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Review

Understanding Fatigue: A Psychological Framework for Health and Performance

Andrew M. Lane [1,*], Dominic Micklewright [2] and Carla Meijen [3]

[1] School of Health and Wellbeing, University of Wolverhampton, Walsall WS1 3DB, UK
[2] School of Sport, Rehabilitation & Exercise Sciences, University of Essex, Colchester CO4 3SQ, UK; dpmick@essex.ac.uk
[3] Faculty of Social and Behavioural Sciences, University of Amsterdam, 129 1018 Amsterdam, The Netherlands; c.meijen@uva.nl
* Correspondence: a.m.lane2@wlv.ac.uk

Abstract

Fatigue is a multidimensional phenomenon with profound implications for performance, health, and wellbeing. Its complexity means that no single discipline can adequately explain its causes or management, highlighting the need for integrative approaches. This article introduces the F.L.A.M.E.S. framework, a psychological model that integrates self-report, physiological, emotional, and contextual perspectives on fatigue. The framework combines validated assessment tools with evidence-based management strategies including goal setting, motivational self-talk, attentional control, and emotion regulation and embeds these within proactive, reactive, and preventative approaches. Applications are illustrated through case studies in sport, healthcare, and education, showing how the model can be co-constructed with practitioners to ensure ecological validity and uptake. By linking mechanisms to management and scaling solutions across domains, the F.L.A.M.E.S. framework provides a roadmap for enhancing performance, resilience, and sustainable wellbeing.

Keywords: fatigue; contextualization; co-construction; assessment; validity; wellbeing

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1. Introduction

Fatigue is a widely recognised yet inconsistently defined phenomenon that affects individuals across all areas of life. Fatigue limits performance, impairs decision-making, and, if unmanaged, contributes to burnout and ill health. Fatigue has been examined in many ways, producing multiple definitions with limited agreement. It varies according to context: exhaustion after high-intensity exercise, weariness from prolonged concentration, and depletion from long work hours each reflect different forms. Insights from one setting rarely transfer to another. Examining fatigue across contexts may offer conceptual clarity, provided the contextual factors shaping its expression are recognised. In this article, we explore the multidimensional nature of fatigue and its implications across sport, education, health, and occupational domains. We first examine conceptual and measurement challenges that challenge progress in fatigue research [1], before turning to evidence-based psychological strategies that support individuals in managing fatigue [2]. To guide this analysis, we adopt a previously published working definition [1]: "Perceived fatigue is a feeling of diminishing capacity to cope with physical or mental stressors, either imagined or real" (p. 2377). This conceptualization bridges physical and mental domains while emphasising perception as a unifying feature of how fatigue is experienced and acted upon.

Previous research [1] distinguished between two forms of fatigue. Physical fatigue which reflects reductions in the ability to generate or sustain force, often tied to physiological strain (e.g., muscle exhaustion, metabolic by-products, neuromuscular impairment), and mental fatigue, which arises from prolonged periods of sustained cognitive or emotional effort, leading to slower processing speed, lapses in attention, and reduced executive control. Although distinct in origin, both share a common perceptual core: the subjective sense that capacity to meet demands is waning.

Fatigue: a concept that transcends multiple areas of application

Systematic reviews consistently demonstrate that fatigue poses a serious threat to performance, safety, and wellbeing across different areas of life. In sport, both mental and physical fatigue reduce performance and heighten vulnerability to injury and illness [3–6]. In healthcare, fatigue among nurses and physicians contributes to medical errors, diminished safety, and poorer organisational outcomes [7–9], while compassion fatigue has been identified in emotionally demanding roles [10]. Surgical fatigue impairs technical performance and decision-making [11,12]. Occupational fatigue is linked to accidents, cognitive errors, and reduced productivity [13,14]. Aviation has long recognised fatigue as a safety risk, generating reviews of causes, consequences, and countermeasures [15–17]. In education, chronic fatigue can significantly impair student functioning and academic engagement [18]. Taken together, these findings highlight the urgent need for strategies that address both psychological and physiological mechanisms of fatigue.

Possibly not surprisingly, each area of application focuses on the aspect of fatigue relevant. Some studies emphasise physical and emotional exhaustion [7], whilst other areas of research emphasise demographic correlates [14], sleep deprivation and circadian disruption [3,15]. In sport, athletes and coaches may misinterpret fatigue as low motivation, overlooking signs of overtraining or illness [4]. In healthcare, compassion fatigue may be pathologized as burnout or apathy when it reflects empathy overload or systemic stressors [10]. These misattributions encourage researchers and practitioners to follow a multidimensional framework that integrates perception, context, and emotion. Psychological models such as ego depletion illustrate this complexity. While early accounts linked self-control to finite metabolic resources [19], critiques have questioned the biological plausibility [20] and proposed motivational or belief-based explanations [21]. More recent perspectives [19,22] describe “self-control fatigue” as a multicomponent construct shaped by emotional, motivational, and situational influences.

Taken together, this body of work underscores the need for an integrative biopsychosocial model of fatigue. Rather than treating fatigue as a unitary or mechanistic process, researchers should specify which elements are under investigation, which will be influenced by contextual factors, reconcile conflicting findings, and develop tailored interventions. This approach is particularly relevant in high-demand fields such as sport, education, and healthcare, where cognitive effort and emotional labour co-exist with physical strain.

2. Advancing the Measurement of Fatigue: Integrating Self-Report, Physiology, and Emotion

Fatigue cannot be understood in isolation from the context in which it occurs and this needs to be factored into how it is measured. Situational demands and individual responses such as the extent to which a person is motivated to sustain performance despite feelings of fatigue shape both how fatigue is experienced and how it manifests. This means that no single measure can capture fatigue adequately. Common approaches include self-report tools, behavioural indices, and physiological markers such as heart rate variability, core temperature, lactate thresholds, or cortisol levels. Each provides only partial insight and combining them offers a more complete picture of the context-dependent nature of fatigue.

Reviews highlight that inconsistency arises when physiological markers are interpreted without considering context, and that limited integration across methods undermines understanding [13,18]. For example, occupational studies often rely on disparate, unvalidated self-reports [13], while school-based research demonstrates substantial heterogeneity in tools for chronic fatigue [18].

The development and validation of the Rating-of-Fatigue (ROF) produced a method to quantify consciously perceived fatigue rather than inferring it from performance decline [1,23]. Validation studies demonstrated that the ROF is sensitive to internal state changes and reflects the integration of attentional, emotional, cognitive, and motivational signals, evidence consistent with the view that fatigue is centrally mediated. Crucially, subjective fatigue does not always map directly onto physiological strain. For example, in exhaustive cycling tasks, participants reported high fatigue and showed impaired memory and attentional narrowing even while sustaining physical output [1,23].

These findings reinforce the value of combining subjective and physiological data. In sport, there are times when subjective fatigue and physiological markers align, such as during prolonged endurance exercise where rising lactate, heart rate, and thermal strain correspond with increasing perceptions of exhaustion. Continuing with athletes, misalignments can occur when people report low scores for self-reported fatigue but evidence intense physiological strain maintain a high intensity of performance, for example an elite marathon runner. Misalignments can also occur in healthcare shift work, where subjective reports of tiredness generally rise in step with disrupted sleep and circadian markers, but where some individuals underreport fatigue to maintain performance, masking underlying physiological risk. In education, classroom testing often produces high reported fatigue without corresponding physiological disturbance, though extended periods of poor sleep or overwork can bring the two into alignment.

Taken together, these examples show that convergence and divergence between subjective and physiological fatigue are not anomalies but a consistent feature of human functioning across settings. This is precisely why both forms of measurement are essential. The strength of the ROF scale lies not only in capturing the perceptual dimension of fatigue but also in the rigorous validation process. The ROF scale was designed to be short, simple, and practical, while retaining scientific robustness [1]. As a result, it offers one of the few tools that could be used across laboratory, sporting, educational, occupational, and clinical contexts. In short, the ROF provides a validated and versatile foundation for integrating subjective and physiological approaches, offering the most comprehensive way forward in understanding fatigue across contexts.

The strength of the ROF scale lies not only in capturing the perceptual dimension of fatigue but also in its validation as a robust, practical tool across contexts. Yet, even with a reliable self-report measure, interpretation of fatigue signals is shaped by the emotional and motivational state of the individual. In other words, perception of physiological strain does not occur in a vacuum; it is filtered through emotion and mood.

Building on this psychophysiological account, research shows that fatigue is not passively endured but actively interpreted through individual beliefs, emotions, motivation, and attentional focus. Placebo studies provide compelling evidence. When beliefs and expectations are experimentally manipulated, perceived exertion changes independently of biological status [24–26]. For example, simply telling participants they had received a fatigue-reducing treatment reduced their reported fatigue, altered physiological responses, and in some cases improved performance, even when no treatment had been given. These effects demonstrate that beliefs actively shape both perception and physiology. Crucially, because beliefs can be modified, fatigue is not a fixed consequence of workload but a

malleable state, and one that is open to cognitive and behavioural interventions designed to unlock latent performance capacity.

Emotions and mood further shape fatigue perception. Fatigue has been conceptualised as an emotion-like signal guiding energy conservation, and reflects evolutionary mechanisms for prioritising action when opportunity costs are high [27]. Further researchers [28] have highlighted reappraisal as a central strategy in emotion regulation, emphasising how shifts in interpretation can modify both affective experience and behavioural outcomes. In experimental work [29], researchers manipulated feedback to create positive or negative emotional contexts during cycling. Negative feedback produced higher reported fatigue and more disturbed physiological responses to the same workload. When participants used emotion regulation to manage negative affect, they tolerated greater workloads, with some sustaining performance at a higher VO_2 level despite adverse conditions. This demonstrates that emotion regulation not only alters perception but also reshapes physiological responses to identical physical demands.

The 4Rs model [30] provides a structured framework for managing affective influences on fatigue, with its central strength lying in the distinction it makes between moods and emotions. This distinction is crucial: moods are longer-lasting and diffuse, often colouring overall experience, while emotions are acute and linked to specific events [31]. Misinterpreting one for the other can lead to unhelpful strategies; for example, attempting to "fix" a transient emotional response with long-term mood interventions, or dismissing a persistent low mood as if it were a passing emotional reaction. The model therefore begins by encouraging individuals to recognise whether they are experiencing a mood or an emotion, and then to reflect on what that state signifies. Notably, a 5th R reflection was omitted [30], but clearly, such reflection is needed for an awareness of what is being experienced. Once awareness is established, individuals can choose strategies to restore balance (e.g., through rest and recovery), resolve underlying issues (e.g., workload or interpersonal stress), or regulate their emotional response (e.g., through mindfulness or motivational self-talk).

These processes are highly adaptable across contexts. A student who is overwhelmed mid-assignment may recognise their state as acute anxiety (emotion) rather than a deeper lack of motivation (mood), prompting immediate regulation strategies such as reframing or breathing techniques. A healthcare worker nearing burnout may instead identify a sustained low mood, signalling the need for restoration or resolution at a systemic level rather than quick regulation. Importantly, the 4Rs model can be embedded into a multimodal assessment framework alongside validated self-report tools (e.g., ROF) and physiological markers. By clarifying whether fatigue is being shaped primarily by an emotional episode, a longer-term mood state, or physiological strain, the 4Rs adds diagnostic precision. This integration ensures that interventions target the right mechanism, whether that is restoring energy balance, addressing mood dysregulation, or reframing acute emotional responses, and thereby improving both the accuracy of fatigue assessment and the effectiveness of subsequent interventions.

Motivation also plays a pivotal role. Motivational Intensity Theory [32,33] emphasises that effort reflects a cost–benefit calculation: individuals invest energy when success is seen as both possible and worthwhile. If the task seems unachievable or unrewarding, even high-capacity individuals may disengage. From this perspective, fatigue operates less as a marker of depletion and more as an adaptive regulatory signal and thereby encouraging strategic withdrawal when costs outweigh benefits. Interventions that promote cognitive reappraisal help individuals ask "Is this worth the effort?" and "Can I succeed?", distinguishing between justified withdrawal and premature disengagement.

Attention and focus influence how fatigue is tolerated. Under high effort, attention often narrows [23]. An internal focus of attention can intensify fatigue by drawing awareness to discomfort, whereas an external focus can support more efficient management of effort. Strategies such as attentional control, cue-based self-talk, or task segmentation can redirect focus and sustain performance despite strain.

Taken together, these findings demonstrate that fatigue is shaped not just by physiological load but also by how individuals interpret and regulate internal states. Comprehensive evaluation should therefore combine three strands of evidence: (1) validated self-report scales (e.g., ROF), (2) physiological markers such as heart rate variability, lactate, or cortisol, and (3) emotion and mood profiling tools (e.g., BRUMS, ecological momentary assessment, affective computing). This multimodal approach clarifies whether high fatigue reflects depletion, overload, or dysregulation. Embedding emotional and cognitive assessment into multimodal measurement enables practitioners to distinguish adaptive fatigue signals (e.g., conserving resources) from maladaptive responses (e.g., disengagement driven by negative affect), supporting more precise diagnosis and targeted intervention. Importantly, because beliefs, emotions, motivation, and attention can all be modified, this body of work sets the stage for integrated psychological interventions aimed at reshaping how fatigue is experienced and managed.

3. From Mechanisms to Management: Integrated Psychological Interventions for Fatigue

Interventions aiming to address fatigue can be categorised by their timing and orientation: reactive, proactive, and preventative [6,34]. *Reactive* interventions, as suggested previously, respond once symptoms are present; for example, rest, hydration, cooling, recovery protocols, or short-term psychological strategies such as distraction, breathing techniques, or attentional refocusing. *Proactive* interventions are embedded into daily routines to anticipate and manage fatigue before it escalates, including structured sleep practices, balanced nutrition, regular recovery routines, and psychological skills training such as self-talk and mindfulness. *Preventative* interventions operate further upstream, targeting systemic or long-term risk factors before fatigue has a chance to develop. Examples include workplace policies that limit overload, education programmes that train individuals to recognise early signs of fatigue, and ergonomic adjustments that reduce cumulative strain [13]. Importantly, these three categories are not mutually exclusive but complementary, addressing fatigue at different stages of its development.

These categories are not only conceptual: empirical work demonstrates their practical value. Previous research has shown how self-regulation, pacing, and attentional control can be taught and applied across reactive, proactive, and preventative levels to sustain endurance under fatigue [2]. Their more recent study [35] illustrated the feasibility of delivering brief, tailored interventions to support competitive athletes using online methods. The principles underpinning their work; structured self-regulation, pacing, and attentional deployment are directly transferable to occupational, clinical, and educational contexts, demonstrating that fatigue interventions can be designed to be both context-sensitive and scalable [35–37].

Within this framework, emotion regulation theory provides a foundation for understanding how psychological interventions exert their effects. Gross's process model of emotion regulation [31] distinguishes between strategies that intervene early in the emotion-generative process, such as situation selection or attentional deployment and those that intervene later, such as cognitive reappraisal or suppression. Previous research [28] has reinforced this view, highlighting reappraisal as a flexible and powerful mechanism for adapting to fatigue-related challenges by reshaping how individuals interpret effort and

strain. Therefore, if feelings are identified as emotion, then there is a clearly defined theory-based intervention to followed to aid regulation. This distinction maps closely onto reactive, proactive, and preventative approaches to fatigue. For example, preventative strategies align with situation selection (structuring environments to avoid overload), proactive strategies align with attentional deployment (directing focus to manage effort efficiently), and reactive strategies align with reappraisal or response modulation (reframing exertion or using breathing to regulate arousal).

Cognitive reappraisal provides a good illustration of this principle. Reappraisal involves reframing perceptions of effort in light of goals and resources, thereby altering motivational investment. Research [28] has emphasised that reinterpretation processes are central to effective emotion regulation, directly linking appraisal mechanisms to improved resilience under fatigue. Recent psychophysiological work [33] shows that cardiovascular responses, such as systolic blood pressure reactivity, reflect motivational effort and can be influenced by reappraisal. By changing how exertion is interpreted, individuals adjust whether further energy investment is justified. In sport, this might help an athlete decide mid-race whether a personal best is worth the push; in healthcare, it may guide a fatigued patient in choosing between rest and activity. Such decisions are grounded in beliefs about energy cost, likelihood of success, and anticipated reward, all of which are amenable to intervention.

Consistent with other psychological skills, reappraisal must be taught, practised, and contextualised, just like physical training. Once embedded, it can be deployed reactively to reassess goals during performance, proactively to anticipate and manage strain, or preventatively to monitor long-term energy use. Other strategies identified in Gross's [31] model such as attentional deployment, mindfulness, and situation modification can likewise be mapped onto intervention levels. Together, these skills demonstrate how interventions work most effectively when they target mechanisms of change (e.g., attention, appraisal, emotion regulation) rather than only alleviating symptoms [31].

For interventions to be credible, they must also articulate the mechanisms of action clearly. If the aim is to reduce psychological fatigue by improving sleep, the proposed pathway might involve reduced neuroinflammation or improved cognitive recovery [38]. If the aim is to alleviate mental fatigue in sport, the mechanism may involve reduced perceived effort through attentional control or pacing strategies [2,6]. Defining mechanisms strengthens internal validity, facilitates tailoring to specific contexts or populations, and avoids one-size-fits-all approaches.

There is growing empirical support for these approaches. In clinical settings, exercise and self-management interventions have reduced fatigue in cancer populations [39], while cognitive-behavioural therapy (CBT) has proven effective in managing fatigue in multiple sclerosis [40,41], inflammatory bowel disease [42], and chronic fatigue syndrome [43]. In sport, meta-analyses indicate that mindfulness, brain-endurance training, and motivational strategies offer modest but consistent benefits in reducing mental fatigue [26]. However, variability in outcome measures remains a challenge. Large individual differences in recovery timelines after competition were found [44] and similarly highlighted the need for tailored psychological strategies despite encouraging results for interventions such as self-talk and attentional refocusing.

Taken together, this body of work supports an integrative framework in which fatigue emerges from the interaction of mood, cognition, physiology, and context. Such an approach clarifies mechanisms, reconciles conflicting findings, and guides the design of tailored interventions. A particularly promising direction is the use of transdiagnostic frameworks interventions designed to operate across conditions or populations by targeting shared psychological mechanisms. Transdiagnostic approaches focus on core processes such as

emotion regulation, motivational appraisal, and attentional control, which underpin fatigue in both clinical and performance settings. This allows interventions to be scalable, flexible, and individualised, supporting both population-level and personalised strategies.

In summary, effective fatigue management requires an interdisciplinary and psychologically informed approach. By targeting the beliefs, moods, goals, and attentional patterns that shape perception, and combine reactive, proactive, and preventative strategies with physiological foundations. As such, these interventions can enhance not only short-term coping but also long-term resilience and sustainable performance.

4. Toward a Model for Working with Fatigue: The FLAMES Framework

To translate the psychological principles discussed into actionable practice, we propose the F.L.A.M.E.S. framework (see Table 1, Figure 1). The acronym captures the idea that fatigue, much like a flame, can ignite from small sparks of strain, spread across physical, cognitive, and emotional domains, and either be contained or left to burn unchecked. The FLAMES framework provides a structured pathway for understanding and managing fatigue: from identifying its Framework for Context, recognising its Levels of Impact, applying valid Assessment Tools, implementing Management Strategies, raising Education and Awareness, and finally developing Scalable Solutions that adapt across domains. In this way, the metaphor of "flames" aligns closely with the lived experience of fatigue as something that emerges, intensifies, and requires active regulation to prevent escalation.

Table 1. The F.L.A.M.E.S. Fatigue Framework.

Letter	Component	Description
F	Framework for Context	Fatigue is always context-dependent; sport provides a laboratory, but principles apply equally in healthcare, education, and work.
L	Levels of Impact	Fatigue influences physical performance, cognition, and wellbeing, requiring multidimensional monitoring.
A	Assessment Tools	Use validated, reliable measures that combine self-report and physiology to capture fatigue accurately.
M	Management Strategies	Integrate physiological recovery with psychological resilience skills (e.g., reappraisal, attentional control, 4Rs).
E	Education & Awareness	Train individuals and teams to recognise, reflect on, and regulate fatigue.
S	Scalable Solutions	Develop co-constructed, adaptable methods for managing fatigue across domains.

4.1. F—Framework for Context

Fatigue manifests in every domain where individuals face sustained demands, but sport provides a particularly useful starting point because athletes voluntarily push to physiological and psychological limits in pursuit of measurable goals. The principles derived from this setting include balancing effort, strategy, and recovery apply equally to healthcare workers on long shifts, teachers managing classrooms, or employees under sustained cognitive load. Sport, however, provides the clearest laboratory for studying fatigue under controlled, measurable conditions. Athletes must recognise when to conserve energy and when to push harder, balancing effort, strategy, and recovery. This provides a natural laboratory for studying fatigue, pacing, and performance under pressure. In sport, they have also developed standardised tests for studying fatigue involving athletes voluntarily

performing exercise to exhaustion in measurable, ethically acceptable ways (e.g., VO_2 max tests, 2000 m rowing trials [45]. The motivational demands of sport make it especially valuable for examining how individuals respond when physical strain, cognitive effort, and emotional regulation converge [2]. Increasingly accessible sport science laboratories, now common in universities, training centres, and community settings offer controlled environments for testing, intervention, and data collection beyond elite populations [2].

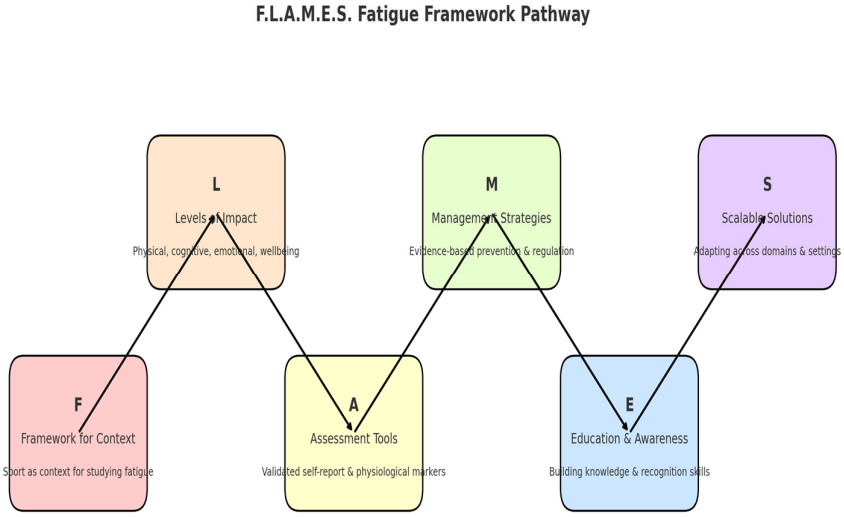


Figure 1. The F.L.A.M.E.S. Fatigue Framework presented as a pathway model, illustrating how context, impact, assessment, management, education, and scalable solutions connect to guide fatigue understanding and intervention.

4.2. L—Levels of Impact

Fatigue exerts influence across multiple levels, extending beyond physical strain to shape cognition, emotion, and motivation. Physically, it may reduce strength, endurance, or coordination. Cognitively, fatigue impairs attention, memory, and decision-making, narrowing focus and slowing response times. Emotionally, it amplifies negative affect and reduces tolerance for frustration, while motivationally it alters the perceived value of continuing effort, prompting disengagement even when capacity remains.

Recognising these layers helps to explain why the same physiological load may be experienced so differently across individuals or contexts. For instance, one person may experience fatigue primarily as slowed thinking, while another perceives it as emotional exhaustion or loss of drive. Early indicators such as irritability, lapses in concentration, or diminished persistence can be captured through brief self-report tools (e.g., mood check-ins, single-item fatigue ratings) and observed behaviours (e.g., reduced accuracy, hesitation, withdrawal).

By mapping fatigue across these domains, practitioners and researchers can identify which aspect of functioning is most affected and therefore which type of intervention is most relevant, whether physical recovery, cognitive reframing, emotional regulation, or motivational support. This layered perspective sets the stage for more systematic assessment protocols that can quantify the impact of fatigue and test strategies for managing it.

4.3. A Assessment Tools

Accurately assessing fatigue requires tools that capture both its physiological and psychological dimensions, and that reveal how fatigue affects performance. Multiple methods are essential: combining physiological measures (e.g., heart rate variability, lactate, VO_2) with validated self-report tools such as Ratings of Perceived Exertion (RPE) or the

Rating of Fatigue (ROF) provides a more complete picture of fatigue as both a bodily state and a subjective experience.

Fatigue has multifaceted effects on physical performance, cognition, and wellbeing. Simple check-ins, such as the Brunel Mood Scale (BRUMS) or single-item fatigue ratings, can detect early signs of disengagement or overload [30]. Embedding these assessments into routines fosters emotional awareness and resilience, supporting performance in high-pressure settings [30]. Advances in wearable technology such as tracking heart rate variability, movement patterns, or sleep can further enable individuals to link mood and cognitive states with physiological strain, creating personalised fatigue profiles [2,35–37]. Importantly, recognising these different levels helps clarify whether fatigue reflects depletion, attentional overload, or affective dysregulation. This layered insight is valuable across contexts: in sport it may distinguish between pacing error and physiological strain; in healthcare it may reveal whether errors arise from physical exhaustion, cognitive lapses, or emotional burnout.

Assessment is not only about recording fatigue but also about understanding its functional impact. Standardised protocols make it possible to observe how fatigue influences performance under controlled conditions and to test whether interventions are effective. In endurance sport, for example, VO_2 max tests or 2000 m rowing trials are widely used to examine how individuals sustain effort until exhaustion [37,45]. Such protocols provide replicable conditions under which the effects of pacing strategies, motivational self-talk, or recovery methods can be evaluated.

Outside of sport, however, equivalent systematic protocols are rare. Professionals in healthcare, education, or social care typically discover the effects of fatigue *through lived experience* rather than structured assessment. This absence limits opportunities to trial and refine interventions under standardised conditions. Developing context-specific, co-constructed fatigue tests such as simulations, structured observations, or embedded micro-tests (e.g., error tracking, response latency, speech analysis) would allow individuals and organisations to benchmark performance under fatigue, evaluate strategies, and monitor progress over time. In this way, assessment becomes not only diagnostic but also an experimental platform for innovation in fatigue management.

4.4. M Management Strategies

Effective fatigue management requires aligning physiological, cognitive, emotional, and motivational perspectives, and ensuring that strategies are appropriately timed. Management can be organised into reactive, proactive, and preventative approaches, each serving different functions across contexts.

4.4.1. Reactive Strategies

Reactive strategies are used once fatigue symptoms are present. In sport, athletes may rely on motivational self-talk, attentional cues, or breathing techniques to maintain focus during competition. In healthcare, reactive strategies might involve brief “micro-breaks”, hydration, or mindfulness exercises during demanding shifts. For teachers, stepping back momentarily to reframe a stressful situation can prevent escalation, while industrial workers may use task-switching to relieve momentary strain. These approaches help individuals recover composure and sustain performance under acute pressure.

4.4.2. Proactive Strategies

Proactive strategies are embedded into routines to anticipate and manage fatigue before it escalates. In sport, this includes structured pacing plans, pre-competition routines, and regular monitoring of mood and physiological signals. Healthcare professionals may proactively manage fatigue through structured shift patterns, consistent hydration, and

regular use of emotion regulation techniques such as reappraisal. In education, proactive strategies include lesson planning that balances high- and low-intensity tasks, while in office settings, task-rotation and scheduled breaks help preserve concentration. Proactive management requires deliberate practice so that strategies become automatic when strain emerges.

4.4.3. Preventative Strategies

Preventative strategies target systemic or long-term factors that influence fatigue risk. In sport, these include periodised training programmes, sleep hygiene protocols, and recovery planning to reduce overload. In healthcare, preventative strategies involve organisational policies that limit consecutive long shifts and foster supportive team structures. For teachers, preventative measures include institutional workload management and professional development on resilience. In occupational and clinical settings, ergonomic adjustments, CBT programmes, and lifestyle interventions (exercise, nutrition, sleep) help prevent chronic fatigue from taking hold. These upstream approaches alter the conditions under which fatigue develops, building resilience over time.

Management also benefits from psychological frameworks that guide strategy selection. Emotion regulation theory [31] and mood profiling models such as the 4Rs [30] help individuals identify whether fatigue stems from acute emotional responses, sustained mood states, or genuine physical strain. This distinction enables more targeted choices: for example, using reappraisal when negative affect is amplifying fatigue, or prioritising sleep and nutrition when physical depletion is the primary driver. By integrating physiological recovery (hydration, nutrition, sleep) with psychological resilience (self-talk, attentional control, mindfulness), management strategies become more holistic and adaptable.

Across contexts, effective management requires recognising the source of fatigue, the demands of the task, and the resources available. A reactive strategy that is effective for an athlete mid-race may be inappropriate for a nurse experiencing cognitive overload at the end of a night shift. By combining reactive, proactive, and preventative approaches and tailoring them to specific environments fatigue management can enhance both performance and wellbeing.

4.5. E—Education and Awareness

The previous section outlined management strategies, reactive, proactive, and preventative, that can help individuals sustain performance under fatigue. However, strategies are only effective if people can recognise when to apply them, adapt them to context, and persist with them over time. This is where education and awareness play a critical role.

Education is best understood as the process of cultivating self-regulation skills that enable people to use management strategies effectively. These skills do not develop through knowledge alone but through repeated practice, feedback, and reflection. It is well established that psychological skills improve with practice: techniques such as self-talk, pacing, attentional control, or mindfulness must be rehearsed in different situations until they become fluent and automatic. In sport, athletes identify fatigue management as a performance goal and therefore integrate such training into daily routines. Intervention studies [2] show how athletes benefit from structured opportunities to trial strategies, reflect on outcomes, and refine their use across multiple sessions.

This educational process also addresses the beliefs and expectations that shape fatigue, linking back to evidence reviewed earlier on placebo effects and feedback manipulations. For example, evidence from a negative feedback [29] study highlights that beliefs can either undermine or enhance resilience. Education provides the context in which such beliefs can be recalibrated through guided experience, helping individuals develop confidence in

their ability to regulate fatigue. The mechanism underpinning education can be described as a self-regulation cycle: Recognition involves identifying early signs of fatigue using subjective (ROF, BRUMS) and objective (wearables) tools introduced earlier in this paper. Reflection, interpreting whether fatigue reflects physical depletion, attentional overload, or emotional dysregulation, drawing on emotion regulation theory [31] and mood profiling frameworks such as the 4Rs [30]. Response via selecting an appropriate management strategy (reactive, proactive, or preventative), as outlined in the previous section. And finally, Review, evaluating whether the response was effective, reinforcing adaptive beliefs and preparing for future challenges.

This cycle integrates the elements introduced throughout the paper measurement tools (Section 4.3), emotional and motivational influences (earlier discussion of Gross and the 4Rs), and management strategies (Section 4.4) into a learning process that builds resilience over time. Crucially, education requires individuals to identify fatigue management as a goal worth pursuing. Athletes do this naturally because performance depends on it, but healthcare workers, teachers, and other professionals can benefit equally if fatigue regulation is treated as a skill to be developed rather than a burden to be endured.

In short, education links the recognition of fatigue to the effective deployment of strategies, while reshaping beliefs that may otherwise undermine resilience. By embedding reflection and feedback into daily routines, education transforms fatigue management from an ad hoc response into a deliberate practice of self-regulation. This provides the foundation for scaling skills beyond the individual level, a step addressed in the next section.

4.6. S—Scalable Solutions

The final component focuses on creating scalable, adaptable fatigue management methods. Advances in sport science and wearable technology allow both large-scale monitoring and individual case analyses [1,36]. Increasingly, these tools are being applied outside elite sport such as in education, healthcare, and occupational settings, and are an integrated aspect of many wearables such as watches. As such, this enables possible links between emotional states, recovery patterns, and performance outcomes [22]. When combined with the self-regulation skills described in the previous section, they provide a foundation for extending fatigue management from individual practice to collective culture.

Sport again provides a useful proof of concept. Standardised protocols (e.g., VO_2 max, time-to-exhaustion trials) give athletes credible benchmarks for evaluating fatigue, creating a shared understanding of its meaning. For other domains, however, such as healthcare, education, and social care, there is a lack such systematic tools. Here, fatigue is often discovered through lived experience rather than structured assessment. For fatigue management to scale, parallel credibility must be established elsewhere: what VO_2 max is to athletes, decision fatigue may be to healthcare workers, emotional labour to teachers, or moral distress to social workers.

The key mechanism is co-construction. Rather than imposing tools top-down, co-construction involves active collaboration with the professionals who will use them. Teachers, nurses, or social workers help to identify the fatigue states most relevant to their practice, ensuring that assessments and interventions reflect lived realities. This participatory approach enhances ecological validity, fosters ownership, and increases adoption. It also aligns with principles of psychological empowerment and organisational change, embedding fatigue management into professional cultures rather than leaving it to individual discretion.

A staged development pathway offers a roadmap for scaling:

1. Stakeholder mapping and consultation to identify domain-specific fatigue demands and experiences.
2. Collaborative design workshops to agree on meaningful markers and assessment content.
3. Pilot testing and refinement based on user feedback and feasibility.
4. Validation studies linking outcomes with observed performance and wellbeing.
5. Integration strategies embedding tools into reflective practice, training, or institutional reviews.

This process transforms fatigue management into a scalable, context-sensitive practice. At the team level, shared assessment tools create a common language of fatigue, enabling colleagues to recognise early signs and coordinate workload. At the organisational level, policies such as workload limits, structured breaks, and training provision embed fatigue regulation into daily operations. At the system level, validated assessments and interventions can inform professional standards, accreditation frameworks, and policy, ensuring fatigue management is recognised as a core competency across sectors.

In summary, scalable solutions extend the self-regulation cycle (Education) into shared practices at group, organisational, and systemic levels. By adapting sport-derived principles through co-construction, fatigue management becomes not only credible and measurable but also meaningful and impactful across diverse domains.

5. Examples in Practice: Applying the FLAMES Framework

The value of the FLAMES framework becomes clearer when applied to real-world scenarios. In each case, fatigue is not simply an abstract concept but a pressing issue with direct consequences for performance, safety, or wellbeing. The following examples show why understanding fatigue matters, and how the six components of the framework can be applied.

5.1. Case Study 1: Judo Athlete Preparing for Competition

For a judo athlete, fatigue is a decisive factor that can determine whether they maintain composure in the final bout or lose control under pressure. Success requires not only physical conditioning but also emotional regulation (e.g., controlling aggression, managing frustration) and tactical awareness. Understanding and managing fatigue therefore becomes central to both performance and athlete safety.

- Framework for Context (F): Competition preparation and tournament performance in judo involve repeated high-intensity bouts with limited recovery, quick decision-making, combining physiological strain, technical precision, and emotional regulation.
- Levels of Impact (L): Fatigue manifests physically (reduced grip strength, slower reaction times), cognitively (slowed tactical decision-making), and emotionally (frustration or over-arousal).
- Assessment (A): Self-report measures such as ROF ratings and BRUMS profiles are used alongside physiological monitoring (HRV, weight-management strain, lactate) to track readiness before a fight and recovery post-fight. Coaches and athletes also review fight footage to detect attentional lapses and pacing errors under fatigue, which of course can feed into assessment and education.
- Management (M): Reactive strategies include in-bout attentional cues and breathing control, proactive strategies involve structured training cycles with planned overreaching and recovery, while preventative measures include weight-management protocols designed to minimise excessive fatigue before competition.
- Education (E): Athletes and coaches work together to interpret self-report and physiological data, reflect on patterns of fatigue during training and competition, and practice

regulation strategies such as tactical pacing, reappraisal, or relaxation techniques. Over time, repeated practice helps athletes deploy these strategies in high-stakes situations.
- Scalable Solutions (S): At the team and organisational level, fatigue management is embedded into training camps and coach education. Shared protocols for monitoring and intervention reduce injury risk, foster resilience, and ensure that athletes approach competition with a sustainable balance of physical capacity and psychological readiness.

5.2. Case Study 2: Nurse on a 12-Hour Shift

In healthcare, fatigue has direct implications for patient safety as well as staff wellbeing. Long shifts, high cognitive demands, and emotional stress create conditions where lapses in attention or judgement can have serious consequences. For nurses, learning to manage fatigue is not optional; it is critical to effective care.

- Framework for Context (F): A 12 h shift involves sustained physical activity, cognitive load such as decision-making under pressure, and emotional engagement with patients and colleagues.
- Levels of Impact (L): Fatigue manifests as muscle soreness, reduced focus, irritability, and motivational decline.
- Assessment (A): Short ROF ratings, mood check-ins, and HRV data identify early warning signs before errors occur.
- Management (M): Reactive micro-breaks and hydration sustain performance during the shift, proactive rest and nutrition routines support recovery, and preventative rostering policies reduce long-term strain.
- Education (E): Training programmes teach nurses to distinguish between physical, cognitive, and emotional fatigue and to select appropriate strategies. Peer reflection at handovers supports shared learning.
- Scalable Solutions (S): At the organisational level, fatigue monitoring informs staffing policies, structured breaks, and wellbeing initiatives, embedding fatigue management into hospital systems.

5.3. Case Study 3: Teacher During Exam Season

For teachers, in countries where there is an exam season there are intense cognitive and emotional demands. This is likely to be experienced for teachers during busy marking periods. Sustaining accuracy in marking, clarity in teaching, and patience in pastoral care is essential for student outcomes. Without effective fatigue management, teachers risk burnout, reduced performance, and disengagement.

- Framework for Context (F): Exam periods involve sustained lesson delivery, marking, and administrative load under tight deadlines.
- Levels of Impact (L): Fatigue is expressed as eye strain, headaches, decision fatigue in marking, irritability, and loss of motivation.
- Assessment (A): Fatigue is tracked using BRUMS, single-item scales, and behavioural indicators such as response time and error rates.
- Management (M): Reactive strategies (reframing, mindfulness) mitigate acute stress; proactive pacing and collaborative lesson planning distribute workload; preventative measures address structural workload balance.
- Education (E): Professional development sessions and peer mentoring teach teachers to interpret fatigue signals, trial strategies, and reflect on their effectiveness.
- Scalable Solutions (S): At the system level, co-constructed policies acknowledge teacher workload and embed fatigue management into professional standards and wellbeing frameworks.

6. Conclusions

Effective fatigue management requires an interdisciplinary approach that integrates psychological, emotional, and physiological perspectives. The F.L.A.M.E.S. framework translates this understanding into a practical model that bridges sport, healthcare, education, and occupational domains by combining contextual analysis, validated assessment, evidence-based management strategies, and scalable implementation.

By encouraging co-construction, the framework ensures that fatigue assessments are credible, contextually meaningful, and aligned with real-world demands. This participatory approach enhances ecological validity and supports the development of domain-specific tools, whether addressing decision fatigue in healthcare, emotional labour in education, or moral distress in social care. With the F.L.A.M.E.S. model, we position fatigue not as a barrier to overcome but as a meaningful signal that can guide pacing actions, recovery, and sustainable engagement. The F.L.A.M.E.S. model provides a roadmap for applied research and practice, supporting interdisciplinary, context-sensitive, and person-centred solutions.

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