https://doi.org/10.70882/0cscgd41

SCIENCE FORUM (JOURNAL OF PURE AND APPLIED SCIENCES) 26, (5 Special) (2026), 902 - 915

Science Forum (Journal of Pure and Applied Sciences)

Journal Homepage: https://atbuscienceforum.com.ng/index.php/jpas

Mental Fatigue and Athletic Performance: Neurocognitive Mechanisms, Assessment, and Practical Strategies; Review Article

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Abstract

Mental Fatigue is a psychobiological response that occurs as a result of extended or intense mental effort and can affect an athlete's ability to maintain effort, control attention, perform technical skills and make decisions. Because the cognitive demands of sport are a frequent occurrence and are related to tactical analysis, academic and occupational tasks, digital media consumption, traveling, competitive pressure, and extended training periods. This narrative review aims to summarize the conceptual foundations of mental fatigue, proposed mechanisms of mental fatigue, its effects on endurance and physical performance, as well as in sport-specific skill and decision-making, methods of mental fatigue assessment and possible countermeasures. Most literature suggests that mental fatigue is not a uniform exposure and that the effects are influenced by the task employed to induce fatigue, athlete's pre-exposure baseline state, the context of the sport and the performance domain measured. Evidence is especially important for endurance regulation, technical execution and decision making, and less so for strength and power outcomes, which in many cases are less definitive and of lesser magnitude. Strategies for improving learning in practice include cognitive-load management, opportunities for recovery, task-specific preparation, motivational and attentional strategies and individualized monitoring. Evidence is still inconsistent and lab protocols can't be viewed as evidence for all competition scenarios. Future research needs to increase fatigue assessment accuracy, utilize sport-specific, ecologically valid assessment outcomes, and incorporate a wider population of athletes while clearly separating mental fatigue from other factors (stress, boredom, sleep loss, and physical fatigue).

Keywords

Mental Fatigue;
Athletic Performance;
Cognitive Load;
Decision-Making;
Endurance;
Technical Skill;
Recovery;
Sport Psychology

EISSN: 3156-5190 (Online)
ISSN: 1119-4618 (Print)
JPAS
Faculty of Science, ATBU Bauchi

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1. Introduction

The interaction between physiological capacity, technical skills, tactical knowledge, psychological readiness and environmental conditions, determine the athletic performance. In modern sports, the ability to perform is no longer a one-way street, as an athlete must be able to think his way through, process a lot of information, make decisions and monitor performance in a stressful situation. Such cognitive demands can accumulate over time of mental work, and may lead to what is referred to as mental fatigue (Van Cutsem et al., 2017; Sun et al., 2024; Marcora et al., 2009; Wu et al., 2024).

The study of mental fatigue has been conducted in the context of endurance exercise, performance of motor skills, reaction time, tactical decision making and perception of effort. A common research method employed in experimental studies is to fatigue a cognitive task prior to a physical or sport-specific task to determine if fatiguing the cognitive task affects subsequent performance on the physical or sport-specific task. While several studies have observed negative outcomes, the degree and consistency of the effects have depended on the induction method, induction duration, sport, measurement of outcome, and participant characteristics (Van Cutsem et al., 2017; Sun et al., 2024; Smith et al., 2018; Sun et al., 2021; Smith et al., 2016; Trecroci et al., 2020).

Conceptual precision is needed in interpreting the results of mental-fatigue studies. Mental Fatigue is not synonymous with Physical Fatigue, Sleep Deprivation, Emotional Stress, Boredom or simply Fatigue. In the real sport, they can be identical, but in different sport exposures and thus may yield different mechanisms and performance effects. Thus, it is imperative to differentiate the cognitive task/exposure that causes fatigue, the subjective and behavioral state following the task/exposure, and the resulting sport-performance outcome (Sun et al., 2024; Wu et al., 2024; Qian et al., 2025).

In this review, an overall picture of mental fatigue in sport is presented, highlighting suggested mechanisms, domains of performance, assessment techniques, interventions, implications, flow of the literature and future priorities for research.

2. Review Methodology

This article is a narrative review of the peer-reviewed literature relating to mental fatigue, cognitive effort, athletic performance, decision making, countermeasures, and sport-specific skill in the context of endurance. Literature was identified by conducting search terms using PubMed, Google Scholar, journal websites, and literature searches through bibliographic records on the combination of terms: "mental fatigue" or "cognitive fatigue" and "sport performance" or "athletes" and "endurance" or "technical performance" or "decision-making" or "reaction time" and "intervention" or "brain endurance training". Only systematic reviews, meta-analyses, experimental studies and recent reviews were considered, and only when they helped to develop conceptual or mechanistic understanding of the field was foundational studies considered.

The review was focused on summarizing and analyzing the literature. The discussion provides a review of the literature that examines the effects of mental fatigue on athletic performance in light of evidence-based findings, mechanisms of mental fatigue, methods used to evaluate mental fatigue, and potential mental fatigue countermeasures.

3. Conceptual Definition and Characteristics of Mental Fatigue

Mental fatigue typically refers to a psychobiological state that follows prolonged or challenging mental tasks and includes alterations in effort, motivation, attention and the desire or ability to persist with mental activity. The construct is multi-dimensional – that is, the two types of fatigue (subjective and behavioral fatigue) do not necessarily occur simultaneously. An athlete can experience high mental fatigue and still have good performance for a while with motivation or external stimuli or incentives, or have good performance and not report mental fatigue (Van Cutsem et al., 2017; Marcora et al., 2009; Wu et al., 2024).

Examples of common experimental induction procedures are prolonged Stroop tasks, sustained attention tasks, complex cognitive tasks, video or screen exposure tasks, and other tasks that involve continuous cognitive attention. These methods vary in terms of the cognitive, emotional, length of time and ecological relevance. Thus, a protocol for inducing fatigue in one population or setting may not result in fatigue in another population or setting. Manipulation check is important and can be subjective ratings or task-performance indicators or complementary physiological measures (Sun et al., 2024; Wu et al., 2024; Qian et al., 2025).

Table 1. *Conceptual Distinction between Mental Fatigue and Related States*

Related state	**Typical features**	**Why distinction matters**
Mental fatigue	Perceived cognitive tiredness, effort, reduced willingness to sustain cognitive work	May influence attention, pacing, skill, or decisions
Physical fatigue	Reduced capacity following muscular or metabolic demand	May alter force, speed, coordination, and exercise tolerance
Sleep loss	Insufficient or disrupted sleep opportunity	Can affect alertness, recovery, mood, and performance independently or alongside mental fatigue
Stress	Psychological or physiological response to perceived demands	May increase arousal or impair performance depending on intensity and context
Boredom/underload	Low stimulation or repetitive activity	May reduce engagement but is not necessarily equivalent to fatigue

4. Neurocognitive and Psychophysiological Mechanisms

4.1 Executive Control and Attentional Regulation

Allocation and maintenance of attention, inhibition of irrelevant information, updating of working memory, and flexible switching between tactical options - all these are required for sport performance. Mental fatigue can reduce the effectiveness of executive-control processes and make it easier for the person to give up as they perceive it to be more difficult to keep engaged in the task. In the sport context, this might be especially important for athletes who need to effectively process visual information, track opponents, predict actions and decide on responses quickly under pressure. The effect is likely to vary depending on the task, as there are different demands on the EFs across different sports (Boksem & Tops, 2008; Van Cutsem et al., 2017; Smith et al., 2016; Sun et al., 2021; Habay et al., 2021; Lu et al., 2026).

4.2 Motivation, Effort, and Perceived Cost

The motivational control accounts suggest that mental fatigue can affect performance partially because of an individual's perception of the cost of effort and/or by lowering the desire to invest more effort. Thus, if the task demands a lot of effort and there is little perceived reward, performance may suffer, whereas if the task demands a little effort and there is a lot of perceived reward, performance may not suffer. It offers an explanation as to how fatigue might impact self-paced endurance performance - tasks that it is up to the athlete to control their

effort on, versus short maximal efforts or externally paced activities (Marcora et al., 2009; Noakes, 2012; McCormick et al., 2015; Boksem & Tops, 2008).

4.3 Central Regulation and Neurophysiological Processes

Central nervous system processes have been investigated, such as cortical activity and neurotransmitter-related hypotheses as well as cognitive control/motor regulation. Altered regulation of effort, changes in neural efficiency, and changes in task demands/cognitive resources are suggested explanations. These mechanisms are still being studied, and should not be presented as one definite pathway. The relationship between the laboratory marker and sport performance needs to be further validated, and the results of the neurophysiological test vary with the protocol used (Wu et al., 2024; Qian et al., 2025; Boksem and Tops, 2008; Noakes, 2012; Lu et al., 2026).

4.4 Perceived Exertion and Exercise Regulation

Fatigue may impact how one feels about effort in later workouts. For endurance activities, the athlete can feel the same workload as more or less challenging, which can impact pacing, intensity or duration of the activity. Perceived exertion is not just a reactive phenomenon to physical stress, it can also play a role in behavioral decision making to either continue, increase or decrease effort. However, there is no consistency between perceived exertion and physiological responses and not all mental fatigue protocols have the same effects (Marcora et al., 2009; Smith et al., 2018; Habay et al., 2026; Noakes, 2012; McCormick et al., 2015).

4.5 Developed Integrated Pathway

The cognitive exposure concept is well connected to a fatigue-like state, and this is then related to the expression of the task. Extended task demands can result in subjective fatigue and alterations in attention, effort control, and/or motivation. These can become behaviorally relevant during the performance of a subsequent task, which may call for a high level of concentration, technical accuracy, speed of response or decision making. The model is probabilistic: that is, the pathway is affected by the athlete's state, characteristics of the task, motivation, training status and environmental context.

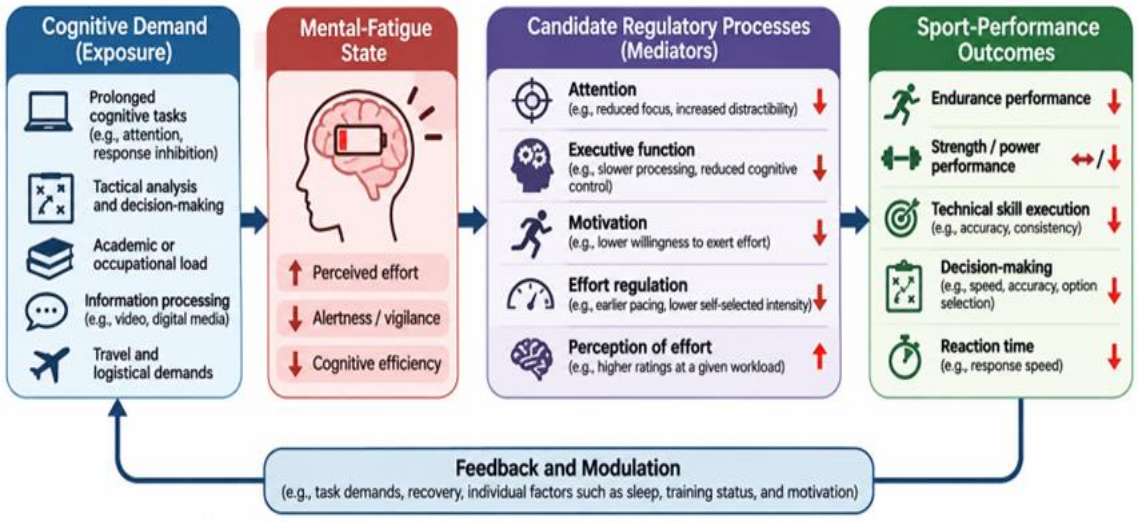

Figure 1. *Conceptual pathway linking cognitive demand, mental-fatigue state, candidate regulatory processes, and sport-performance outcomes.*

5. Effects of Mental Fatigue on Athletic Performance

5.1 Endurance Performance

One of the areas that have been prone to research regarding mental fatigue is endurance performance. Many experimental studies have evaluated subsequent cycling, running or other endurance tasks following cognitively demanding activities. Mental fatigue has been shown to have a negative effect on endurance performance in the literature, but the magnitude depends on the exercise mode, duration, intensity and the protocol used to induce mental fatigue (Van Cutsem et al., 2017; Marcora et al., 2009; Smith et al., 2018; Habay et al., 2026; McCormick et al., 2015).

Possible factors are a greater perceived effort, changes in effort regulation, decreased willingness to maintain high levels of effort, or shifts in attentional control. During self-paced exercise, the athlete's awareness of discomfort and exertion, in addition to environmental information and pacing decisions, may be especially relevant to these processes. However, the results do not necessarily indicate that there is a generalized effect of mental fatigue on endurance capacity in all athletes and under all exercise conditions.

5.2 Strength, Power, and Resistance Exercise

Evidence relating to strength and power has been more inconsistent. Brief maximal actions could be regulated by different control processes than prolonged endurance exercise and the role of mental fatigue might be influenced by task length, motivation, familiarization and the type of resistance exercise. There have been recent reviews of resistance-exercise performance and explosive power separately, and the results of these reviews suggest that using resistance-exercise performance and explosive power as a single measure should be avoided unless the distinct physiological and methodological requirements for each measure are taken into account (Solon-Júnior et al., 2026; Wang et al., 2026).

The practical implication is that mental fatigue is a possible concern for training quality, especially when training sessions require repeated efforts, complex movements, or require a high cognitive demand, but there is not sufficient evidence to universally recommend training be affected by mental fatigue.

5.3 Technical Skill and Motor Execution

To perform technically, movement must be coordinated, the timing is precise, perceptual information is needed and errors must be corrected. Technical execution can be impaired in sports like football, basketball, racket, volleyball, and combat sports as a result of attention and/or the selection of appropriate action. Systematic reviews indicated that mental fatigue affects skilled sport performance, but there was variability in the direction and magnitude of the effects across skills, experimental protocols and sports (Sun et al., 2021; Smith et al., 2016; Trecroci et al., 2020; Habay et al., 2021; González-Víllora et al., 2022; Pan et al., 2025).

The tasks have varying difficulty levels, and they can require varying degrees of attention. An open skill (which depends on adapting to an opponent or changing environmental cues) may be more vulnerable under some conditions, while a closed and well-practiced skill may be more resilient. These differences make sense and need to be tested on a sport-by-sport basis and not generalized.

5.4 Decision-Making and Tactical Performance.

In sport, decisions are made on the basis of the perception of relevant cues, the prediction of opponent actions, the selection of an action and updating of decisions as and when necessary. Mental fatigue might be especially important for sustained attention, working memory, inhibition and rapid selection among alternatives. In the literature, the separation of decision-making and reaction-time/technical outcomes is increasing, as these are not interchangeable (Sun et al.

2021; Lu et al. 2026; Habay et al. 2021; Pan et al. 2025).

Some recent evidence syntheses suggest that mental fatigue may have an effect when it comes to decision-making outcomes that could be described as fairly consistent, though individual studies have limited sample sizes, task designs and the representativeness of the laboratory assessments. It is therefore necessary to view a decision-making test in the context of the sport-specific information provided, complexity of the task, and the test's representation of the perceptual and tactical demands of the sport.

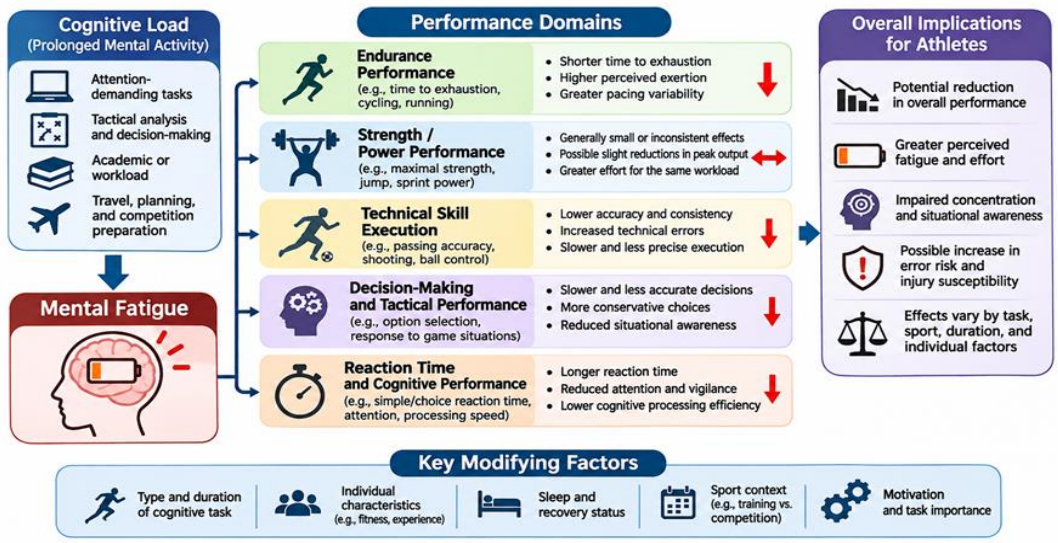

Figure 2. *Potential effects of mental fatigue across different athletic performance domains.*

6. Factors Modifying Mental-Fatigue Effects

The impact of mental fatigue on performance could be altered by different factors. These can include the length of the induction task and the cognitive content; baseline fatigue; athlete training status; motivation; sport type; task complexity; competition level; and time between cognitive exposure and testing. Sleep, travel, nutrition, ambient temperature, and physical stress combined with mental stress could also affect the findings, with some potentially being exposures distinct from mental fatigue (Sun et al., 2024; Wu et al., 2024; Qian et al., 2025).

Table 2: *Factors Modifying the Effects of Mental Fatigue on Athletic Performance*

Potential moderator	**Possible relevance**	**Research implication**
Induction-task duration and type	Different protocols may elicit different fatigue profiles	Report protocol and verify fatigue state
Sport and task demands	Open skills and tactical tasks may require greater cognitive flexibility	Use sport-specific outcomes
Motivation and incentives	May alter willingness to sustain effort	Measure motivation and task engagement
Baseline state	Sleep, stress, prior training, and fatigue may influence responses	Record baseline and contextual variables

Timing	Delay between cognitive task and sport test may change effects	Standardize and report timing
Athlete characteristics	Training level, age, experience, and individual differences may modify response	Recruit diverse and adequately sized samples

7. Assessment of Mental Fatigue

7.1 Subjective Measures

It is common that subjective ratings are used, given that mental fatigue is partially defined as experiencing mental tiredness and effort. There are several types of rating scales that can be used to rate perceived fatigue, mental effort, motivation, concentration or task difficulty. These measures are useful and can be used before and after a protocol but are also open to expectations, response bias and varying interpretations. A construct description should, therefore, go with a subjective assessment. (Aveiro et al., 2026)

7.2 Behavioral Manipulation Checks

The results obtained for the cognitive induction task could be indicative of diminished task efficiency or changed engagement. But, when fatigue state is present, there does not have to be a deterioration of task performance, and the participant can continue to perform on the task but experience greater effort. Behavioral indicators are not used as the only means to verify the subjective ratings and protocol details (Sun et al., 2024; Wu et al., 2024).

7.3 Physiological and Neurophysiological Measures

The researchers have investigated heart-rate variability, electroencephalography, eye-tracking and other physiological/neurophysiological indicators as indicators of mental fatigue. These techniques can be used in combination with each other to gain complementary information, however, there is no single marker that is universally recognized as an indicator of mental fatigue in sport. The selection of measurements depends on the research question, the validity evidence, feasibility, and avoiding overinterpreting the nonspecific response of the physiological measures (Wu et al., 2024; Qian et al., 2025; Boksem and Tops, 2008; Aveiro et al., 2026)

7.4 Sport-Specific Assessment

A combination of a validated subjective assessment and a sport-specific performance task could be the most informative assessment. For instance, before making a mental fatigue rating, both before and after a cognitive task, and after a rating of mental fatigue, a technical accuracy, a decision quality, a reaction time, and/or an endurance under a standardized protocol could be measured. These designs enhance relevance but maintain the separation of the induction and the resulting performance. (Habay et al., 2021; Aveiro et al., 2026.

Table 3: *Assessment Methods for Mental Fatigue in Athletes: Applications and Limitations*

Assessment method	**Examples**	**Primary purpose**	**Limitations / interpretation**
Subjective measures	Mental-fatigue rating; validated questionnaires; perceived cognitive effort	Capture the athlete's perceived fatigue state and change over time	Subjective; affected by context, expectations, and reporting
Cognitive-task performance	Sustained attention; Stroop-type task; reaction-time task	Assess performance during or after cognitive demand	Task performance is not a direct or unique measure of mental fatigue
Sport-specific testing	Decision task; skill accuracy; tactical response; sport-specific	Determine whether fatigue is expressed in the athlete's sport	Test reliability and task specificity require

	reaction test	context	consideration
Physiological measures	HRV; heart rate; EEG; eye tracking (where available)	Explore physiological or neurophysiological correlates	Measures are nonspecific and should not be interpreted alone
Contextual monitoring	Sleep; stress; cognitive workload; training and competition schedule	Identify potential contributors and interpret fatigue reports	Contextual associations do not establish causation

8. Strategies to Manage or Counteract Mental Fatigue

8.1 Cognitive-Load Management

Managing the cognitive load can involve arranging complex tactical discussions, video review, academic work, media commitments, and training activities to prevent significant cognitive loads all coming at once prior to important performance events. This practice won't necessarily remove cognitive involvement; rather, it is about the when and the how much of it in the athlete's programming. (Sweller, 2011)

8.2 Recovery and Rest Opportunities

Opportunities for recovery can have a variety of forms such as short breaks, less cognitive stimulation, relaxation and movement in between challenging activities. An ideal recovery strategy may be different depending on the athlete, the task and how much they are tired. Rest should be regarded in the context of the other recovery factors, and not as a simple countermeasure with a specific period of time.

8.3 Motivational and Attentional Strategies.

The motivational interventions, goal setting, attentional focus and task engagement can impact performance under mentally demanding situations. There is, however, emerging evidence of countermeasures and interventions should be chosen based on the performance domain and tested in the appropriate context. An athlete's strategy to sustain effort in endurance exercise is not necessarily related to the enhancement of technical accuracy or tactical decision-making (Sun et al., 2024).

8.4 Brain Endurance Training

Brain endurance training incorporates cognitive training and physical training in order to try and build tolerance to cognitive load. This method has garnered research attention as it could more accurately mimic the multi-modal cognitive/physical nature of sport. However, the evidence is still emerging and the feasibility of implementing it in practice depends on the quality of any trials, the type of training protocol and the type of sport-performance outcomes that are being investigated (Wang et al., 2026).

8.5 Individualized Monitoring

Monitoring can include subjective ratings (short duration), training records and periodic checks of sport specific performance. Balancing and support should be maintained in monitoring. Beware of over measuring or rating an element as a diagnosis if it is just a single measurement. To detect patterns and to facilitate communication between athletes, coaches, sport scientists and medical personnel.

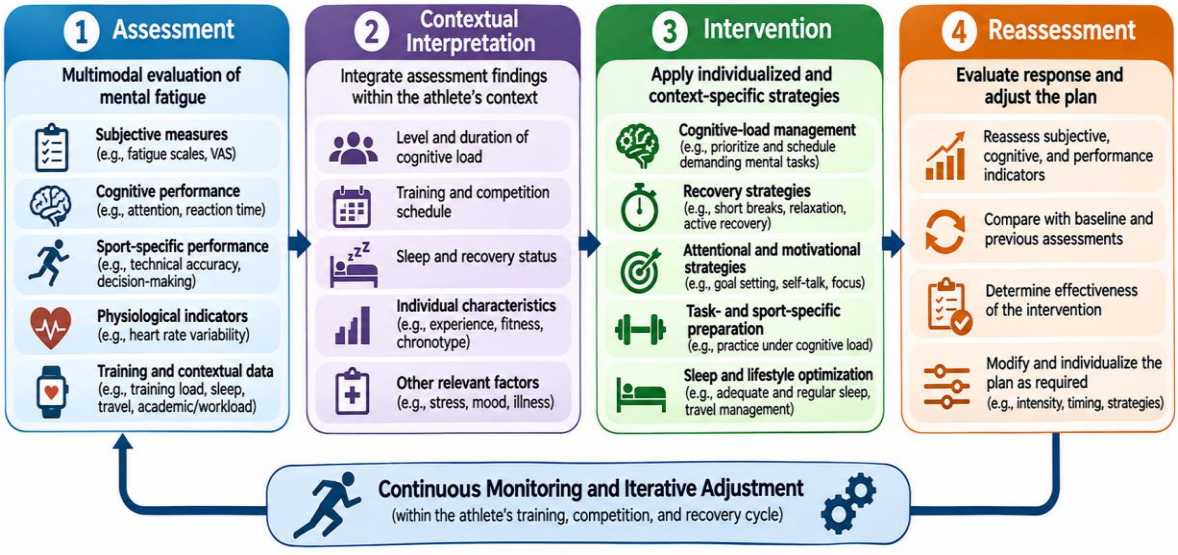

***Figure* 3.** *Practical framework for assessment, contextual interpretation, intervention, and reassessment of mental fatigue in athletes.*

Table 4: *Practical Strategies for the Prevention and Management of Mental Fatigue in Athletes*

Strategy	**Practical application**	**Implementation note**
Cognitive-load management	Organize video, tactical, academic, and media demands around priority training or competition	Consider timing, duration, and cumulative demands
Recovery breaks and transitions	Provide brief breaks, low-stimulation periods, and clear transitions between demanding activities	Individual responses may differ; monitor perceived benefit
Scheduling	Avoid unnecessary clustering of prolonged cognitive tasks immediately before key sessions when feasible	Integrate with the overall training and competition plan
Individualized monitoring	Use brief fatigue ratings and training/context records; review patterns	Use consistent measures rather than isolated ratings
Motivational and attentional strategies	Goal setting, task engagement, attentional cues, and supportive coaching	Select strategies that fit the athlete and sport task
Sport-specific preparation	Use familiar, reliable sport-specific tests or routines when evaluating readiness	Avoid introducing untested interventions immediately before competition
Referral / broader assessment	Seek appropriate professional assessment when fatigue is	Do not assume mental fatigue is the sole cause

	persistent, severe, or unexplained	

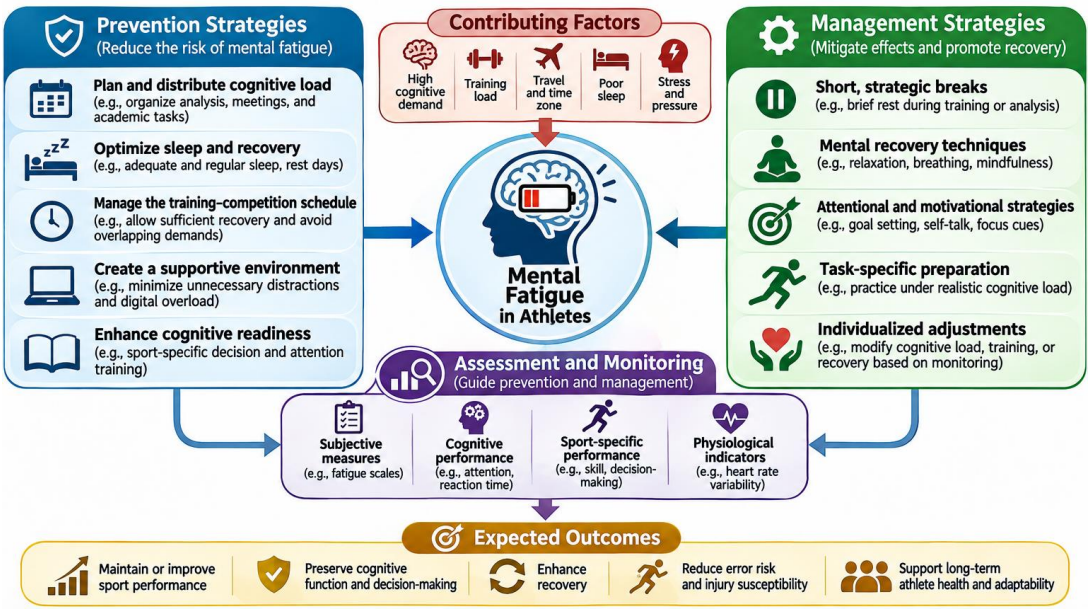

Figure 4. *Evidence-informed framework for the prevention and management of mental fatigue in athletes.*

9. Practical Implications for Athletes, Coaches, and Sports Staff

Mental fatigue should be regarded as being a part of the athlete's entire preparation and recovery environment. Coaches and sports staff might want to start to recognize activities which can require a significant cognitive load, such as tactical meetings, video analysis, travel planning, academic work, and media commitments. The timing of these activities may be varied when they are immediately preceded to sessions where technical, tactical and/or perceptual demands are high.

Simple and consistent self-monitoring can be used by athletes to determine patterns of mental fatigue and readiness to perform. Monitoring shouldn't be a "one-size-fits-all" type of decision making, however. Interpretation should be individualized, especially if the athlete is experiencing sleep disturbance, emotional stress, illness, physical fatigue or other factors may be contributing to their state.

The importance of sport-specific testing is that general tests of cognition cannot always capture the information processing requirements of a specific sport. Practical assessment can consist of technical accuracy, decision quality, tactical response, task specific endurance (as long as it is reliable and relevant to the athlete's role & competitive demands).

Table 5. *Practical Recommendations for the Prevention and Management of Mental Fatigue in Athletes*

Setting	**Practical consideration**
Training schedule	Avoid unnecessary stacking of prolonged cognitive tasks immediately before high-priority performance sessions when feasible.
Video/tactical meetings	Consider duration, timing, breaks, and the cognitive demands of the meeting.
Competition preparation	Use individualized routines and avoid introducing untested countermeasures immediately before competition.
Monitoring	Combine brief subjective information with context and periodic performance observations.
Support pathway	Persistent or severe fatigue should prompt broader assessment rather than being attributed automatically to mental fatigue.

10. Discussion

Mental fatigue is a concept supported by literature that could be relevant to athletic performance, but it needs to be considered in a multidimensional and task-specific manner. There is no evidence that mental fatigue causes the same level of decrement in performance or in all sports. Rather, the potential outcomes are a function of the combination of the fatigue state, the subsequent task, and the athletes' ability to control the selection of attention, effort, and motivation (Van Cutsem et al., 2017; Sun et al., 2024; Marcora et al., 2009; Wu et al., 2024; Smith et al., 2018; Sun et al., 2021; Smith et al., 2016; Habay et al., 2021; González-Víllora et al., 2022; Pan et al., 2025; Lu et al., 2026).

The difference between inducing and inducing mental fatigue and the state of mental fatigue is especially significant. The cognitive tasks employed in experimental research can have very different durations, complexity, emotional load and involvement. Thus, no task is guaranteed to induce mental fatigue in all participants, and the type of task mental fatigue can occur after can differ between individuals. Induction task should be included in future studies in sufficient detail to enable replication and comparisons (Sun et al., 2024; Wu et al., 2024; Qian et al., 2025; Aveiro et al., 2026), and a manipulation check should be performed.

Self-paced exercise is a continuous regulation of effort, hence there has been a great deal of research interest in endurance performance. Mental fatigue can make exercising more difficult and perhaps affect the pacing decisions that are made, which may lead to a decreased desire to maintain exercise intensity. This explanation does not exclude motivational and effort-regulation explanations, but should not be considered as a singular mechanism. Physiological, perceptual, motivational and contextual processes can interact with each other and can vary in importance depending on the protocol and exercise task (Marcora et al., 2009; Noakes, 2012; McCormick et al., 2015; Smith et al., 2018; Habay et al., 2026).

Technical and decision-making performances are also relevant since in many sports, athletes must act on the information that they receive, but is changing. Precision, error control, response selection and tactical adaptation could be related to mental fatigue. But, the quality of the technical performances is frequently variable and there are variations in the way the sport-specific task is designed that can make comparisons difficult. An isolated accuracy test

may not include the perceptual and decision-making needs of competition. To facilitate research, performance domains should be clearly defined and not be aggregated into a general category of performance (Sun et al., 2021; Habay et al., 2021; Trecroci et al., 2020; González-Víllora et al., 2022; Pan et al., 2025; Lu et al., 2026).

When evaluating strength and power it is important to be careful with the interpretation of the evidence. The impact of mental fatigue may vary depending on the duration of the task, motivation, familiarization and the type of exercise and might not be as reliable as in other domains of endurance or cognitive performance. This makes it even more important to have outcome-specific reviews and experiments that have an appropriate power rather than general claims of physical performance being impaired in everyone (Solon-Júnior et al., 2026; Wang et al., 2026).

The practical implications are mainly on organizational and individual level. Athletes and coaches can think about considering the overall cognitive load of training, tactical preparation, travel, school/academic/competitive responsibilities and schedules. When possible, these may be integrated, such as recovery opportunities, cognitive-load management and targeted strategies. Interventions must be assessed based on evidence, however, do not necessarily have the same effects across all athletes. Persistent symptoms require clinical and/or professional assessment and monitoring should not be used to replace this (Sun et al., 2024; Wang et al., 2026).

There are still many methodological weaknesses. Very few studies have large samples, long induction periods, lab tasks, or fewer sport-specific outcomes. There are several ways of inducing and measuring fatigue, which makes synthesis difficult. The sample of athletes examined does not necessarily represent all the levels of competition, sport, age or sex. The evidence base can also be influenced by publication/reporting biases. Additionally, sleep loss, stress, physical fatigue and travel are common co-occurrences with mental fatigue in the real world, but often one exposure is studied at a time in experimental studies. Isolation enhances the causal interpretation of the material but may also diminish the ecological validity of the material.

Future study should use preregistered and well-powered studies, fatigue verification that is standardized, repeated measures, and sport-specific outcomes. Investigations should involve a variety of athlete populations, as well as differences in athletes, training status, motivation, chronotype, competition context, and cognitive and physical demands interaction. In addition, studies should differentiate subjective fatigue from performance changes and report effect estimates with confidence intervals to better interpret the results and ensure their replicability (Sun et al., 2024; Sun et al., 2021; Qian et al., 2025; Lu et al., 2026; Wang et al., 2026; Aveiro et al., 2026; Lu et al., 2026).

11. Future Research Directions

Future studies should: (1) provide a standardized description of the cognitive-fatigue induction task; (2) incorporate valid subjective and behavioral manipulation checks; (3) separate mental fatigue from sleep deprivation, stress, boredom and physical fatigue; (4) involve ecologically valid sport-specific tasks; (5) describe sex, age, sport, training level and baseline state; (6) investigate dose-response and recovery-time relationships; (7) report complete statistical information and confidence intervals; and (8) evaluate countermeasures in a randomized design. A multidisciplinary approach involving the sport psychology, physiology, neuroscience and performance analysis could enhance the understanding of the mechanisms and practical translation.

12. Conclusion

Mental fatigue is a state that is relevant to psychobiology and could affect endurance regulation, technical performance, cognition and decision making in sport. It has diverse effects that vary according to the induction protocol, the characteristics of the athletes, the demands of the task, and the measures of outcome. There

is currently evidence to suggest that a prudent, tailored and cautious approach is warranted that takes into account aspects of cognitive-load management, recovery opportunities, sport-specific assessment and appropriate monitoring. The effects of mental fatigue do not necessarily affect all the components of a performance equally and results from laboratory research do not necessarily translate to competition. Research in this area needs to be improved in terms of design, ecological validity, and sufficient power to clarify mechanisms, identify sensitive performance domains, and determine the effectiveness of practical interventions.

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