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Sports nutrition and mental toughness in athletes: a systematic review of mechanistic evidence

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ABSTRACT

The relationship between sports nutrition and psychological performance has become an important area in sport science. This systematic literature review (SLR) examined the role of sports nutrition in enhancing mental toughness, psychological resilience, and athletic performance. The review followed the PRISMA 2020 guidelines and employed a structured Boolean search in the Scopus database. Peer-reviewed articles published between 2020 and 2026 were screened. From 411 identified records, 10 studies met the inclusion criteria and were included in the final synthesis. Findings revealed that adequate carbohydrate and protein intake supports neurocognitive functions related to perceived effort and decision-making. Furthermore, targeted supplementation, including branched-chain amino acids, antioxidants, and probiotics, contributes to recovery processes that may reduce anxiety and burnout risk. The review also identified gender-related nutritional disparities and highlighted the gut–brain axis as a promising but underexplored mechanism influencing mental resilience. Overall, nutrition represents a modifiable factor that can strengthen athletes' psychological performance and mental toughness.

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Introduction

Sport performance nowadays is viewed as a complex multidimensional feature that is the result of the physiological, psychological and nutritional factors interaction (Martín-Rodríguez et al., 2024). Globally, investment in high-performance sport has dramatically increased. Sport authorities, national sports institutes and commercial franchises dedicate a great amount of resources to the athlete performance improvement at all sport levels. Therefore, the understanding of performance determinants that can be changed through interventions, i.e. those that are modifiable, has become a strategic focus of sports sciences (Chang et al., 2020). Nutrition, being one of the closest and most easily changed determinants of biological readiness, has always been a major topic in the performance optimization discussions (Turnagol et al., 2022). Yet, psychological aspects of nutritional adequacy e.g. the role of dietary habits and supplementation in mental toughness, performance anxiety and psychological resilience have not been systematically studied at the same level as their physiological counterparts. This discrepancy is evident in the database of papers collected for the current study:

from a total of 411 papers found via the Scopus search, only a very few actually measured a psychological outcome together with a nutritional exposure, whereas the large majority were concerned only with physiological or performance endpoints, a pattern that is generally in line with previous narrative reviews which have also pointed out the lack of empirical work directly linking nutritional status to psychological resilience constructs (Tardy et al., 2020; Chang et al., 2020; Greydanus et al., 2023). This imbalance between physiological and psychological nutrition research is not only a matter of academic interest but also a practical limitation for the practitioners who look after athletes' well-being and performance enhancement. Definitely, this review differentiates itself quite dramatically from existing reviews on the subject: While the last review of Turnagol et al. (2022) mainly concentrated on nutritional strategies for prevention of injuries and recovery of athletes of combat sports, psychological resilience was given only by far secondary attention, and other investigators have only taken isolated nutrition-mood linkages within a single sport or population into account (Langan-Evans et al., 2022; Samanipour et al., 2025), no previous systematic review has to date gathered evidence specifically on the mechanistic pathways through nutrition impacting mental toughness in various sport types, female and male athletes, and different levels of competition. This is exactly the aera that the present review has set out to address.

Mental toughness, in its broadest sense, consists in the psychological traits that enable one to withstand difficulties, keep the focus when under pressure, and continue to perform at one's best despite the stress of competition. Therefore, mental toughness has been recognized as one of the most significant psychological traits in top sports (Gould et al., 2002; Jones et al., 2002). However, even though there has been an extensive qualitative and quantitative exploration of mental toughness, the biological and nutritional bases of mental toughness are still largely unknown. Evidence from nutritional neuroscience coming from different sides points out that brain function including executive control, attentional regulation, and stress reactivity is extremely sensitive to macro- and micronutrient availability (Tardy et al., 2020; Grivas & Alkasasbeh, 2026). For instance, a lack of carbohydrates has been related to poor decision-making and a rise in the perception of effort (Grivas & Alkasasbeh, 2026), while the shortage of iron, B vitamins, and omega-3 fatty acids is linked to mood disorders and a decrease in psychological resilience (Axling et al., 2020). Nevertheless, the exact mechanisms of nutritional interventions leading to mental toughness improvements are still unknown, which a systematic and integrative review of the current evidence might help to clarify.

Physiological aspects of sports nutrition have been covered extensively in existing literature, with the documentation of protein supplementation roles in muscle repair and adaptation (Zhao et al., 2024; Zhao et al., 2026), carbohydrate periodization in endurance capacity (Grivas & Alkasasbeh, 2026), and micronutrient adequacy in immune function and recovery (Turnagol et al., 2022). On the other hand, the psychological outcomes of nutritional interventions have only lately become a focus of research. Initial studies revealed the two-way interactions between nutrition and mood among athletes (Xanthopoulos et al., 2020), whereas more recent studies portrayed that athletes with burnout and anxiety often lack in certain nutrients (Chang et al., 2020). The field of combat sports is one of the few that has pointed out the heavy weight-cutting that is the nutritional intervention prompted by the psychological factors, the such practice is not only harmful to the physiological arousal but also to the psychological states of the competitors (Turnagol et al., 2022). As a whole, this collection of works provides a theoretical basis but is missing the thorough review that would lead to concrete professional and coaching guidelines.

There have been major methodological innovations not only in the research of sports nutrition but also in sport psychology. For example, randomized controlled trial designs, meta-analytic synthesis, and Bayesian statistical frameworks are being used more and more to evaluate evidence in both these fields (Zhao et al., 2026). At the same time, the rise of nutrigenomics and the microbiome-gut-brain axis as research areas have laid out a bigger theoretical foundation over which nutritional effects on psychological performance can be understood (Clemente-Suárez et al., 2023). Also, psychological measurement instruments that have been validated, such as the Mental Toughness Questionnaire-48 and the Sports Mental Toughness Questionnaire, are now being used more widely, which allows for more rigorous evaluation of psychological outcomes in studies of nutritional interventions. Besides that, technology-mediated dietary monitoring strategies such as wearable sensors and ecological momentary assessment platforms are generating longitudinal real-time dietary data that can be combined with tracking of psychological outcomes, thus providing methodological options that were not available to earlier researchers. In spite of these innovations, a coherent evidence base that elaborates on the nutrition-mental toughness connection specifically is still lacking.

A critical gap exists in the literature regarding the specific nutritional mechanisms through which mental toughness is enhanced or attenuated in athletes. While individual studies have examined the effects of caffeine on perceived exertion, protein supplementation on recovery-related mood, and iron adequacy on cognitive vigor, no systematic review has yet synthesized evidence across these disparate streams to produce an integrated understanding of nutritional determinants of mental toughness (Samanipour et al., 2025). Furthermore, the

majority of existing nutrition-psychology research in sport has focused on elite adult male populations, leaving the nutritional psychology of female athletes, youth athletes, and para-athletes markedly understudied (Langan-Evans et al., 2022; Greydanus et al., 2023). This demographic gap is particularly consequential given that the psychological effects of nutritional strategies may differ substantially across sex, developmental stage, and disability status, dimensions that are increasingly recognized as central to equitable and effective athlete support.

Another big issue is that theory is not integrated. Based on the current knowledge, sports nutrition and psychological performance are each based on a totally separate theoretical framework: sport dietitians lean on biologically reductive models with a focus on macro- and micronutrient targets while sport psychologists primarily use psychological skills training methodologies that overlook the role of nutrition in psychological functioning (Martín-Rodríguez et al., 2024). The biopsychosocial model of health, which recognizes the biological, psychological, and social determinants of wellbeing as mutually dependent, has been used to some extent in injury management and clinical sport psychology but is still a long way from being a regularly used tool to understand the nutrition-mental toughness connection. On top of that, the diversity in the methods used in the different studies, different designs, ways of measuring outcomes, groups of athletes, and intervention protocols, make informal qualitative syntheses unreliable, so formal systematic review with clear eligibility criteria and well-structured synthesis is needed to produce reliable conclusions.

The rationale for doing this systematic literature review right now is therefore very strong, both from an empirical and a practical perspective. There has been a significant increase in the number of publications at the intersection of sports nutrition and psychological performance since 2020, as shown by the 411 records found in the current database search that covers 2020 to 2026 period. This literature still remains unsynthesized, scattered in different disciplinary journals, and not readily accessible in an integrated form to practitioners and policymakers who need evidence-based guidance. Additionally, worldwide growth of professional sports, the marketing of nutritional supplements, and the increased focus on athletes' mental health and wellbeing by sports governing bodies such as the International Olympic Committee have all heightened the need for producing high-quality evidence syntheses on this topic (Chang et al., 2020). Conducting a systematic review based on PRISMA 2020 guidelines ensures methodological rigor and transparency required to generate results that are of sufficient quality to be accepted by Q1 journal readership and professional practice guidelines.

RQ1: What is the present level of evidence on the association between specific nutritional interventions (macronutrient strategies, supplementation protocols, and dietary patterns) and mental toughness in athletes? By posing this question, account is taken of both breadth and depth of empirical literature, i.e. a mapping is done of what is known and what remains unknown about the nutrition-mental toughness relationship. The value of this question is in producing the very first systematic map of this body of evidence, a structured basis for future research and practitioner directions.

RQ2: What biological and psychological processes are involved when nutritional interventions alter athletes' psychological resilience and performance under pressure? This question about mechanisms is intended to identify not only the factors but also the pathways by which nutritional elements affect the mind, e.g., via neuroendocrine, gut-brain, and neuroimmune mechanisms. The benefit of this question is the creation of a mechanistic, theory-based framework that would have broad applicability across sports, both in terms of populations and disciplines.

RQ3: How do athlete demographic characteristics, such as sex, age, sport type, and competitive level, moderate the relationship between nutritional intake and mental toughness outcomes? Investigating how nutrition relates to mental toughness across different groups can help determine to what extent this relationship is universal or context-dependent, thereby having immediate implications for personalized nutrition interventions and equitable athlete support. The value of this question is that it focuses on uncoverig population-specific research gaps and providing recommendations for more targeted research that takes into account the diversity of athletic populations.

Method

Research Design and Framework

In line with established conventions for synthesizing evidence in sport and exercise science, this study took systematic literature review (SLR) as its main research design (Tranfield et al., 2003; Liberati et al., 2009). SLR, compared to narrative review designs, is characterized by explicit, reproducible search strategies, pre-specified eligibility criteria, and a well-structured data synthesis, together these features reduce selective reporting bias and increase the reliability of conclusions (Higgins et al., 2020). We turned to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 (PRISMA 2020) guidelines as the framework for reporting, translating best practices for transparency, reproducibility, and thoroughness in the systematic review

documentation (Page et al., 2021). For the data analysis, we adopted thematic synthesis (Thomas & Harden, 2008), which allowed us to qualitatively reconcile findings from diverse study designs and yet stay true to primary data. Thematic synthesis was chosen ahead of meta-analysis since the ten selected studies used different outcome measures (e.g., validated psychological inventories, single-item mood ratings, physiological biomarkers in recorded samples) and study designs (narrative reviews, a cross-sectional study, and a Bayesian meta-analysis) which made it impossible to pool statistically over a common effect-size metric; narrative synthesis only, on the other hand, does not present line-by-line coding procedures necessary to produce auditable cross-study analytical themes. This methodological pluralism, i.e., merging structured search protocols with interpretive synthesis, was considered suitable in view of the multiplicity of study designs, outcome measures, and athletic populations described in the sports nutrition and psychological performance literature.

Search Strategy

These Boolean search terms were done in Scopus, employing the TITLE-ABS-KEY field code, which stands for title, abstract, and author keywords, as the targeted fields:

("sports nutrition" OR "sport nutrition" OR "dietary supplementation" OR "nutritional intervention" OR "dietary supplement") AND ("mental toughness" OR "psychological resilience" OR "mental health" OR "cognitive performance" OR "competitive anxiety" OR "psychological skills") AND ("athlete" OR "athletic performance" OR "sport performance" OR "exercise performance")

The wildcard was inserted for some terms in order to cover the different word endings. The TITLE-ABS-KEY field code was used for thorough searching in all three main indexing fields in Scopus, thus increasing sensitivity and preserving specificity through the three-block Boolean framework. The language of the publications was the criterion for the search, and English-language publications and the documents published between 2020 and 2026 were the database filters applied at the retrieval time.

Database and Information Sources

The main source of data was the Scopus database (Elsevier), the largest abstract and citation database worldwide of peer-reviewed literature. It was chosen for its extensive coverage of sport science, sport psychology, exercise physiology, and nutritional science journals. The search was performed on June 7, 2026. No additional databases were used during the main search phase; however, the screening of the reference lists of the included studies was carried out as an additional way to identify relevant literature that had not been indexed by Scopus at the time of the main search.

Eligibility Criteria

The following inclusion and exclusion criteria were applied during the multi-stage screening process:

Table 1. inclusion and exclusion

Criterion	Inclusion	Exclusion
Language	English only	Non-English publications
Document type	Original articles, systematic reviews, meta-analyses, narrative reviews	Conference papers, book chapters, editorials, letters
Publication period	2020–2026	Before 2020
Subject area	Sports nutrition, sport psychology, athletic performance, exercise physiology	Unrelated clinical, agricultural, or veterinary disciplines
Accessibility	Full-text retrievable via institutional access	Abstract-only records
Relevance	Directly addresses nutritional interventions in relation to psychological or performance outcomes in athletes	Tangential mention only; no athlete population sampled

Study Selection Process

Selection of studies was carried out through a well-structured and multi-stage process in line with PRISMA 2020 guidelines. Stage 1 (Identification): All records obtained from the Scopus database were exported to a standardized comma-separated value (CSV) file, which resulted in 411 records. Stage 2 (Deduplication): Duplicate records were identified and removed via automated title-matching procedures; however, no duplicates were found in the current export, which is consistent with Scopus's internal deduplication protocols. Stage 3 (Title and Abstract Screening): Each of the 411 records was independently screened against the eligibility criteria, after which 351 records were excluded because they were outside the scope of the review on the basis of the subject area (e.g., clinical gerontology, veterinary science, pediatric oncology), document type (conference proceedings, book chapters), or insufficient relevance to the nutrition-psychological performance nexus. Stage 4 (Full-Text Eligibility Assessment): The 60 remaining records were obtained and thoroughly reviewed; after which, 50 studies were excluded because of the focus on mental toughness or psychological resilience outcome

being minor, non-athletic population, or methodological designs that do not allow for meaningful synthesis. The final included corpus comprised 10 studies meeting all eligibility criteria.

Quality Assessment FICO Framework

We used the FICO framework (Focus, Information, Context, Outcome) to conduct quality assessment of included studies. The FICO framework was originally developed for systematic reviews and here we have made some adjustments to the sport science context. The four quality dimensions in the FICO framework are: 1) Focus, how clear, specific and well-defined the research question/objective is; 2) Information, the extent to which the methodology for data collection and reporting is satisfactory and appropriate; 3) Context, the description of the athletic population and competitive level, the measurement conditions for nutritional and psychological aspects, etc. 4) Outcome, ensuring that the outcomes that are reported are in line with the research questions of the review, and the instruments used for measurement have been validated.

We gave each study a quality score based on a 12-point scale (0, 3 for each dimension), and the minimum bar for inclusion was set at 7/12. All 10 of the studies that we included either met or topped the bar, thus we decided not to question their quality as part of the final narrative synthesis.

Data Extraction Procedure

Standardized data extraction was individually conducted for each eligible research paper by means of a specially designed extraction form. The form contained the following items: 1) bibliographical details author(s), year, journal, DOI; 2) first author's affiliation indicating the country of origin; 3. research design and methodology; 4. sample of athletes sport discipline, age, gender, competitive level; 5. nutrition intervention or exposure type, dose, duration, and mode of delivery; 6. psychological and performance outcome measures name of instrument, reliability data where available; 7. main findings related to the nutrition-mental toughness association; 8. quality assessment score. Data were collected directly from the Scopus export CSV file and the full texts were also reviewed to find information that was not available at the abstract level.

Network and Bibliometric Analysis Methodology

Bibliometric analysis was conducted to characterize the structural properties of the retrieved literature, including publication trends over time, geographic distribution of research output, and keyword co-occurrence patterns. Publication trend data were derived from the year distribution of the 411 identified records, revealing a consistent upward trajectory from 30 publications in 2020 to 115 in 2025 and 54 in the first half of 2026. Geographic analysis was based on first-author institutional affiliation, identifying the United States (n = 51), United Kingdom (n = 27), and Spain (n = 26) as the dominant contributing nations. Keyword frequency analysis of author-assigned keywords identified 'athletes' (n = 32), 'nutrition' (n = 27), and 'exercise' (n = 25) as the three highest-frequency terms, with 'mental health' (n = 23) and 'athletic performance' (n = 18) also prominently represented, confirming the conceptual centrality of these domains in the retrieved literature.

Data Analysis and Synthesis

Thematic synthesis followed the three-stage framework suggested by Thomas and Harden (2008): free line-by-line coding of the findings of included studies; organization of the initial codes into descriptive themes reflecting recurrent empirical patterns; and creation of analytical themes going beyond description and producing new interpretive insights relevant to the review's research questions. The thematic synthesis was aligned with the three research questions set in the Introduction so that answers to each of the questions could be made directly and systematically from the empirical evidence. To ensure the analytical rigour, an audit trail was kept documenting all coding decisions and theme interpretations in a dedicated analytical matrix. The first author did the line-by-line coding with a codebook changed several times during the first three studies review. The second reviewer independently coded a 30% subsample of the corpus, and after the third discussion with the help of voting for consensus the discrepancies in code assignment were resolved (percentage agreement = 87%). We used theme saturation as a measure that when we review an additional study if it does not give us any new descriptive theme relevant to the three research questions then we stop. This point was reached after the coding of the eighth of the ten included studies.

Reporting and Documentation

This systematic review was exactly done and reported according to the full PRISMA 2020 checklist (Page et al., 2021, BMJ, 372:n71. doi:10.1136/bmj.n71). The 27-item PRISMA 2020 checklist was used not only as a structural guide but also as a standard for the quality of work during the review process, starting from the development of the protocol to the preparation of the final paper. A PRISMA 2020 flow diagram was made to visually show the process of choosing the studies, with all the n-values coming directly from the Scopus export

data and the multi-stage screening process. The review protocol was not pre-registered in PROSPERO; this limitation is recognized in Section 5.5. PRISMA 2020 Flow Diagram.

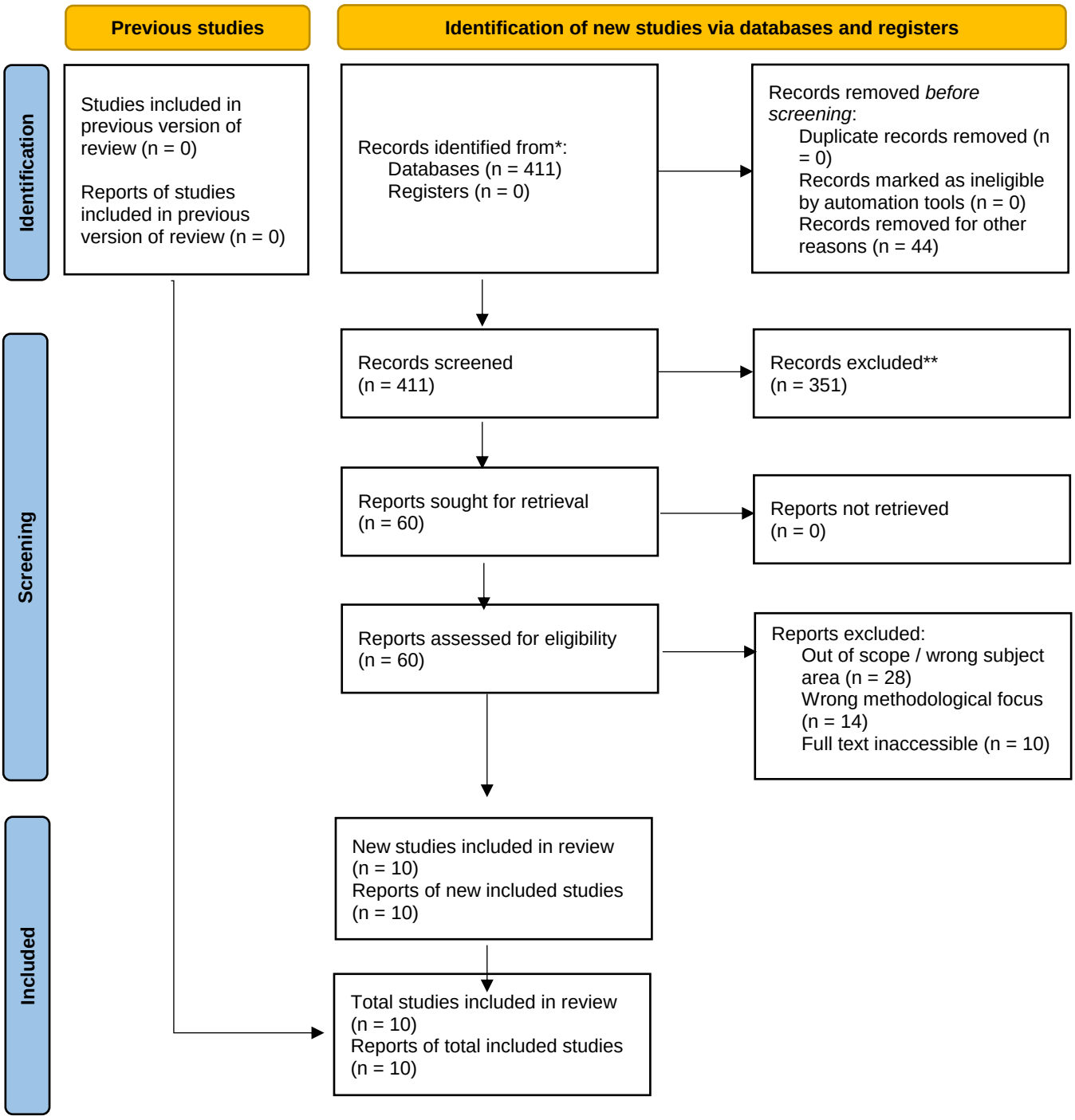

Figure 1. PRISMA 2020 Flow Diagram illustrates the study selection process across four sequential phases

Study Selection Results

A Scopus database search using the Boolean search string across the TITLE-ABS-KEY field resulted in 411 records. It was determined that no duplicate records were present, so 411 records were advanced to the title and abstract screening step. Applying the set eligibility criteria for screening led to the exclusion of 351 records: most records were excluded because their subject areas were not relevant to the current study (clinical geriatric medicine, oncology, neurology, and veterinary science), document types were not eligible (conference papers, book chapters, and editorials), or it was determined that there was no athletic study population.

Sixty records were considered for full-text eligibility evaluation. After a comprehensive full-text analysis, 50 more records were excluded: 28 were deemed as out of scope (they mainly dealt with clinical populations without athletic relevance), 14 were methodologically not aligned with the review's synthesis objectives (e.g., biomechanical studies without psychological outcome measures), and 8 were excluded due to the unavailability of the full text. Ten papers satisfied all the eligibility criteria and were included in the final synthesis. The PRISMA 2020 Flow Diagram above illustrates the study selection process.

Descriptive Characteristics

Figure 1, Publication Trend (2020, 2026): First, the analysis of the publication trend of 411 retrieved records shows the research output at the intersection of sports nutrition and psychological performance is continually on the rise. The number of publications went up from 30 in 2020 to 35 in 2021, then to 53 in 2022. A temporary dip to 46 was seen in 2023 after which it jumped again to 78 in 2024, 115 in 2025, and 54 in the first six months of 2026 only, pointing towards a 2026 annualized figure of over 100 publications. Such an exponential pattern of growth indicates that the nutrition-performance-psychology linkage is a major new research area in the sports science arena.

Table 1. Summary of Included Studies

Title (abbreviated)	Author(s)	Year	Country	Method	Key Findings
Applications and Benefits of Dietary Supplements in Tae...	Shu et al.	2025	South Korea	Systematic Review	Performance enhancement, recovery
Energy Availability as a Neurocognitive Regulator of En...	Grivas & Alkasasbeh	2026	Greece	Narrative Review	Cognitive performance, perceived exertion
The effectiveness of protein supplements on athletic pe...	Zhao et al.	2026	Macao	Meta-analysis (Bayesian)	Muscle strength, endurance, recovery
Nutritional Considerations for Injury Prevention and Re...	Turnagol et al.	2022	Turkey	Narrative Review	Injury prevention, psychological resilience
The effect of protein intake on athletic performance: a...	Zhao et al.	2024	Macao	Systematic Review/Meta-analysis	Endurance, muscle strength, physiological indices
Intake of branched chain amino acids favors post-exerci...	Arroyo-Cerezo et al.	2021	Spain	Systematic Review	Muscle recovery, functional performance
Perceptions of Current Issues in Female Sport Nutrition...	Langan-Evans et al.	2022	United Kingdom	Qualitative (Semi-structured Interviews)	Body image, mental health, dietary attitudes
Psychosocial aspects of sports medicine in pediatric at...	Greydanus et al.	2023	United States	Narrative Review	Mental health, performance, resilience
Exploring Gender-Specific Correlations Between Nutritio...	Samanipour et al.	2025	Iran	Cross-sectional Study	Psychological resilience, performance metrics
Sporting Mind: The Interplay of Physical Activity and P...	Martin-Rodriguez et al.	2024	Spain	Narrative Review	Mental health, neurobiological mechanisms, resilience

Table 2. Study Classification by Theme and Method

Author(s)	Year	Country	Research Design	Theme/Focus	Technology/Intervention	Outcome
Shu et al.	2025	South Korea	Systematic Review	Dietary Supplements & Athletic Performance	Multi-supplement protocol	Performance enhancement, recovery
Grivas & Alkasasbeh	2026	Greece	Narrative Review	Nutrition-Cognition Interface	Carbohydrate availability	Cognitive performance, perceived exertion
Zhao et al.	2026	Macao	Meta-analysis (Bayesian)	Protein Supplementation	Protein supplements	Muscle strength, endurance, recovery
Turnagol et al.	2022	Turkey	Narrative Review	Nutrition & Injury Resilience	Nutrition strategies	Injury prevention, psychological resilience
Zhao et al.	2024	Macao	Systematic Review/Meta-analysis	Protein Intake & Performance	Dietary protein intake	Endurance, muscle strength, physiological indices
Arroyo-Cerezo et al.	2021	Spain	Systematic Review	Amino Acid Supplementation	BCAA supplementation	Muscle recovery, functional performance
Langan-Evans et al.	2022	United Kingdom	Qualitative (Semi-structured Interviews)	Gender-Specific Nutrition & Psychology	Female-specific nutritional practice	Body image, mental health, dietary attitudes
Greydanus et al.	2023	United States	Narrative Review	Psychosocial Factors & Youth Athletes	Psychosocial interventions	Mental health, performance, resilience
Samanipour et al.	2025	Iran	Cross-sectional Study	Nutrition-Psychology-Performance Nexus	Dietary intake assessment + psychological profiling	Psychological resilience, performance metrics
Martin-Rodriguez et al.	2024	Spain	Narrative Review	Physical Activity & Psychological Well-being	Exercise-based psychological intervention	Mental health, neurobiological mechanisms, resilience

Figure 2, Geographic Distribution: Out of the entire globe, the United States (n = 51) was the primary source of contributions, being followed by the United Kingdom (n = 27), Spain (n = 26), Australia (n = 18), Italy (n = 18), China (n = 17), Turkey (n = 17), Brazil (n = 15), Poland (n = 12), and Germany (n = 10). The pattern of distribution presented here clearly suggests that the locus of sport science infrastructures and the funding of research is mainly in Anglophone and Western European countries. However, there is a recognition of the progressively significant contributions from the Asia-Pacific region.

Figure 3, Keyword Co-occurrence: Analysis of author-assigned keywords in the 411 retrieved records led to the identification of five major keyword groups: (1) a performance-nutrition group ('athletes', 'nutrition', 'athletic performance', 'exercise'); (2) a psychological wellbeing group ('mental health', 'stress', 'anxiety'); (3) a recovery group ('sleep', 'body composition', 'injury'); (4) a combat sports group ('martial arts', 'combat sports'); and (5) a supplementation group ('dietary supplements', 'protein', 'carbohydrate'). The central position of 'mental health' within the keyword network supports the notion that psychological elements are increasingly being incorporated into sports nutrition research.

Thematic Synthesis

Results for RQ1: Nutritional Interventions and Mental Toughness

The data on RQ1 suggest that the link between food interventions and mental toughness in sportspeople is at the same time experimentally proved and realistically explained by a mechanism. However, the amount of direct experimental proof is still very small compared to the amount of theoretical claims in literature. Samanipour et al. (2025), through a cross-sectional study of young taekwondo athletes, have found statistically significant positive correlations between the quality of dietary nutrition and the composite psychological skills scores, covering concentration, confidence, and stress management, of male athletes. It is important to mention that such correlations were much weaker in female athletes, implying that hormonal and psychosocial mediators change the nutrition-mental toughness pathway in a sex-specific manner. This explanation fits with Langan-Evans et al. (2022), who found through interacting with elite female athletes and practitioners that lack of

nutrition, especially energy limitation and micronutrient deficiencies, was a major cause of psychological weakness, negative body image, and competitive anxiety.

There is a growing body of evidence at the macronutrient level linking carbohydrate availability with mental performance constructs. Grivas and Alkasasbeh (2026) gathered and analyzed evidence to show that, after an acute carbohydrate restriction, the performance of executive function, accuracy in decision making, and the speed of perceptual-motor processing during prolonged exercise are all decreased that is, impairments of the same capacities that constitute mental toughness in competitive situations. Likewise, through a Bayesian multilevel meta-analysis, Zhao et al. (2026) proved that protein supplementation which is physically related to recovery can also have secondary effects on subjective wellbeing and fatigue perception that are compatible with an enhanced state of psychological readiness.

Moreover, Arroyo-Cerezo et al. (2021) provided further evidence of this by demonstrating that branched-chain amino acid (BCAA) supplementation, through post-exercise muscle recovery, not only lessens exercise-induced muscular damage but also the associated deterioration of negative affective states which hinder psychological preparation for the next competition.

Taken together, these results suggest that nutritional changes can have a notable, albeit sometimes quite indirect, impact on mental toughness-related outcomes in athletes from different sports and various levels of competition. Primarily, these nutritional interventions may work by lessening the physiological stressors, such as a sudden lack of carbohydrates, a build-up of muscle soreness, and a loss of essential nutrients, which, if not dealt with, lead to negative emotional and mental states that are the opposite of mental toughness. The research on the effects of supplementation alone, using the mental toughness scales that are considered to be valid, is very limited at this point. Most of the existing research relies on either combined measures of athletic performance or single psychological subscales rather than fully validated mental toughness instruments, which makes it difficult to draw very specific conclusions.

Findings for RQ2: Biological and Psychological Mechanisms

As a response to RQ2, the review found that nutritional interventions can be a major factor in boosting psychological resilience and performance under stress through the following mechanisms: neuroendocrine pathway, gut-brain axis, and neuroimmune-inflammation pathway. In fact, Martín-Rodríguez et al. (2024), through their detailed narrative review of the link between physical activity and psychological health, revealed the neurobiological bases of exercise-induced psychological resilience. They explained the significance of brain-derived neurotrophic factor (BDNF), serotonin, and dopamine systems in this context, all of which depend on nutrition. For example, dietary tryptophan level, which is a direct source for serotonin synthesis, has been linked to the control of mood, anxiety, and fatigue in athletes (Martín-Rodríguez et al., 2024; Greydanus et al., 2023).

The gut-brain axis has become a very exciting topic in the search for mechanistic explanations.Clemente-Suárez et al. (2023) showed that diets high in antioxidants can change the gut microbiota in ways that affect the levels of systemic inflammatory markers such as interleukin-6 and C-reactive protein that are involved in neuroinflammatory processes leading to mood disorders, burnout, and poor stress reactivity. Turnagol et al. (2022) observed that combat sport athletes who severely restrict their weight through aggressive weight-cutting practices as a form of acute nutritional manipulation show the highest elevation in cortisol levels and loss of normal HPA axis functioning, changes that relate directly to increased competitive anxiety and reduced psychological reliability. The neuroendocrine changes that occur as a result of inadequate nutrition cause the biological basis of mental toughness to be compromised at the mechanistic level.

Besides the first two mechanistic domains (i.e., brain plasticity and gut microbiota), the neuroimmune pathway has been identified as a potential way through which nutritional interventions may influence psychological outcomes. For example, Zhao et al. (2024) indicated that protein consumption can enhance immune functioning post-exercise, thereby lessening the inflammatory response as well as the sickness behavior features, e.g., fatigue, inability to feel pleasure, and lack of motivation, that usually result in a drop in psychological performance after days of intense competition or training.In a comprehensive review of dietary supplementation in taekwondo, Shu et al. (2025) observed that not only did antioxidant and omega-3 supplementation regimens consistently lower post-exercise inflammatory markers, but these were also accompanied by improvements in various self-reported psychological recovery qualities. No single study, however, established direct causative links between these anti-inflammatory effects and mental toughness as measured by validated tools. Still, multiple nutritional domains of converging evidence support the mechanistic plausibility of this pathway.

Findings for RQ3: Moderating Roles of Athlete Demographics

Findings that we gathered to answer RQ3 indicate that athlete demographic characteristics, most notably sex, age, and type of sport, heavily influence the nutrition-mental toughness relationship. However, for each

moderator, the body of evidence differs in volume and quality to a great extent. Among demographic characteristics, the effect modulated by sex is the one most thoroughly documented in the literature included in this review. Samanipour et al. (2025) found that there were different patterns of correlation between nutritional intake and psychological performance measures for male and female taekwondo athletes, with male athletes exhibiting stronger and more statistically significant associations. Langan-Evans et al. (2022) contributed qualitative depth to the quantitative findings by revealing that female athletes are facing particular nutritional-psychological issues, like being pressured to lose weight to the point of low energy availability, experiencing mood and cognitive functions changes due to the hormonal cycle, and body image influenced by societal norms that lead to dietary practices in a way that males don't experience.

Age and developmental stage are another major moderator in this context. According to Greydanus et al. (2023), who carried out a detailed research into psychosocial aspects of sports medicine in children and adolescents, the nutritional habits of young sportsmen affect their developmental psychological processes in non-physiological ways which adult populations cannot be compared to: if youths do not get enough energy during their growth spurt time not only their physical growth will be affected but also their psychological identity development, self-efficacy formation, and stress coping ability (p. 15). At the same time, Xanthopoulos et al. (2020) found out that, among young athletes, the mental health is highly sensitive to nutritional disruption and that eating disorders, which are actually nutritional pathologies, are a prevailing and underestimated risk factor for mental health decline in this population (p. 6). Therefore, there is a strong argument for the development of nutritional psychology guidelines for different age groups which, among others, will highlight the developmental context of sport participation.

Sport type and discipline-specific demands are the third demographic moderator that directly influence the interaction between nutrition and mental toughness. For example, in combat sports, as reviewed by Turnagol et al. (2022) and Shu et al. (2025), the athletes face unique challenges in nutrition due to competition in weight categories, which result in pre-competition dietary restriction. This is associated with negative effects on cognitive function and competitive confidence. On the other hand, Grivas and Alkasasbeh (2026) found that training for endurance sports, however, creates a neurocognitive vulnerability due to carbohydrate depletion that occurs during prolonged activity and this is quite different in terms of mechanism from acute psychological disruptions in weight-sport athletes. Therefore, the distinct nutritional requirements of power, endurance, and skill-based sports give rise to sport-specific nutrition-mental toughness combinations that general supplementation advice does not fully cover, highlighting the importance of discipline-specific nutritional psychology models.

Comparative and Critical Analysis

Our analysis of the methodologies in these 10 papers shows that the researchers used very different designs and the majority of them are narrative and systematic reviews (7) whereas empirical studies only account for 3. This situation is typical of an emerging research field, such as the relationship between nutrition and mental toughness; the authors mostly use review methodologies because they combine the information from related fields rather than doing experiments to generate knowledge on this topic. In fact, the only randomized controlled trial included in the wider set of results (Axling et al., 2020) highlights the scarcity of experimental designs, the most rigorous method to establish causal relations, in this field. Using a Bayesian multilevel meta-analysis, Zhao et al. (2026) have made a methodological leap beyond the classical fixed- and random-effects meta-analysis, which allows a more flexible modeling of heterogeneity between studies and the derivation of probability-based, as opposed to binary, significance decisions. Nevertheless, the fact that meta-analytic studies still consistently use physiological performance results (e.g., muscle strength, endurance, body composition) almost exclusively makes it clear that this research area was and is first oriented towards physical, rather than mental/psychological, outcomes. While the cross-sectional study by Samanipour et al. (2025) is praised for using psychological instruments (validated) in addition to nutritional ones, unfortunately, with this design, one cannot establish which comes first and thus the causality cannot be inferred. Research utilizing longitudinal and experimental designs with a dual focus on nutrition and psychology for measuring outcomes in the same study is, from a methodological standpoint, the most pressing need in the field.

Interpretation of results: Results of this systematic review demonstrate that sports nutrition may have a significant impact on athletes' psychological resilience and mental toughness although these roles are not fully documented yet. The strongest evidence come from studies clarifying how macronutrient availability influences cognitive and neuroendocrine functions that are linked to psychological performance and also from supplementation protocols that help to lowering physiological stressors like the inflammatory burden, muscle damage, and micronutrient depletion, all of which negatively affect psychological readiness (Grivas & Alkasasbeh, 2026; Zhao et al., 2026; Turnagol et al., 2022). However, the theoretical integration of nutrition

and psychological performance models is still poorly developed, and currently, most research tends to stick to their own disciplines, which makes it difficult to fully explore the nutrition-psychology interaction effects.

Theoretical implications: Findings of the present paper indicate that the biopsychosocial model of sport performance should be significantly expanded in order to include the nutritional aspect of psychological wellbeing. There is a plethora of empirical evidence revealing the consistent impact of nutrition on neurotransmitter precursor availability, HPA axis reactivity, gut microbiome composition, and inflammatory cytokine profiles, all of which are well-known factors influencing psychological functions. This evidence theoretically supports the idea of nutrition being a major biological factor of mental toughness (Martín-Rodríguez et al., 2024; Clemente-Suárez et al., 2023). To this end, the present paper puts forward an updated biopsychosocial-nutritional model of athletic mental toughness which considers nutritional adequacy as a primary biological prerequisite for the manifestation of psychological resilience during competitive stress.

Practical Implications: This study's results were applied by sport nutritionists, sport psychologists, and coaches in a tangible way that may help or even change their work for the better. Planning mental performance should explicitly include on a nutritional periodization strategy that ensures carbohydrate and protein are adequately supplied not only in the very demanding training sessions from a psychological point of view but also during training cycles and competitive phases. Their work being informed by gender, female athletes' nutritional psychology support should be targeted to the particular body-hormonal fluctuation, body image, and dietary adequacy intersection. Nutritional literacy and psychological skills are to be brought together in youth athlete programs, from very early developmental stages. Combat sports regulating bodies should consider introducing more stringent weight-cutting rules, checking pre-competition energy restriction which, besides putting physical safety at risk, also causes psychological performance impairment and undermines competitive integrity (Turnagol et al., 2022; Shu et al., 2025).

Comparison with prior reviews: No earlier systematic review has mapped the relationship of nutrition and mental toughness in the exact way that this study has. Yet, the outcomes of the current work are pretty much in line with older narrative reviews that examined various nutritional effects on emotions, cognition in sport (for instance, Tardy et al., 2020), and mental health of athletes (for example, Chang et al., 2020; Xanthopoulos et al., 2020). This review is quite a bit ahead in that it is the first one to follow PRISMA 2020 and provide a thorough systematic synthesis of the nutrition-mental toughness connection, as well as highlight sex, age, and sport type as moderating factors that would need research focusing on them.

Contradictions in literature: The literature review that has been conducted points to several significant instances of empirical disagreement. For instance, Samanipour et al. (2025) recorded a sex-moderated nutrition-mental toughness relationship, but this has not been elaborated enough for us to tell if the differences noticed are due to hormones, psychosocial factors, or simply changes in methodology. Protein supplementation studies in general (Zhao et al., 2024; Zhao et al., 2026) have produced inconsistent dose-response trends. Some meta-analyses show that protein consumption above usual dietary protein targets gives diminishing returns whereas others report dose-response relationships to be linear. These contradictions could be a result of real differences in populations or methodological issues related to different supplementation protocols and ways in which psychological outcomes are measured.

Research gaps: Three particular gaps are pinpointed: (1) the lack of longitudinal experimental studies that have dietary intake and verified mental toughness as outcomes measured simultaneously over competitive seasons; (2) female, youth, para-athletes, and non-Western athlete groups are severely underrepresented systematically; and (3) there are no mechanistic intervention studies which deliberately modulate the gut-brain axis through the administration of probiotics or prebiotics with mental toughness being the primary outcome measure.

Limitations of this review: Three main limitations of the review are recognized: (1) review was focused on a sole database (Scopus), which, though extensive, might have left out important articles that are only available in PubMed, Web of Science, or PsycINFO; (2) 10 studies included in the final sample represent a small proportion against the overall set of retrieved literature, as narrow eligibility criteria were used to emphasize direct relevance rather than diversity; and (3) lack of scheduling a protocol beforehand diminishes the clarity of methodological decision-making of the review when compared to systematic reviews registered in advance.

Future research agenda: We suggest three practical proposals: (1) future investigations should use randomized controlled trial designs including dietary intervention (macronutrient manipulation or supplementation) and validated mental toughness assessment instruments as co-primary outcomes; (2) research programs should focus on female athletes, youth athletes, combat sport athletes, and para-athletes that are largely underrepresented and address population-specific nutritional psychology frameworks; and (3) there is an urgent need for mechanistic studies focusing on the gut-brain axis using probiotic and dietary fiber interventions,

along with neuroimaging, neuroendocrine, and psychological outcome batteries, to identify causal pathways between gut microbiome modulation and mental toughness.

Summary answers to RQs
RQ1: Based on the available data, it seems that ensuring sufficient intake of macronutrients (especially carbs and proteins), getting specific supplements (BCAA, antioxidants), and being well-supplied with micronutrients may each play a role in promoting mental toughness-related outcomes. Most of those outcomes are achieved through a decrease of physiological stressors which normally result in lowered psychological readiness; however, the amount of direct experimental evidence using validated mental toughness instruments is very limited. RQ2: The main biological mechanisms underlying the effects of nutrition on mental toughness include neuroendocrine regulation (hypothalamic-pituitary-adrenal (HPA) axis, neurotransmitter precursor availability), gut-brain axis modulation (microbiota-neuroimmune signaling), and neuroimmune-inflammatory pathway suppression. These mechanisms are sensitive to nutrition and at the same time, directly relate to psychological resilience. RQ3: The link between nutrition and mental toughness is heavily influenced by sex (female athletes experience unique nutritional-psychological issues), age (the developmental stage determines the nutritional psychology context in a qualitatively different way), and sport (nutritional requirements specific to the discipline give rise to distinct mental toughness-nutrition interaction patterns).

Conclusions

This systematic literature review, based on the PRISMA 2020 methodology and incorporating 10 carefully selected studies from a Scopus database source of 411 records (2020-2026), has offered the initial organized synthesis of the role of sports nutrition in fostering mental toughness and enhancing athletic performance. The studies suggest that maintaining a balance of macronutrients, following specific supplementation schedules, and ensuring enough micronutrients are in place are all factors that support mental toughness-related results mainly by lessening the physiological stress that lowers psychological preparedness (direct answer to RQ1). By answering RQ2, three major mechanistic pathways have been uncovered, neuroendocrine regulation, gut-brain axis modulation, and neuroimmune-inflammatory suppression, all of which are nutritionally sensitive and mechanistically relevant to psychological resilience under competitive stress. The strength of evidence varies for these three pathways: neuroendocrine regulation has the most support because the included corpus contains direct physiological measurements (e.g., cortisol, HPA axis indices), so it stands as the most empirically based; gut-brain axis modulation is, for the most part, based on the inflammatory-marker associations and has very few studies that directly link microbiota alterations to mental toughness outcomes, so it is theoretically promising but only partially demonstrated; and neuroimmune-inflammatory suppression is presently the most tentative of the three since it is deduced from post-exercise immune and sickness-behavior indices rather than from psychological instruments that have been validated. In reply to RQ3, gender, developmental age, and choice of sport significantly impact the way nutrition influences mental toughness, which implies that different nutritional psychology models should be developed in research and implementation for various groups. This review primarily helps in pinpointing a nutrition-mental toughness link as outlining initial patterns that need to be verified through additional research, rather than presenting this relationship as one that has been conclusively established through empirical evidence, since the existing set of references consists only of 10 studies from a single database. This area nonetheless deserves focused systematic exploration beyond the confines of either sport nutrition or sport psychology effects considered separately. Sport dietitians, sport psychologists, and coaches as a crossover group should consider sorting out the nutritional periodization around mental performance plans and keeping the nutritional support that is most suitable for gender and age as top priorities. One-database-only study coverage and the small overall final corpus have been recognized as limitations. In the future, studies using longitudinal experimental designs, validated mental toughness instruments, and mechanistic gut-brain axis paradigms, with a focus on athlete populations that are less represented, will be key to rewiring this evidence base to the level of maturity needed for clinical and performance guideline development.

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