not be taken to imply the absence of physiological or contextual confounding. Priority directions include longitudinal and controlled training designs with verified professional or high-ranked samples, direct comparisons with athletes on identical measures, genre-specific analyses, and preregistration, given evidence of bias in the adjacent action-video-game literature (Hilgard et al., 2019).

For practice, recommendations must be graded by evidence, because construct similarity does not establish intervention efficacy. Esports-specific intervention evidence is limited and mixed. A pilot of esports-adapted coping effectiveness training with five elite players increased perceived coping effectiveness and subjective performance but did not change psychological distress, well-being, or resilience, and it had no control group (Poulus et al., 2023). A randomized registered-report trial with 300 competitive *Counter-Strike* players found that a synergistic-mindsets intervention did not improve tournament performance (Behnke et al., 2024). An eight-week physical-training trial improved physical fitness without improving gaming performance (Wachholz et al., 2025), whereas small randomized trials suggest acute ergogenic effects of caffeine and γ-aminobutyric acid (Hara et al., 2025; Rogers et al., 2024). Other performance-oriented recommendations—such as mental-skills packages, pre-performance routines, and periodized recovery or conditioning—are primarily extrapolated from conventional sport and should be treated as interventions requiring esports-specific evaluation rather than established approaches. Physical activity and ergonomic measures remain justified on health grounds, given the low habitual activity and overuse complaints documented in players (DiFrancisco-Donoghue et al., 2022, 2025).

For governing bodies, the evidence does not settle classification, but it helps specify the competing considerations. Decisions to include or exclude esports are, in effect, decisions about how much weight physicality should carry relative to competitive cognitive-motor skill in each body's own definition of sport, and they must also contend with publisher ownership of competitive titles—a structural feature without a close parallel in traditional sport.

### *4.5. Limitations*

This synthesis has several limitations. First, this is a narrative review: selection was not governed by a registered protocol, the number of records screened was not recorded, study quality was appraised by design level rather than a formal risk-of-bias tool, and only English-language sources were included. Second, the authors' disciplinary perspective may have shaped selection and interpretation, although the physicality question was given dedicated treatment to counter this. Third, esports is heterogeneous: real-time-strategy, first-person-shooter, MOBA, fighting, and sports-simulation titles impose different demands, and pooled findings may not generalize across genres. Fourth, institutional recognition is changing quickly, and Section 3.5 describes the situation only as of September 2026. The implications of the cross-sectional evidence base and of the scarcity of direct athlete comparisons are stated where the relevant evidence is presented (Sections 3.1–3.4) rather than only here.

## 5. Conclusions

The psychological, cognitive, neuroscientific, physiological, and social evidence supports a well-founded conclusion that esports is a domain of competitive cognitive-motor expertise: players show measurable stress and coping processes, meta-analytic expert advantages in attention and spatial cognition, and expertise-associated neural characteristics, within an extensively institutionalized competitive system. The same evidence does not, by itself, establish that esports is a sport, because these properties are shared by other skilled competitive activities, and the dimension that discriminates sport from them—physicality—is only weakly met. Whether esports is called a sport therefore depends less on further evidence than on how much weight a given definition assigns to physical exertion. A graded conceptualization, in which esports is an atypical and borderline member of the sport category, is the position most consistent with current evidence. Longitudinal designs and direct comparisons with athletes are needed to establish whether the expertise documented here is acquired through practice or reflects selection.

## CRediT Authorship Contribution Statement

**R.K.J**: Conceptualization, Investigation, Writing – original draft, Visualization.

**M.K**: Conceptualization, Methodology, Validation, Writing – review & editing.

## Declaration of generative AI in scientific writing:

During the preparation and revision of this manuscript, the authors used Claude (Anthropic) to assist with language editing. The authors reviewed and edited all AI-assisted output and take full responsibility for the accuracy, originality, and integrity of the manuscript.

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## Data availability

No new data were created or analyzed in this study. This review synthesizes previously published literature and publicly available governance documents; all sources are listed in the reference list, with DOIs or URLs provided where available.

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