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The Interwoven Triad: A Review of Sleep Quality, Cognitive Function, and Emotion Regulation

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Abstract

Background: The importance of sleep quality for neurobiological and psychological health is increasingly recognized in multidisciplinary research. Current findings indicate that sleep quality serves as a key mediator connecting advanced cognitive operations with emotional control, highlighting the need for a unified overview of these interrelated processes.
Objective: This review seeks to combine current research to clarify the two-way connections between sleep quality, fundamental cognitive areas (attention, memory, executive function), and emotion regulation abilities, and to describe the common neural foundations that support these interactions.
Methods: A narrative study was performed. Literature from 2000–2025 was gathered from PubMed, PsycINFO, and Web of Science using search terms such as "sleep quality," "cognitive function," "emotion regulation," "prefrontal cortex," "amygdala," "sleep deprivation," and "neuroimaging." Selected studies included meta-analyses, randomized controlled trials, longitudinal studies, and notable neuroimaging research.
Results: Strong evidence indicates that inadequate sleep quality—including short duration, fragmentation, and disrupted sleep stages—significantly harms attention, memory formation, and all aspects of executive function. At the same time, it increases negative emotional responses, reduces positive emotions, and weakens the ability to control emotions consciously. Neurobiological research points to dysregulation in the prefrontal-amygdala circuit and impaired hippocampal activity as central explanations. These influences are bidirectional, creating harmful cycles that can contribute to mental health disorders.
Conclusion: Sleep quality is a fundamental component of mental and brain health, inseparably connecting cognitive and emotional functioning. Sleep-focused interventions, such as Cognitive Behavioral Therapy for Insomnia (CBT-I), offer broad treatment potential for improving thinking skills and emotional well-being. Future studies should use long-term designs and examine factors related to individual differences.

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Introduction

Sleep is not a passive state but a dynamic and biologically essential process important for bodily balance, recovery, and brain adaptability. In recent decades, the concept of "sleep quality"—which includes subjective satisfaction, objective measures of duration and continuity, and the structure of sleep stages (NREM and REM cycling)—has moved from a secondary issue to a central factor in daily performance and long-term well-being [1, 2]. This change reflects a shift in scientific thinking, acknowledging that cognitive and emotional

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processes are interconnected and interdependent. Higher-level cognitive functions like executive control, sustained attention, and memory consolidation are now seen as constantly interacting with emotion regulation—the skill of monitoring, assessing, and adjusting emotional experiences to support goal-directed actions [3, 4].

A growing body of research identifies sleep quality as a crucial moderator of this cognitive-emotional link. Experimental and clinical reports consistently show that even one night of poor sleep can trigger a range of difficulties: slower responses, attention lapses, impaired judgment, greater irritability, and emotional sensitivity [5, 6]. These issues have serious consequences for job performance, academic achievement, public safety, and social relationships [7]. Furthermore, long-term sleep problems are a recognized risk factor for various psychiatric and neurological conditions, including depression, anxiety disorders, and Alzheimer's disease, where cognitive decline and emotional instability are common symptoms [8, 9].

Although many studies examine sleep and cognition or sleep and emotion separately, a unified explanation of how sleep quality simultaneously influences both is essential for progress in theory and application. This review proposes that sleep is a non-negotiological requirement for integrated brain health. We will: 1) summarize evidence on how sleep quality affects specific cognitive and emotional functions; 2) explain the shared brain pathways, mainly involving the prefrontal cortex, amygdala, and hippocampus; 3) discuss the bidirectional nature of these relationships and their clinical relevance across life stages; and 4) identify key gaps in knowledge to direct future inquiry. By combining insights from experimental psychology, neuroimaging, and clinical science, this review intends to offer a broad framework for understanding why "sleeping on it" remains valuable advice for mental clarity and emotional balance.

Methods

This article uses a narrative review and synthesis approach to combine results from human experimental, longitudinal, and neuroimaging studies. The goal was to present a thorough, critical summary rather than a statistical meta-analysis.

Literature Search*:* Electronic databases (PubMed, PsycINFO, Web of Science) were searched for English-language peer-reviewed articles published from January 2000 to September 2025. Search combinations included: ("sleep quality" OR "sleep deprivation" OR "sleep architecture") AND ("cognitive function" OR "executive function" OR "memory" OR "attention") AND ("emotion regulation" OR "emotional reactivity" OR "affect") AND ("neuroimaging" OR "prefrontal cortex" OR "amygdala").

Selection Criteria: Included studies were: (1) primary research articles (experimental, observational, neuroimaging) or systematic reviews/meta-analyses; (2) focused on human adults or adolescents; (3) directly examined the link between a sleep measure and at least one cognitive and/or emotion regulation outcome. Excluded were studies on young children (without adolescent focus), animal studies, and articles unavailable in full text.

Results

Impact of Sleep Quality on Core Cognitive Domains

Evidence for sleep-related cognitive impairment is strong and varies by cognitive area.

- ***Attention & Vigilance****:* Complete and partial sleep loss consistently weaken sustained attention, increasing brief lapses (microsleeps) and slowing response speed. This is one of the most sleep-sensitive deficits, associated with disrupted thalamocortical activity and increased sleep drive [10, 11]. Meta-analyses confirm large effects on vigilance even after moderate sleep reduction (5–6 hours/night) [12].
- ***Learning & Memory***: The dual-process model of sleep-dependent memory consolidation is well-supported. Slow-wave sleep (SWS) is vital for the hippocampal-neocortical communication that strengthens declarative memories (facts, events) [13, 14]. REM sleep, on the other hand, is involved in consolidating procedural and emotional memories [15]. Poor sleep, especially reduced SWS, directly weakens recall and neural plasticity markers like sleep spindles [16].
- ***Executive Function:*** Higher-order processes managed by the prefrontal cortex (PFC)—working memory, cognitive flexibility, inhibitory control, and complex decision-making—are particularly vulnerable. Sleep restriction lowers PFC metabolic activity and functional connectivity, resulting in rigid thinking, greater risk-taking, and poor impulse control [17, 18]. A key study showed that sleep loss produced a state similar to PFC dysfunction seen in psychiatric conditions [19].

Impact of Sleep Quality on Emotion Regulation

Sleep loss creates a pattern of emotional dysregulation marked by heightened reactivity and reduced control.

- ***Hyper-Reactivity:*** Neuroimaging studies consistently find that sleep deprivation increases amygdala reactivity to negative emotional stimuli by over 60%

compared to a rested state [20]. This heightened limbic activity occurs alongside a reduced capacity to experience positive emotions or reward [21].

- ***Diminished Top-Down Control****:* The overactive amygdala happens together with weakened connectivity between the amygdala and the medial PFC (mPFC), a pathway needed for contextualizing and inhibiting emotional reactions [20, 22]. This neural "disconnect" appears behaviorally as exaggerated emotional responses and poor frustration tolerance.
- ***Social-Emotional Processing****:* Sleep-deprived individuals show a negative interpretation bias, more often seeing neutral facial expressions as threatening and displaying less empathy [23, 24]. This impairment in social understanding worsens interpersonal conflict and stress, which can further disrupt sleep.

Shared Neurobiological Substrates

The simultaneous occurrence of cognitive and emotional problems arises from common brain mechanisms:

- ***Prefrontal Cortex Vulnerability****:* The PFC, with its high energy needs and dependence on optimal neurotransmitter levels (e.g., adenosine), is highly sensitive to sleep loss. Its malfunction explains combined deficits in executive control (cognitive) and emotion regulation (affective) [25, 26].
- ***Amygdala-mPFC Circuit Dysregulation****:* This is the central pathway. Good sleep maintains mPFC inhibitory control over the amygdala. Poor sleep weakens this inhibition, leading to an amygdala-driven state of emotional and cognitive impulsivity [20, 27].
- ***Neurochemical Alterations:*** Sleep deprivation raises cortisol (stress hormone) and inflammatory markers (e.g., IL-6), while disturbing serotonin and dopamine systems involved in mood and reward [28, 29]. This creates a neurochemical environment that hinders both focused thinking and emotional balance.
- ***Glymphatic System & Synaptic Homeostasis:*** The restorative "synaptic homeostasis hypothesis" suggests that SWS reduces synaptic strength to save energy and optimize neural networks [30]. At the same time, the glymphatic system, most active during SWS, clears metabolic waste like beta-amyloid [31]. Long-term poor sleep may therefore gradually harm neural efficiency and increase toxic buildup in the brain.

Discussion

This review brings together extensive evidence to propose that sleep quality is a basic biological factor for integrated brain function, acting as a shared pathway through which cognitive accuracy and emotional stability are preserved. The results show a consistent trend: disturbances in sleep—whether in length, continuity, or structure—lead to related declines in executive control, memory processes, and adaptive emotional responding. The main neurobiological mechanism behind this triad is the disruption of the prefrontal-limbic network, where a sleep-deprived PFC cannot provide necessary inhibitory and integrative control over an overreactive amygdala and a functionally weakened hippocampus [20, 32]. This model offers a straightforward explanation for the co-occurrence of rigid thinking and emotional instability after poor sleep.

The Bidirectional Cycle and Its Clinical Significance

The relationship between sleep, cognition, and emotion is deeply reciprocal, creating self-reinforcing cycles with important clinical consequences. While experiments clearly show that sleep disruption *causes* impairment, in clinical groups the direction is often circular. For example, the repetitive thinking and high alertness common in anxiety disorders directly interfere with falling and staying asleep [33]. The resulting fragmented sleep then worsens attention to threats and impairs problem-solving, thereby increasing anxiety [34]. This vicious cycle is a core maintaining factor in many conditions, including major depression and PTSD, where sleep abnormalities are considered a transdiagnostic feature [35, 36]. Moreover, in neurodegenerative diseases, the bidirectional link is equally important. Poor sleep, via reduced glymphatic clearance, may speed up the buildup of harmful proteins like beta-amyloid, which then disrupts sleep-generating brain areas, creating a pathological loop that accelerates cognitive and functional decline [37, 38].

Intervention as a Transdiagnostic Lever

The interconnected nature of this triad offers a strong intervention opportunity: improving sleep may produce broad benefits for both cognitive and emotional health. Cognitive Behavioral Therapy for Insomnia (CBT-I) is a prime example. As a first-line treatment for chronic insomnia, its effectiveness is well-documented [39]. Notably, research now indicates that treating insomnia with CBT-I in people with co-occurring disorders (e.g., depression, PTSD) not only enhances sleep but also leads to meaningful reductions in primary psychiatric symptoms and related cognitive difficulties [40, 41]. This suggests that improving sleep quality can partly rebuild the functional integrity of the PFC-limbic circuit, interrupting the maintenance cycle of mental illness. Beyond therapy, public health and educational efforts that emphasize sleep hygiene and later school start times for adolescents apply this knowledge, aiming to safeguard cognitive development and emotional strength during sensitive periods [42].

Limitations and Conclusion

Despite strong evidence, several areas need further exploration. First, most experimental studies involve acute, total sleep deprivation in young, healthy adults. More research on the effects of *chronic*, everyday sleep restriction and fragmentation across the lifespan is necessary [43]. Second, the distinct roles of specific sleep stages (e.g., REM vs. SWS) in different cognitive-emotional tasks require further clarification using advanced sleep manipulation methods [44]. Third, there are considerable individual differences in resistance to sleep loss, influenced by genetics (e.g., PER3 gene variations), age, sex, and baseline brain structure [45, 46]. Future studies should use a personalized approach to predict vulnerability and customize interventions. Finally, long-term studies that track brain, cognitive, and emotional measures together with sleep over many years are crucial to establish causal pathways to illness and decline [47].

In summary, sleep quality is fundamentally connected to the smooth integration of thought and emotion. It is not just a restorative break but an active state of brain programming and upkeep that fine-tunes our cognitive abilities and emotional experiences. Increasing awareness in society, clinical practice, and personal life about the essential role of sleep is therefore a vital public health goal. "Sleeping on it" is not just a saying but reflects a core neurobiological fact: the soundness of our waking minds—our capacity to think, learn, remember, and interact socially with emotional insight—is fundamentally shaped during sleep.

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Authors Contributions

The authors contributed to the data analysis. Drafting, revising and approving the article, responsible for all aspects of this work.

Conflict of Interest

None

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