

NEURO-PHYSIOLOGICAL MECHANISMS OF COGNITIVE FATIGUE IN SCHOOLCHILDREN AND MODERN APPROACHES TO ITS PREVENTION

Khaydarova Pardakhol Bobokulovna

Uzbek National Pedagogy named after Nizami

Associate Professor of the Department of Biology at the university.

Kholboeva Bonu Gulmurodovna

4th year student of the Biology educational direction

ABSTRACT Cognitive fatigue is a widespread issue among schoolchildren, negatively affecting attention, memory, and academic performance. This article explores the neurophysiological mechanisms underlying cognitive fatigue, including the role of the prefrontal cortex, neural oscillations, and brain connectivity. It also examines key contributing factors such as prolonged mental workload, sleep deprivation, and emotional stress. Based on a review of contemporary research, modern prevention strategies are discussed, including neurodidactic approaches, optimization of learning schedules, physical activity, and sleep hygiene. The study concludes that cognitive fatigue primarily disrupts executive functions and neural efficiency, emphasizing the importance of integrated educational and health-based interventions.

Keywords: Cognitive fatigue, schoolchildren, neurophysiology, executive functions, prefrontal cortex, EEG, prevention, neurodidactics, sleep hygiene

Introduction - In modern educational environments, schoolchildren are increasingly exposed to intensive cognitive demands, digital technologies, and high academic expectations. These factors contribute to the development of cognitive fatigue, a condition characterized by a temporary decline in mental performance due to prolonged cognitive activity.

Cognitive fatigue manifests in reduced attention span, slower information processing, impaired working memory, and decreased motivation. From a neurophysiological perspective, it is closely associated with changes in brain activity, particularly in regions responsible for executive functions such as the prefrontal cortex.

Understanding the mechanisms of cognitive fatigue is essential for developing effective strategies to enhance learning efficiency and protect children's mental health. This article aims to analyze the neurophysiological basis of cognitive fatigue and identify modern approaches to its prevention.

Literature Review - The concept of cognitive fatigue has been extensively studied in neuroscience, psychology, and education. It is generally understood as a state resulting from sustained mental effort, leading to reduced efficiency in cognitive processing.

Neurophysiological Basis

Research using electroencephalography (EEG) shows that cognitive fatigue is associated with changes in brain wave activity. Increased alpha and theta activity are commonly observed, indicating reduced alertness and decreased cognitive control. At the same time, beta activity, which is associated with active thinking and concentration, tends to decrease.

Event-related potential (ERP) studies demonstrate that fatigue reduces the amplitude of the P300 component, which reflects attention allocation and working memory updating. This suggests that fatigued individuals have fewer cognitive resources available for processing information.

Role of the Prefrontal Cortex

The prefrontal cortex plays a central role in executive functions, including planning, decision-making, and inhibitory control. Cognitive fatigue leads to reduced activation in this region, impairing the ability to regulate attention and behavior effectively.

Impact of Sleep and Stress

Sleep deprivation is one of the most significant contributors to cognitive fatigue in children. Lack of sleep disrupts neural connectivity and reduces the efficiency of information processing. Emotional stress and anxiety further exacerbate fatigue by increasing cognitive load and interfering with attentional control.

Educational Context

In school settings, cognitive fatigue is often caused by prolonged lessons, excessive homework, and continuous exposure to digital screens. These factors lead to cumulative fatigue, which negatively impacts academic performance and overall well-being.

Research Methodology- This article is based on a qualitative analysis of existing scientific literature and empirical studies on cognitive fatigue in schoolchildren.

Data Sources

Peer-reviewed journals in neuroscience, psychology, and education were analyzed to identify key findings related to neurophysiological mechanisms and prevention strategies.

Methods Used in Reviewed Studies

Electroencephalography (EEG) for measuring brain activity

Event-related potentials (ERP) for assessing cognitive processing

Behavioral cognitive tests (e.g., attention and memory tasks)

Surveys and questionnaires on sleep, stress, and academic workload

Analytical Approach

The collected data were systematically reviewed and synthesized to identify common patterns, mechanisms, and effective interventions.

Analysis and Results

1. Neural Mechanisms of Cognitive Fatigue

Cognitive fatigue results in decreased efficiency of neural networks, particularly those involved in attention and executive control. Functional connectivity between brain regions becomes less coordinated, leading to slower and less accurate cognitive performance.

2. Changes in Brain Activity

EEG studies reveal:

Increased alpha and theta waves (associated with drowsiness and reduced alertness)

Decreased beta activity (linked to reduced concentration)

These changes reflect a shift from active information processing to a more passive brain state.

3. Impairment of Executive Functions

Fatigue significantly affects:

Attention regulation

Working memory

Decision-making

Response inhibition

Children experiencing cognitive fatigue show slower reaction times and increased error rates in complex tasks.

4. Role of External Factors

Key contributing factors include:

Prolonged cognitive load without breaks

Insufficient sleep

High emotional stress

Excessive screen time

These factors interact to exacerbate fatigue and reduce cognitive efficiency.

5. Academic and Behavioral Outcomes

Cognitive fatigue leads to:

Decreased academic performance

Reduced motivation

Increased irritability and behavioral issues

Difficulty maintaining focus in class

Modern Approaches to Prevention

1. Neurodidactic Approaches

Neurodidactics integrates neuroscience principles into teaching. Strategies include:

Interactive and multisensory learning

Chunking of information

Frequent feedback and engagement

These methods enhance attention and reduce cognitive overload.

2. Optimization of Learning Schedules

Effective time management in schools can significantly reduce fatigue:

Short breaks between lessons

Alternation of difficult and easy subjects

Limiting continuous cognitive load

3. Physical Activity

Regular physical exercise improves cerebral blood flow and supports brain function. Even short physical breaks during lessons can restore attention and reduce fatigue.

4. Sleep Hygiene

Promoting healthy sleep habits is crucial:

Maintaining consistent sleep schedules

Reducing screen time before bed

Ensuring adequate sleep duration for age

5. *Digital Hygiene*

Managing digital exposure includes:

Limiting screen time

Encouraging offline activities

Using technology in a structured and purposeful way

6. *Psychological Support*

Emotional well-being plays a key role in preventing cognitive fatigue. Schools should:

Provide stress management programs

Encourage positive learning environments

Support student motivation and self-regulation

Discussion

The findings highlight that cognitive fatigue is not merely a psychological phenomenon but a complex neurophysiological process involving multiple brain systems. The prefrontal cortex and neural oscillatory activity are particularly affected, leading to impairments in executive functioning.

Preventive strategies must therefore be multidisciplinary, combining educational reforms, health interventions, and psychological support. Schools play a critical role in implementing these strategies and creating environments that support cognitive health.

Conclusion - Cognitive fatigue in schoolchildren is a significant challenge in modern education systems. It arises from neurophysiological changes in brain activity and is influenced by various environmental and lifestyle factors.

Understanding these mechanisms allows educators and policymakers to develop effective prevention strategies. By integrating neurodidactic methods, promoting healthy lifestyles, and optimizing academic demands, it is possible to reduce cognitive fatigue and improve both learning outcomes and student well-being.

REFERENCES

1. Macchitella, L., et al. (2020). Sleepiness and cognitive performance in children. *Brain Sciences*.
2. Yao, S., et al. (2025). Acute cognitive fatigue and executive control. *Biology*.
3. Zhumabayeva, Z., et al. (2025). Neurodidactics in modern education. *Frontiers in Education*.
4. Lim, J., & Dinges, D. F. (2010). Sleep deprivation and cognitive performance. *Neurobiology of Sleep*.
5. Boksem, M. A. S., & Tops, M. (2008). Mental fatigue and brain function. *Brain Research Reviews*.