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Cognitive-motor coupling in beach volleyball: a systematic review of attention, anticipation, decision-making, and psychological-affective correlates of performance

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ABSTRACT

Beach volleyball is a physically demanding dyadic Olympic sport in which performance depends on interacting physical, technical, perceptual-cognitive, and psychological factors. This systematic review synthesised evidence on visual attention, anticipation, decision-making, cognitive load, and psychological-affective states in beach volleyball. Following PRISMA 2020 guidance, Scopus, PubMed, and ScienceDirect were searched during the review period; the database search reported in the manuscript yielded 982 records, of which 16 duplicates were removed and 966 were screened. Sixty-four reports were sought for full-text assessment, 59 were assessed for eligibility, and 22 studies met the prespecified inclusion criteria and entered the qualitative synthesis. Eligibility was structured using PICOS: beach volleyball participants or expertise comparators; perceptual-cognitive and/or psychological-affective constructs; performance- or expertise-related outcomes; and empirical peer-reviewed designs. Study quality was appraised with a transparent four-domain FICO rubric (Focus, Information, Context, Outcome), with scores of 7–8 classified as high quality and 5–6 as moderate; 19 of 22 studies were rated high quality and the median score was 7/8. The synthesis identified three interconnected themes: action-coupled attention and anticipation, cue- and heuristic-based decision-making under cognitive load, and psychological-affective regulation. Explicit participant samples ranged from 1 to 82 in studies reporting participant counts, while some studies used match-level datasets. Evidence was geographically concentrated: 8 studies were attributed to Germany and 8 to Brazil, with 3 from Estonia, 2 from Switzerland, and 1 from the Netherlands. The heterogeneity of designs and outcomes precluded quantitative meta-analysis. Overall, the evidence supports a cognitive-motor model in which perceptual expertise, decision processes, mental fatigue, and affective states jointly shape performance.



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Introduction

Beach volleyball has developed from a recreational activity into a highly professional Olympic sport and offers a distinctive setting for studying human performance. The two-player format, unstable sand surface, changing wind and light conditions, and continuous alternation among serving, receiving, setting, attacking, blocking, and defending place substantial demands on players' ability to perceive and act under time pressure. Research in dynamic ball sports indicates that performance in such environments depends not only on physical and

technical capacities but also on perceptual-cognitive processes that support the selection and use of task-relevant information (Pan et al., 2025). Neurocognitive research further suggests that expert performance is characterised by efficient information processing and task-relevant neural engagement (DeCouto et al., 2024). Accordingly, understanding how perception, cognition, affect, and movement interact is central to explaining and optimising beach volleyball performance.

The central concept examined in this review is cognitive-motor coupling: the functional relationship through which players perceive information, anticipate opponents' actions, make decisions, and translate those decisions into movement within rapidly changing rallies. In fast ball sports, the time available to respond to an opponent may be shorter than simple reaction time, making advance cue utilisation and anticipation essential (Afonso et al., 2014). Decision quality therefore depends on identifying relevant contextual information and selecting an appropriate action from several alternatives (Magnaguagno & Beck, 2025). These demands are amplified in beach volleyball because only two players cover the court and performance unfolds under environmental uncertainty, including wind, sunlight, and variable ball flight (Chowdhury, 2019).

A substantial literature has examined how athletes visually acquire information in volleyball and related open-skill sports. Eye-movement research shows that experts differ from less experienced performers in the temporal organisation of visual search during anticipation (Kanatschnig et al., 2025) and in the dynamics of gaze during decision-making (Fortin-Guichard et al., 2020). Expert anticipation can also draw on both foveal and peripheral information to identify an opponent's attacking intentions (Schorer et al., 2013). Developmental evidence indicates that perceptual-cognitive abilities improve with age and experience in youth volleyball players (De Waelle et al., 2021a), suggesting that attention and anticipation are trainable rather than fixed capacities.

Recent methodological developments have expanded this field toward cognitive-load, neurophysiological, and technology-mediated approaches. Experimental research shows that mentally fatiguing activities can impair volleyball decision-making and performance (Fortes et al., 2021), whereas different forms of fatigue may affect anticipation and action in distinct ways (Yu et al., 2025). EEG-based approaches have also been used to examine how working memory and attention contribute to athletic cognition (Delgado et al., 2025). In parallel, artificial-intelligence methods have been applied to predict tactical behaviour in volleyball, demonstrating the potential of data-driven approaches for performance analysis (Schrapf et al., 2022). Together, these developments support a broader ecological approach in which cognitive processes are studied in relation to task demands and action.

Despite this progress, evidence specific to beach volleyball remains fragmented. Much of the perceptual-cognitive literature comes from indoor volleyball or laboratory tasks, and expertise effects may vary across sports and stimulus conditions (Harrison et al., 2024). Findings from youth or non-beach volleyball populations, such as the role of visual cognition in age-related decision-making (De Waelle et al., 2021b), cannot be assumed to generalise directly to the two-player, open-air beach environment. Consequently, the sport-specific relationships among attention, anticipation, decision-making, and performance remain incompletely characterised.

A second research stream has focused on psychological and affective states. Early beach volleyball studies showed that the directional interpretation of competitive state anxiety may be more informative than anxiety intensity alone (Raudsepp & Kais, 2002) and that the perceived direction of cognitive and somatic anxiety, together with self-confidence, relates to technical performance (Kais & Raudsepp, 2004). Later work has highlighted idiosyncratic emotion-performance relationships (Raudsepp et al., 2008) and deliberate regulation of activation during high-level competition (Stefanello, 2007). Yet these affective findings have developed largely separately from research on perception, decision-making, and motor performance. A systematic synthesis that integrates these strands is therefore warranted.

This integration is also relevant to athlete welfare. Recent evidence among elite female beach volleyball players indicates clinically relevant symptoms of anxiety and depression alongside vulnerability associated with financial insecurity and limited social support (Niering et al., 2026). Broader research on performance under pressure likewise indicates that psychological interventions can influence choking-related performance declines, although effects vary by task and intervention (Zeng et al., 2026). Bringing together cognitive and affective evidence can therefore inform both performance optimisation and athlete-support systems. Accordingly, this systematic review maps and synthesises the beach volleyball literature around three research questions.

The first objective is to clarify how visual attention, gaze behaviour, and anticipation differentiate expertise and contribute to performance, while identifying implications for trainability and representative practice. RQ1: How do perceptual-cognitive processes-visual attention, gaze behaviour, and anticipation-differentiate expertise and shape performance in beach volleyball?

The second objective is to determine how decision-making is shaped by learned cues, strategic context, sequential outcomes, and cognitive load, with particular attention to mental fatigue. RQ2: What factors govern

decision-making in beach volleyball, and how do strategic, contextual, and cognitive-load factors, including mental fatigue, modulate decision quality and technical-tactical execution?

The third objective is to integrate psychological and affective evidence with perceptual-cognitive findings to develop a coherent account of cognitive-motor coupling in beach volleyball. RQ3: How do psychological and affective states-competitive anxiety, mood, affect, self-confidence, coping, and emotion regulation-relate to competitive performance in beach volleyball?

Method

Research Design and Framework

A systematic literature review was conducted to synthesise fragmented empirical evidence on perceptual-cognitive and psychological-affective determinants of beach volleyball performance. Reporting followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement (Page et al., 2021). The review was designed as a qualitative systematic synthesis because the included studies differed substantially in design, participants, constructs, measures, and outcomes; therefore, quantitative meta-analysis was not considered appropriate.

Search Strategy

A compound Boolean strategy linked beach-volleyball population terms with perceptual-cognitive and psychological-affective construct terms in titles, abstracts, and keywords. Truncation was used to capture word variants, and field codes were adapted to each database. The core search string was:

("beach volleyball" OR "beach volley" OR "sand court*") AND ("anticipat*" OR "decision*" OR "gaze" OR "visual search" OR "perceptual-cognitive" OR "attention" OR "cognit*" OR "mental fatigue" OR "anxiety" OR "mood" OR "affect*" OR "emotion*" OR "psychological*")*

Database searches were conducted in 2025 and subsequently updated through 2026 to capture newly indexed literature. Eligibility filtering was applied after retrieval rather than as an automatic database exclusion step.

Database and Information Sources

Three complementary sources were searched: Scopus for broad multidisciplinary coverage, PubMed for biomedical and sports-medicine indexing, and ScienceDirect for publisher-platform coverage of journal literature. The search records reported in the manuscript yielded 263 records from Scopus, 619 from PubMed, and 100 from ScienceDirect, for 982 records before duplicate removal. The restriction to three databases may have omitted studies indexed elsewhere and is therefore treated as a source-selection limitation.

Eligibility criteria

Eligibility was operationalised through the PICOS framework and applied consistently at screening and full-text assessment. Studies were eligible when they involved beach volleyball players or expertise comparators, examined at least one perceptual-cognitive or psychological-affective construct, reported a performance-, expertise-, decision-, or psychological outcome relevant to the review questions, and used a peer-reviewed empirical design. The framework and operational criteria are detailed in Tables 1 and 2.

Table 1. PICOS framework guiding the eligibility criteria.

Element	Definition applied in this review
Population (P)	Beach volleyball players of any competitive level (youth to elite/Olympic), coaches or referees where they served as expertise comparators, of either sex.
Interest / Exposure (I)	Perceptual-cognitive processes (visual attention, gaze behaviour, anticipation, decision-making) and/or psychological-affective states (anxiety, mood, affect, self-confidence, coping, emotion regulation, mental fatigue).
Comparison (C)	Skill or expertise level, experimental vs. control conditions, winners vs. losers, or within-subject manipulations; a comparison was not mandatory for descriptive designs.
Outcome (O)	Indicators of performance, expertise differentiation, technical-tactical execution, decision quality, or performance-related psychological outcomes.
Study design (S)	Peer-reviewed empirical journal articles: experimental, quasi-experimental, cross-sectional, observational/notational, qualitative, or single-case designs.

Table 2. Inclusion and exclusion criteria.

Criterion	Inclusion	Exclusion
Language	English-language full text	Non-English without an English full text
Document type	Peer-reviewed journal article (empirical)	Conference paper, book/book chapter, editorial, note, erratum, retracted item
Population	Beach volleyball players/experts	Other sports or non-sport samples; incidental mention of beach volleyball
Focus	Perceptual-cognitive and/or psychological-affective construct linked to performance	Purely physical, physiological, biomechanical, injury/epidemiological, or match-analysis studies with no cognitive/psychological outcome
Accessibility	Full text retrievable	Full text unavailable
Relevance	Directly addresses attention, anticipation, decision-making, or psychological states	Tangential or non-substantive treatment of the constructs

Study Selection Process

Records from the three databases were combined, and duplicates were removed using DOI matching and, when a DOI was unavailable, matching of title, authors, and publication year. The deduplicated records were screened against the eligibility criteria at title and abstract level. Reports potentially meeting the criteria were sought for retrieval and assessed in full text. Full-text exclusion reasons were recorded. Ambiguous cases were resolved by re-reading the full text against the PICOS criteria and retaining a study only when a beach volleyball sample or expertise comparator and at least one eligible cognitive or psychological outcome were clearly documented. The available manuscript does not retain reviewer-level decision logs; consequently, an inter-rater coefficient such as Cohen's kappa cannot be reconstructed retrospectively and is not reported.

Quality Assessment - FICO Framework

Methodological quality was appraised with a transparent, study-specific four-domain FICO rubric: Focus, Information, Context, and Outcome. Focus assessed alignment between the study aim and the review constructs; Information assessed methodological rigour, sampling, and measurement; Context assessed ecological relevance to beach volleyball; and Outcome assessed clarity and completeness of reported findings. Each domain was scored 0–2, yielding a total of 0–8. Scores of 7–8 were classified as high quality, 5–6 as moderate, and 4 or below as low; a minimum score of 5 was required for inclusion. Because FICO is a review-specific rubric rather than a formally validated external appraisal instrument, this limitation is explicitly acknowledged in the Discussion.

Data Extraction Procedure

A standardised extraction template captured first author and year, research-group and participant country where reported, study design, sample characteristics, construct examined, technology or intervention, principal outcome measures, and key findings. Extracted information was checked against the source reports and organised into tables to support cross-study comparison and thematic synthesis.

Network and Bibliometric Analysis Methodology

Descriptive bibliometric procedures were used only to characterise the corpus. We calculated the temporal distribution of included studies, geographic distribution by research-group country, and distribution of studies across the three thematic clusters. These analyses were descriptive and were not used for inferential network modelling.

Data Analysis and Synthesis

Given the heterogeneity of study designs and outcomes, thematic synthesis followed the approach of Thomas and Harden (2008). Findings were coded inductively, related codes were grouped into descriptive themes, and the themes were organised into three analytical clusters aligned with the research questions: visual attention and anticipation; decision-making and cognitive load; and psychological and affective states. The synthesis explicitly considered convergence, contradiction, study design, sample size, ecological validity, and the strength or direction of reported associations or effects.

Reporting and Documentation

PRISMA 2020 reporting was used to document identification, screening, eligibility, and inclusion. The flow counts are 982 records identified, 16 duplicates removed, 966 records screened, 902 records excluded at title/abstract level, 64 reports sought for retrieval, 5 reports not retrieved, 59 reports assessed for eligibility, 37 reports excluded at full text, and 22 studies included in the qualitative synthesis.

Results and Discussions

Study Selection Results

The database search yielded 982 records (Scopus, $n = 263$; PubMed, $n = 619$; ScienceDirect, $n = 100$). After 16 duplicates were removed, 966 records were screened. Of these, 902 were excluded at title/abstract level. Sixty-four reports were sought for retrieval, 5 could not be retrieved, and 59 were assessed in full text. Thirty-seven reports were excluded because they did not contain a beach volleyball sample or relevant expertise comparator ($n = 14$), did not report a relevant perceptual-cognitive or psychological outcome ($n = 16$), or were an ineligible publication type ($n = 7$). Twenty-two studies therefore met the inclusion criteria and entered the qualitative synthesis. These counts are consistent with the PRISMA flow diagram (Figure 1).

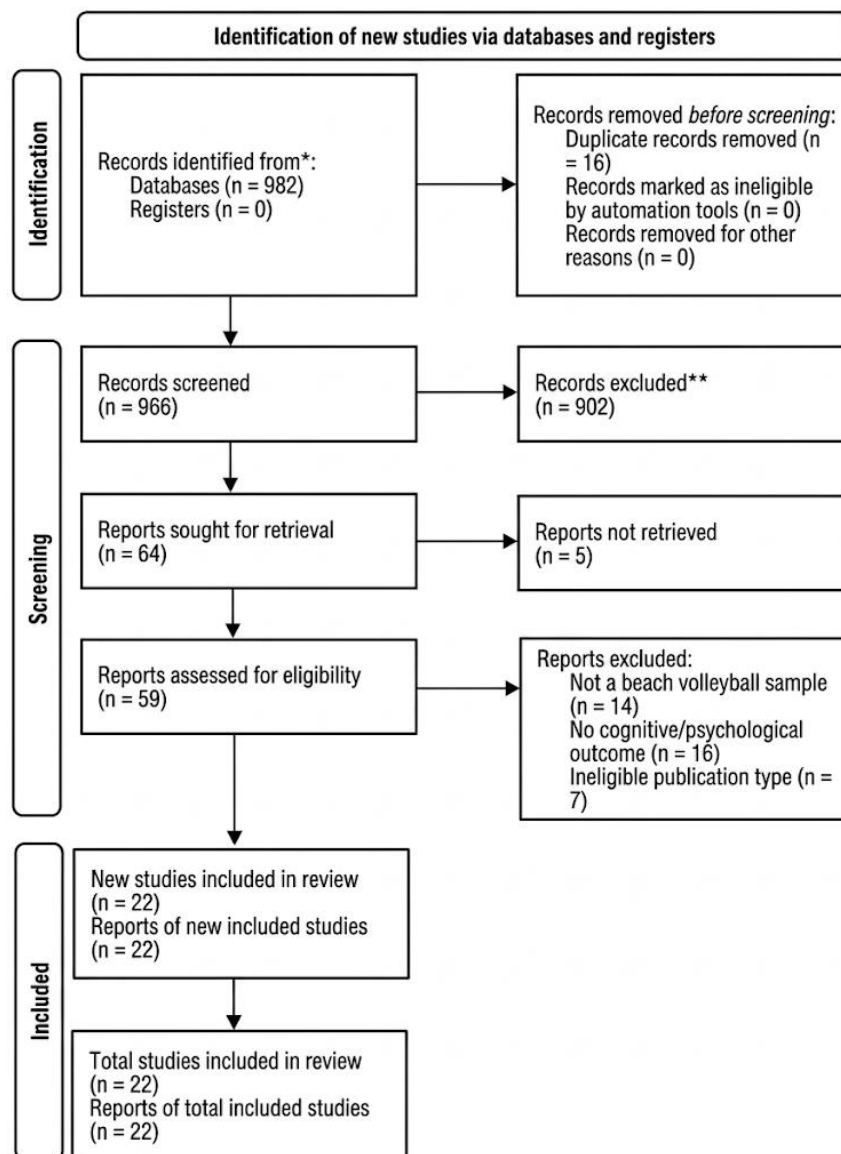


Figure 1. PRISMA 2020 flow diagram of the study selection process (adapted from Page et al., 2021).

Descriptive Characteristics

The 22 included studies were published between 2002 and 2026. Earlier work was dominated by cross-sectional, single-case, and observational designs, whereas later studies increasingly used controlled experiments, crossover designs, mixed methods, eye-tracking, and large match datasets. The thematic distribution indicates a recent growth of research on decision-making and cognitive load. Geographic attribution was based on research-group country: Germany accounted for 8 studies (36.4%), Brazil for 8 (36.4%), Estonia for 3 (13.6%), Switzerland for 2 (9.1%), and the Netherlands for 1 (4.5%). Thus, 14 of 22 studies (63.6%) were attributed to European research groups, whereas 8 (36.4%) were attributed to Brazil. This pattern reflects research-group location rather than a direct estimate of participant-nationality distribution.

Table 3. Characteristics of the 22 included studies (full titles retained).

Author(s), year; country	Design	Sample	Full title	Key findings
Raudsepp & Kais (2002); Estonia	Cross-sectional (CSAI-2)	54 male players	The relationship between state anxiety and performance in beach volleyball players	Facilitative (positive) direction of pre-competitive anxiety and self-confidence related positively to performance; international players read anxiety as more facilitative than national players.
Kais & Raudsepp (2004); Estonia	Correlational; video-rated	66 male players	Cognitive and somatic anxiety and self-confidence in athletic performance of beach volleyball	Directional cognitive/somatic anxiety and self-confidence significantly predicted skill performance, accounting for about 42% of variance.
Stefanello (2007); Brazil	Single-case, competition	Olympic-champion male dyad	Regulation of activation levels in high performance beach volleyball: A case study with Olympic champions	Elite athletes deployed identifiable psychological strategies to self-regulate activation toward an individualised optimal performance state during matches.
Raudsepp, Rikberg & Kais (2008); Estonia	Single-case; idiosyncratic modelling	1 international male player	Affect and performance of an expert beach volleyball player according to an idiosyncratic probabilistic method	Individual affect-related performance zones existed and fluctuated across matches, supporting an idiosyncratic emotion-performance relationship for serve and attack.
Cañal-Bruland, Mooren & Savelsbergh (2011); Netherlands	Temporal-occlusion experiment	8 players, 8 coaches, 8 referees, 8 novices	Differentiating experts' anticipatory skills in beach volleyball	Perceptual-motor experts (players, coaches) out-anticipated watching-only referees and novices at ball contact, indicating perceptual-motor experience underpins anticipation.
Belem et al. (2014); Brazil	Cross-sectional (ACSI-28, CD-RISC)	48 elite athletes	Impact of coping strategies on resilience of elite beach volleyball athletes	Personal coping resources and coping with adversity were the strongest predictors of resilience among elite athletes.
Klostermann et al. (2015); Switzerland	Perceptual-training experiment	Beach volleyball defenders	Perceptual training in beach volleyball defence: Different effects of gaze-path cueing on gaze and decision-making	Gaze-path (colour) cueing altered gaze but not decisions; an anticipation-instruction control produced the largest decision gains, challenging colour-cueing methods.
Schläppi-Lienhard & Hossner (2015); Switzerland	Qualitative interviews; content analysis	19 world-tour defenders (7 Olympic/world champions)	Decision making in beach volleyball defense: Crucial factors derived from interviews with top-level experts	Identified the crucial cues and their interaction with gaze behaviour that structure expert defensive decision-making.
Noël, Hüttermann, van der Kamp & Memmert (2016); Germany	Two experiments	Beach volleyball servers	Courting on the beach: How team position implicitly influences decision-making in beach volleyball serves	Players unconsciously served toward the larger court area created by asymmetric receiver positioning; attentional allocation scaled the implicit effect.
Link & Wenninger (2019); Germany	Observational; large-scale match analysis	965 elite matches; 28,974 sideouts	Performance streaks in elite beach volleyball – Does failure in one sideout affect attacking in the next?	After a sideout miss, players increased technique switching (spike/shot) in the next sideout, evidencing outcome-dependent adaptation of attacking behaviour.

Author(s), year; country	Design	Sample	Full title	Key findings
Wergin, Beckmann, Gröpel & Mesagno (2020); Germany	Randomised pre/post pressure test	54 players	Investigating cumulative effects of preperformance routine interventions in beach volleyball serving	Cumulative and isolated pre-performance routines did not improve serve accuracy under induced pressure, questioning brief-routine efficacy for choking prevention.
Klatt, Rückel, Wagener & Noël (2021); Germany	Cross-sectional profiling	82 elite players (dyads)	Personality Traits and Emotion Regulation Styles of Elite Beach Volleyball Dyads	Successful athletes showed higher emotional stability and lower neuroticism; personality congruence and emotion-regulation style within dyads related to performance and satisfaction.
Nicklas et al. (2022); Germany	Eye-tracking; pressure manipulation	18 expert players	Gaze behavior in social interactions between beach volleyball players- An exploratory approach	Higher performance pressure increased fixation frequency and duration on teammates' faces, suggesting a heightened need for reliable non-verbal communication.
Costa, de Farias et al. (2023); Brazil	Simulated competition (POMS)	16 young male athletes	Comparison of pre-competition mood state between winners and losers: A study with young beach volleyball athletes	An 'iceberg' mood profile prevailed; winners and losers differed significantly on specific mood dimensions, linking pre-match mood to outcome.
da Silva et al. (2023); Brazil	Cross-sectional; Bayesian	Beach volleyball athletes	The Impact of Sleep Quality on Mood in Beach Volleyball Athletes: A Cross-Sectional Study	Sleep quality was associated with pre-match mood states; poorer sleep related to less adaptive mood profiles.
Da Costa, Fortes et al. (2023); Brazil	Real-world case study (VAS)	7 world-class players; 30 matches	Mental fatigue measured in real-world sport settings: A case study of world class beach volleyball players	Perceived mental fatigue rose significantly from pre- to post-match and was associated with technical-tactical effort in ecologically valid competition.
Ittlinger, Lang, Link & Raab (2024); Germany	Mixed-method (survey, Olympic data, experiment)	Coaches; elite athletes; Tokyo data	Sequential Decision Making in Beach Volleyball-A Mixed-Method Approach	Coaches and players believed in the hot hand and followed sequential-choice-theory predictions but did not reliably detect base-rate change-a belief-accuracy gap.
Domingos-Gomes et al. (2024); Brazil	Crossover RCT (Stroop)	12 young males	The mental fatigue impaired beach volleyball attack technical-tactical performance: A crossover and randomized study	Experimentally induced mental fatigue significantly reduced attack coefficient of performance and efficiency.
Ittlinger, Lang, Schubert & Raab (2025); Germany	Mixed-methods; large dataset	43 national-team members; 6,571 matches	How cognitive biases affect winning probability perception in beach volleyball experts	Experts systematically overestimated set-winning probabilities and showed optimism and sunk-cost biases that shape in-game strategic decisions.
Costa, Lopes-da-Silva et al. (2025); Brazil	Randomised crossover pilot	12 trained males	Effect of caffeine on attack decision-making in trained beach volleyball players following prolonged cognitive effort induced by social media use	Low-dose caffeine counteracted mental-fatigue-related impairment of attack decision-making, indicating a pharmacological countermeasure to cognitive fatigue.
Barbosa et al. (2025); Brazil	Randomised crossover; LED visuomotor	14 athletes	Mental fatigue and sleep restriction effects on perceptual-cognitive	Mental fatigue and sleep restriction each impaired perceptual-cognitive reaction

Author(s), year; country	Design	Sample	Full title	Key findings
Niering, Engel, Beurskens & Seifert (2026); Germany	Cross-sectional prevalence	52 FIVB top-200 female players	performance in trained beach volleyball athletes Prevalence of depression and anxiety symptoms among elite female beach volleyball players in the FIVB top 200	time in defensive/blocking simulations, with combined effects most detrimental. Anxiety and depressive symptoms were present in elite female players; financial insecurity and low perceived social support emerged as vulnerability factors.

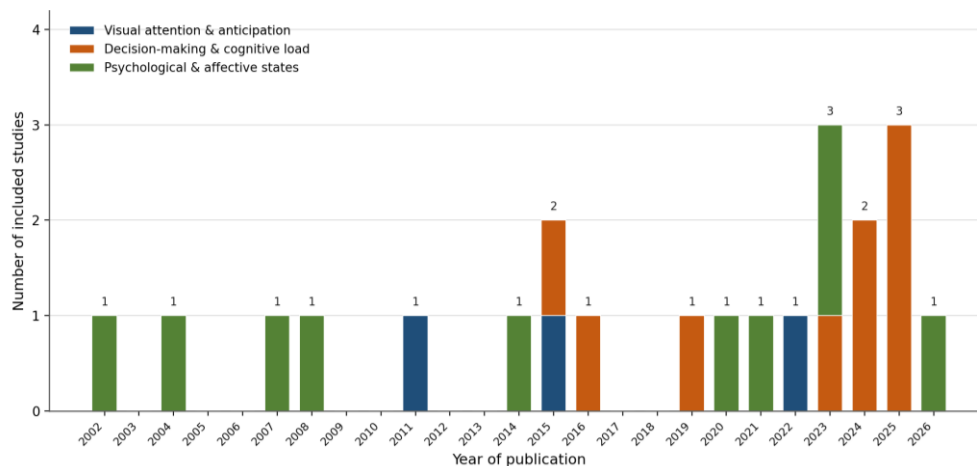


Figure 2. Temporal distribution of the included studies by thematic cluster (2002–2026).

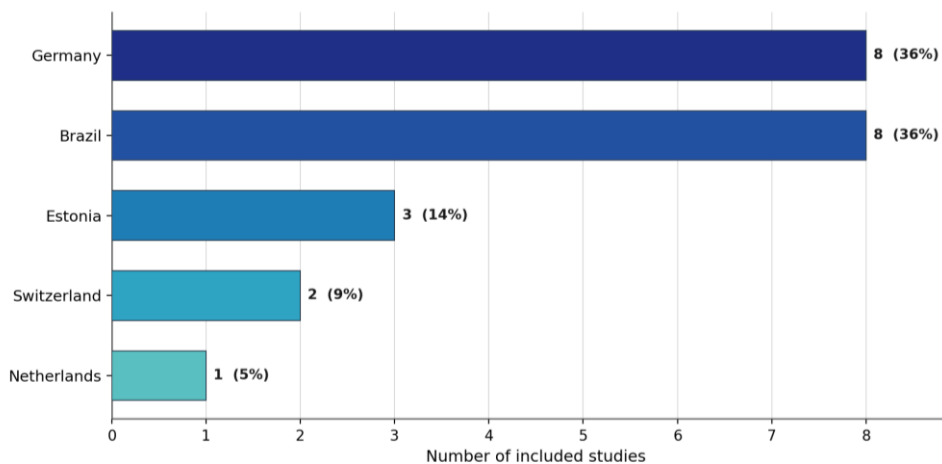


Figure 3. Geographic distribution of the included studies by research-group country (n = 22).

Table 4. Thematic and methodological classification of included studies.

Author(s), year	Theme / research question	Construct	Method	Main outcome
Cañal-Bruland et al. (2011)	RQ1 – Attention & anticipation	Anticipatory (occlusion) skill	Temporal-occlusion experiment	Perceptual-motor experts anticipate best at ball contact
Klostermann et al. (2015)	RQ1 – Attention & anticipation	Gaze training; decision	Training experiment	Gaze cueing changes gaze, not decisions
Nicklas et al. (2022)	RQ1 – Attention & anticipation	Gaze in social interaction	Eye-tracking	Pressure increases fixation on teammate's face
Schläppi-Lienhard & Hossner (2015)	RQ2 – Decision-making & cognitive load	Expert decision cues	Qualitative interviews	Cue-gaze framework for defensive decisions
Noël et al. (2016)	RQ2 – Decision-making & cognitive load	Implicit decision	serve Experiments	Receiver position implicitly biases serve target

Author(s), year	Theme / research question	Construct	Method	Main outcome
Link & Wenninger (2019)	RQ2 – Decision-making & cognitive load	Outcome-dependent choice	Match analysis	Miss increases technique switching next sideout
Ittlinger et al. (2024)	RQ2 – Decision-making & cognitive load	Sequential choice; hot hand	Mixed-method	Belief in hot hand exceeds detection accuracy
Ittlinger et al. (2025)	RQ2 – Decision-making & cognitive load	Cognitive probability bias;	Mixed-methods	Experts overestimate winning probabilities
Da Costa, Fortes et al. (2023)	RQ2 – Decision-making & cognitive load	Mental fatigue (field)	Case study	Mental fatigue accumulates across matches
Domingos-Gomes et al. (2024)	RQ2 – Decision-making & cognitive load	Mental fatigue; attack	Crossover RCT	Mental fatigue impairs attack performance
Costa, Lopes-da-Silva et al. (2025)	RQ2 – Decision-making & cognitive load	Mental fatigue; caffeine	Crossover pilot	Caffeine restores fatigued decision-making
Barbosa et al. (2025)	RQ2 – Decision-making & cognitive load	Fatigue; perceptual-cognitive RT	Crossover	Fatigue and sleep loss slow visuomotor reactions
Raudsepp & Kais (2002)	RQ3 – Psychological & affective states	State anxiety direction	Cross-sectional	Facilitative anxiety relates to performance
Kais & Raudsepp (2004)	RQ3 – Psychological & affective states	Anxiety; self-confidence	Correlational	Anxiety direction predicts skill execution
Stefanello (2007)	RQ3 – Psychological & affective states	Activation regulation	Single-case	Elite self-regulation of activation
Raudsepp et al. (2008)	RQ3 – Psychological & affective states	Affect zones (IAPZ)	Single-case	Idiosyncratic affect-performance zones
Belem et al. (2014)	RQ3 – Psychological & affective states	Coping; resilience	Cross-sectional	Coping resources predict resilience
Wergin et al. (2020)	RQ3 – Psychological & affective states	Pre-performance routine	Randomised test	Brief routines do not curb choking
Klatt et al. (2021)	RQ3 – Psychological & affective states	Personality; emotion regulation	Cross-sectional	Emotional stability marks successful dyads
Costa, de Farias et al. (2023)	RQ3 – Psychological & affective states	Pre-competition mood	Simulated competition	Mood profile differs by match outcome
da Silva et al. (2023)	RQ3 – Psychological & affective states	Sleep; mood	Cross-sectional	Sleep quality shapes pre-match mood
Niering et al. (2026)	RQ3 – Psychological & affective states	Anxiety; depression	Cross-sectional	Symptom prevalence in elite women



Figure 4. Thematic clustering of the included studies across publication periods.

Table 5. Methodological quality appraisal using the FICO rubric (0–2 per domain).

Study	F	I	C	O	Total /8	Rating
Raudsepp & Kais (2002)	2	1	1	2	6	Moderate
Kais & Raudsepp (2004)	2	2	1	2	7	High
Stefanello (2007)	2	1	2	1	6	Moderate
Raudsepp et al. (2008)	2	1	2	1	6	Moderate
Cañal-Bruland et al. (2011)	2	2	2	2	8	High
Belem et al. (2014)	2	2	1	2	7	High
Klostermann et al. (2015)	2	2	2	2	8	High
Schläppi-Lienhard & Hossner (2015)	2	2	2	1	7	High
Noël et al. (2016)	2	2	2	2	8	High
Link & Wenninger (2019)	2	2	2	2	8	High
Wergin et al. (2020)	2	2	2	2	8	High
Klatt et al. (2021)	2	2	1	2	7	High
Nicklas et al. (2022)	2	2	2	1	7	High
Costa, de Farias et al. (2023)	2	1	2	2	7	High
da Silva et al. (2023)	2	2	1	2	7	High
Da Costa, Fortes et al. (2023)	2	2	2	1	7	High
Ittlinger et al. (2024)	2	2	2	2	8	High
Domingos-Gomes et al. (2024)	2	2	2	2	8	High
Ittlinger et al. (2025)	2	2	2	2	8	High
Costa, Lopes-da-Silva et al. (2025)	2	2	2	1	7	High
Barbosa et al. (2025)	2	2	2	2	8	High
Niering et al. (2026)	2	2	2	2	8	High

F = Focus; I = Information (methodological rigour); C = Context (ecological validity); O = Outcome (clarity/completeness). Scores ranged from 6 to 8, with a median of 7 and a mean of 7.32/8. Nineteen studies (86.4%) were rated high quality and three (13.6%) were rated moderate. All included studies met the minimum inclusion threshold of 5.

Thematic Synthesis

Findings for RQ1 - Visual attention and anticipation

The first cluster indicates that beach volleyball expertise is associated with action-specific perceptual-cognitive functioning rather than generic visual ability. Using temporal occlusion, Cañal-Bruland et al. (2011) showed that perceptual-motor experts-players and coaches-anticipated attacking outcomes more accurately than referees with extensive watching experience but less motor expertise, and than novices, particularly near ball contact. This contrast suggests that effective anticipation is linked to an athlete's action repertoire and sport-specific experience. The interpretation is consistent with wider volleyball evidence on expertise-related gaze dynamics during anticipation (Kanatschnig et al., 2025; Fortin-Guichard et al., 2020).

The trainability of visual-attentional skills is more nuanced than a simple gaze-improvement account. Klostermann et al. (2015) found that colour-based gaze-path cueing changed gaze behaviour without improving decisions, whereas an anticipation-instruction condition produced the largest decision gains. This result suggests that overt fixation location and functional information use are not interchangeable. It also supports evidence that both foveal and peripheral information contribute to anticipation (Schorer et al., 2013) and that perceptual-cognitive skill develops with experience (De Waele et al., 2021a).

Attention is also socially embedded and sensitive to competitive pressure. Nicklas et al. (2022) reported more frequent and longer fixations on teammates' faces under higher pressure, consistent with increased reliance on non-verbal communication within the dyad. Together, the evidence answers RQ1 by indicating that attention and anticipation are expertise-sensitive, action-coupled, and socially embedded processes, and that training should preserve the link between information pick-up and task execution.

Findings for RQ2 - Decision-making and cognitive load

The second and largest cluster concerns the cues, heuristics, and contextual constraints that shape in-game decisions. Schäppi-Lienhard and Hossner (2015) identified a set of decision-relevant cues and their interaction with gaze behaviour among world-tour defenders, while Noël et al. (2016) showed that receiver positioning can implicitly bias serve targeting toward the larger available court area. At the level of match behaviour, Link and Wenninger (2019) analysed 28,974 sideouts across 965 elite matches and found that a missed sideout increased subsequent technique switching, indicating outcome-dependent adaptation.

These heuristics can be adaptive yet imperfect. Ittlinger et al. (2024) found that coaches and players believed in the hot hand and showed patterns consistent with sequential-choice theory, while recognition of changes in base rates was limited. Ittlinger et al. (2025) similarly showed systematic distortions in perceived set-winning probabilities among experts. In that study, participants overestimated winning probabilities when trailing and underestimated them when leading; one reported discrepancy during late leading scenarios was associated with

$d = 0.77$. These findings caution against equating expertise with perfect calibration and support the value of naturalistic decision research (Magnaguagno & Beck, 2025).

Decision quality is particularly vulnerable to cognitive load. Field evidence indicates that perceived mental fatigue increases across real competition and is associated with technical-tactical effort (Da Costa, Fortes et al., 2023). In a crossover experiment involving 12 young male players, experimentally induced mental fatigue reduced attack performance; the reported mental-fatigue effect on the manipulation check was $ES = 0.90$, and both attack coefficient of performance and efficiency were lower in the fatigue condition (Domingos-Gomes et al., 2024). A separate study of 14 athletes found that mental fatigue and sleep restriction slowed perceptual-cognitive reaction time, with the combined condition most detrimental (Barbosa et al., 2025). A pilot crossover study of 12 trained young male players also reported improved attack decision-making following caffeine ingestion after prolonged cognitive effort (Costa, Lopes-da-Silva et al., 2025). These findings answer RQ2 by showing that decision-making is cue- and heuristic-based, can be biased, and is sensitive to mental fatigue, while some experimentally tested countermeasures may attenuate impairment.

Findings for RQ3 - Psychological and affective states

The third cluster concerns affective and dispositional conditions associated with performance. Early beach volleyball studies indicated that the direction in which athletes interpreted competitive anxiety was more informative than anxiety intensity alone: facilitative interpretations of cognitive and somatic anxiety, together with self-confidence, were associated with better performance (Raudsepp & Kais, 2002; Kais & Raudsepp, 2004). Individualised modelling further suggested that affect-performance relationships may shift across matches (Raudsepp et al., 2008), while a case study of Olympic champions documented deliberate regulation of activation toward a personally optimal state (Stefanello, 2007).

Mood, sleep, coping, and dyadic regulation also show relevant associations. Pre-competition mood profiles differed between winners and losers in young athletes (Costa, de Farias et al., 2023), and sleep quality was associated with pre-match mood (da Silva et al., 2023). Coping resources were associated with resilience in elite players (Belem et al., 2014), while emotional stability and emotion-regulation styles differentiated more successful and satisfied dyads (Klatt et al., 2021). These findings reinforce the importance of treating the pair as a psychological-performance unit in a two-player sport.

The evidence does not support assuming that every psychological strategy is effective. Wergin et al. (2020) found that brief pre-performance routines did not reliably improve serve accuracy under induced pressure. In parallel, Niering et al. (2026) reported clinically relevant self-reported anxiety and depressive symptoms in 52 elite female players, indicating that athlete welfare should be considered alongside performance outcomes. Taken together, RQ3 is answered by evidence that psychological states are directional, individualised, and dyadically embedded, but their associations with performance remain dependent on context and study design.

Comparative and methodological interpretation. The corpus shows a transition from cross-sectional, single-case, and observational work toward controlled experiments, crossover studies, mixed methods, and technology-assisted assessment. Perceptual-cognitive studies generally achieve strong experimental control but may sacrifice ecological fidelity; decision-making studies increasingly triangulate laboratory and match-level evidence; and psychological studies rely heavily on self-report, which is efficient but vulnerable to recall and social-desirability bias. Explicit participant counts reported in the included studies ranged from 1 athlete to 82 athletes, while other studies were based primarily on large match datasets. This heterogeneity limits direct comparison and means that findings should be interpreted as convergent evidence rather than as pooled estimates.

Interpretation of findings. Across the three research questions, the evidence supports an integrated perceptual-cognitive-affective account of beach volleyball performance. Anticipation is linked to sport-specific action capabilities; decision-making depends on learned cues and heuristics that may be adaptive or biased; and affective states shape the conditions under which perception and choice are expressed. Mental fatigue provides one cross-cutting mechanism because it can degrade perceptual-cognitive reaction time and technical-tactical decision execution.

Theoretical implications. The findings are compatible with ecological and embodied accounts of expertise, in which information pick-up is constrained by available action capabilities (Cañal-Bruland et al., 2011). They also support individualised approaches to emotion-performance relationships (Raudsepp et al., 2008) and extend naturalistic decision-making perspectives by showing that elite expertise does not eliminate cognitive bias (Ittlinger et al., 2024, 2025). The resulting model is therefore better represented as a dynamic cognitive-motor system than as a set of independent psychological and perceptual modules.

Practical implications. Training should prioritise representative perceptual-cognitive tasks that preserve the coupling between information and action, rather than relying exclusively on isolated gaze drills (Klostermann

et al., 2015). Coaches should also monitor mental fatigue and sleep, because beach-specific evidence indicates slower perceptual-cognitive responses and reduced technical-tactical performance under fatigue and sleep restriction (Barbosa et al., 2025; Domingos-Gomes et al., 2024). Psychological support should target functional interpretations of anxiety, dyadic emotion regulation, coping, and athlete welfare rather than assuming that brief generic routines will prevent performance breakdowns (Kais & Raudsepp, 2004; Klatt et al., 2021; Wergin et al., 2020).

Comparison with prior reviews and wider evidence. The present synthesis complements broader reviews of mental fatigue in Olympic ball sports (Pan et al., 2025) and pressure-related interventions (Zeng et al., 2026). Those reviews provide cross-sport context, whereas the current synthesis isolates beach volleyball and integrates perception, decision-making, and affect. The convergence across beach-specific and broader evidence strengthens the interpretation that cognitive load and pressure are not peripheral issues but central constraints on open-skill performance.

Contradictions and boundary conditions. Several findings qualify a simple linear model. Gaze-path cueing altered eye movements without improving decisions in one experiment (Klostermann et al., 2015), suggesting that where athletes look is not equivalent to how they use information. Expert belief in the hot hand coexisted with limited sensitivity to genuine changes in performance probabilities (Ittlinger et al., 2024), and brief routines did not reliably prevent pressure-related performance loss (Wergin et al., 2020). These differences indicate that intervention plausibility and athlete confidence cannot substitute for demonstrated efficacy.

Limitations of the evidence base and the review. The evidence base is geographically concentrated and includes many small samples; research-group attribution indicates that 14 of 22 studies (63.6%) came from European research groups, with the remaining 8 (36.4%) from Brazil. This distribution limits cultural and structural generalisability. The review itself is limited by the use of three databases, English-language full-text eligibility, substantial methodological heterogeneity, and the use of a study-specific FICO appraisal rubric rather than a formally validated external tool. Because the screening archive does not retain reviewer-level decisions, Cohen's kappa could not be reconstructed retrospectively. Formal publication-bias testing was also not performed because the review did not pool effect sizes statistically.

Research gaps and future directions. Longitudinal studies are needed to track the development of cognitive-motor coupling across seasons and skill levels. In-situ eye-tracking and portable neurophysiological measures could clarify mechanisms during authentic competition. Future intervention trials should use adequately powered, multi-site designs with performance and athlete-welfare outcomes. Research should also broaden the geographic and demographic base of participants and report effect sizes and confidence intervals consistently to facilitate future quantitative synthesis.

Synthesis across the research questions. RQ1 is answered by evidence that attention and anticipation differentiate expertise through action-coupled and socially embedded information use. RQ2 is answered by evidence that decision-making relies on learned cues and heuristics and is vulnerable to cognitive fatigue and bias, with preliminary evidence for targeted countermeasures. RQ3 is answered by evidence that anxiety direction, mood, coping, emotion regulation, and broader psychological states are associated with performance and athlete welfare, but that effects vary by context and cannot be reduced to trait anxiety alone.

Future research agenda. Future work should, first, conduct multi-season longitudinal studies that trace how attention, decision-making, and affect co-develop and interact in beach volleyball; second, deploy portable neurophysiological and eye-tracking technologies during authentic competition to move from association to mechanism; and third, run adequately powered, multi-site intervention trials-spanning perceptual-cognitive training, mental-fatigue countermeasures, and psychological-skills programmes-with performance and welfare follow-up. Broadening the geographic and demographic base of the research would further strengthen generalisability.

In summary, the three research questions can be answered directly. Regarding RQ1, perceptual-cognitive processes differentiate expertise through action-coupled anticipation and socially embedded, pressure-sensitive attention. Regarding RQ2, decision-making is governed by learned cues and heuristics that are systematically biased and readily degraded by cognitive fatigue, yet amenable to countermeasures. Regarding RQ3, psychological and affective states-especially the direction of anxiety, mood, coping, and dyadic emotion regulation-are consistent and welfare-relevant determinants of competitive performance.

Conclusions

This systematic review synthesised 22 empirical studies examining perceptual-cognitive and psychological-affective determinants of beach volleyball performance. The qualitative thematic synthesis identified three

interconnected domains. First, expertise is associated with action-coupled attention and anticipation, and representative training appears more defensible than isolated gaze manipulation. Second, decision-making is guided by learned cues and heuristics but can be distorted by cognitive bias and degraded by mental fatigue and sleep restriction; preliminary countermeasure evidence is promising but remains limited. Third, competitive anxiety direction, mood, coping, emotion regulation, and other affective states are associated with performance and athlete welfare, particularly within the dyadic team context. The principal contribution is an integrated cognitive-motor model that treats perception, decision-making, and affect as mutually constraining processes rather than independent abilities. However, the evidence is heterogeneous, geographically concentrated, and often based on small samples. Because no quantitative pooling was undertaken, the review does not claim pooled effect sizes or statistical power. Future research should use preregistered, longitudinal, multi-site, and ecologically valid designs and report comparable effect estimates so that subsequent reviews can move from qualitative integration toward quantitative prediction and intervention.

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