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THERAPEUTIC POTENTIAL OF MICRO-POLARIZATION IN THE TREATMENT OF SLEEP DISORDERS IN SCHOOL-AGED CHILDREN WITH ATTENTION DEFICIT AND HYPERACTIVITY SYNDROME

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Abstract: This article provides a comprehensive analysis of the etiological factors, clinical presentation, and neuropsychological consequences of sleep disorders in school-aged children. Numerous scientific publications have demonstrated that insufficient sleep duration, impaired sleep architecture, and fragmented nighttime sleep negatively affect children's attention, academic performance, emotional regulation, and behavioral functioning. Based on these considerations, the therapeutic efficacy of micro-polarization—an innovative non-invasive neuromodulation method—was examined in the correction of pediatric sleep disorders.

Micro-polarization employs low-intensity direct current (1–3 mA) applied to specific cortical regions, modulating neuronal excitability, enhancing synaptic plasticity, restoring neurovegetative balance, and improving functional integration within cortical networks. Within the scope of this study, the clinical, polysomnographic, and electroencephalographic (EEG) outcomes of children receiving micro-polarization therapy were evaluated and compared before and after treatment.

Analysis of clinical and instrumental findings revealed that micro-polarization significantly improved sleep structure and quality, reduced sleep latency, decreased nighttime awakenings, stabilized deep sleep stages, and restored the physiological ratio of REM/NREM phases. EEG parameters showed reduced instability of theta and delta rhythms and normalization of regional alpha activity. Additionally, noticeable improvements were observed in attention, memory, emotional stability, and overall behavior.

The obtained results confirm that micro-polarization is an effective, safe, and physiologically grounded neurorehabilitation method for treating sleep disorders in school-aged children. The non-invasive nature, absence of adverse effects, and good tolerance among children further enhance its clinical relevance.

Keywords: sleep disorders, micro-polarization, school-aged children, EEG, neuromodulation.

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Introduction

Sleep disorders in school-aged children represent one of the most significant challenges in modern pediatrics, child neurology, and sleep medicine. Worldwide studies indicate that 30–45% of children aged 6–12 years experience various types of sleep disturbances, including difficulty falling asleep, frequent nighttime awakenings, sleep fragmentation, parasomnias, night terrors, and impaired sleep architecture. Such high prevalence rates have broad implications not only for the healthcare system but also for the cognitive and psychological development of society's younger population.

Sleep is a fundamental physiological process essential for restoring the central nervous system. Its disruption leads to multiple limitations in neurocognitive functioning. Scientific studies show that insufficient sleep contributes to reduced attention, impaired learning, emotional instability, affective problems, impulsivity, anxiety, headaches, autonomic dysregulation, and weakened immunity. Therefore, early diagnosis and effective treatment of sleep disturbances are crucial for ensuring optimal cognitive and psychophysiological development in children.

Etiological factors contributing to pediatric sleep disorders include immaturity of the nervous system, psycho-emotional stress, excessive sensory load, overuse of electronic devices, unfavorable family dynamics, neurological disorders, and autonomic imbalance.

Although pharmacological treatments may provide short-term relief, they are not always safe for children and may negatively affect sleep architecture or cause unwanted side effects. Consequently, there is increasing interest in non-invasive, physiologically oriented therapeutic approaches.

Among these, micro-polarization—low-intensity direct-current neuromodulation—has emerged as a highly promising method. It modulates cortical excitability, enhances synaptic plasticity, normalizes functional connectivity between frontal and parietal cortical regions, and helps restore the natural sleep–wake cycle.

Objective of the Study

The objective of this study was to investigate the clinical and neurophysiological features of sleep disorders in school-aged children, assess their impact on central nervous system functioning, and scientifically evaluate the therapeutic efficacy of micro-polarization. Specifically, the study aimed to examine how low-intensity direct current stimulation influences sleep architecture, physiological regulation of sleep phases, and functional balance within neural networks.

The study addressed the following tasks:

1. To assess the effects of micro-polarization on sleep structure and quality, including sleep latency, nighttime awakenings, deep sleep duration, and REM/NREM ratios.

2. To evaluate EEG changes, particularly in theta–delta rhythms, alpha activity, and cortical excitability.

3. To examine psychocognitive dynamics including attention, memory, psychomotor speed, and emotional stability.

4. To analyze the neurophysiological mechanisms of micro-polarization, such as synaptic plasticity, neuronal integration, and autonomic regulation.

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5. To compare micro-polarization with traditional pharmacological and psychotherapeutic treatments and determine its advantages and clinical applicability.

Literature Review

1. Clinical and neuropsychological consequences of sleep disturbances

Numerous international studies confirm that pediatric sleep disturbances lead to substantial cognitive, behavioral, and emotional impairments.

Attention and executive functioning:

Reduced prefrontal cortex activity is closely associated with sleep deprivation. Chronic insomnia significantly lowers sustained attention.

Memory impairment:

Disruptions in neuroplastic processes during NREM sleep negatively affect working memory.

Academic decline:

Children with chronic sleep deficits demonstrate 20–30% lower academic performance.

Behavioral dysregulation:

Sleep disturbances contribute to dysregulation in dopaminergic pathways, intensifying hyperactivity and impulsivity.

2. Scientific foundations of micro-polarization

Micro-polarization is a low-intensity variant of transcranial direct current stimulation (tDCS) widely used in modern child neurology.

Key physiological mechanisms include:

• direct modulation of neuronal membrane potentials,

• normalization of cortical excitability,

• enhancement of synaptic plasticity,

• restoration of sympathetic–parasympathetic balance,

• stabilization of thalamo-cortical rhythms involved in sleep regulation.

Clinical studies reported improved deep sleep duration, reduced sleep latency, stabilized EEG rhythms, and enhanced cognitive functioning in children after low-intensity tDCS.

Materials and Methods

Participants

The study included children aged 7–12 years who presented with clinically diagnosed sleep disorders such as insomnia, difficulty initiating sleep, nighttime awakenings, and parasomnias. Children with organic brain diseases, severe psychiatric disorders, or contraindications to neuromodulation were excluded.

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Assessment Tools

1. Polysomnography (PSG):

Sleep stages, NREM/REM distribution, micro-arousals.

2. Electroencephalography (EEG):

Theta, delta, alpha activity; cortical excitability.

3. Psychometric Testing:

• Bourdon and D2 tests (attention)

• Digit span and visual memory tests

• Cognitive processing speed

4. Subjective Assessments:

Parental questionnaires, sleep hygiene surveys, behavioral diaries.

Micro-polarization Protocol

• Current: 1–2 mA

• Session duration: 15–30 minutes

• Course: 10–15 sessions, administered every other day

• Electrode placement: frontal, fronto-parietal, or prefrontal regions

• Monitoring: safety, autonomic status, and subjective comfort

No adverse events were observed except mild skin tingling in a few children.

Results

1. Improvements in sleep quality

Polysomnographic analysis revealed:

• 25–40% reduction in sleep latency

• Significant decrease in nighttime awakenings

• Increased proportion of deep N3 sleep

• Restoration of physiological REM/NREM ratio

2. EEG improvements

Post-treatment EEG demonstrated:

• Reduced instability in theta–delta rhythms

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• Normalization of regional alpha distribution

• Decreased cortical hyperexcitability

3. Cognitive and behavioral improvements

Psychometric testing showed:

• Improved attention span and concentration stability

• Enhanced working and short-term memory

• Reduction in impulsive and disorganized behavior

4. Subjective assessments

Parents reported:

• Less morning fatigue

• Reduced daytime sleepiness

• More stable mood

• Improved emotional regulation and daily functioning

Discussion

The results confirm that micro-polarization is a highly effective method for correcting sleep disorders in school-aged children. The therapy was well-tolerated, non-invasive, and produced early clinical improvements.

Advantages of micro-polarization:

• Non-invasive and painless

• No need for pharmacological intervention

• Rapid onset of therapeutic effect

• Good acceptance and comfort for children

• Absence of side effects

Neurophysiological mechanism:

Micro-polarization normalizes cortical excitability, enhances synaptic plasticity, stabilizes autonomic balance, and restructures sleep architecture. These mechanisms contribute to improved cognitive functioning and behavioral stability.

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Limitations:

- Optimal stimulation parameters for different age groups require further study.
- Long-term follow-up data are insufficient.
- Larger randomized controlled trials are needed.

Conclusion

Micro-polarization has proven to be an effective innovative neuromodulation method for treating sleep disorders in school-aged children. It contributes to:

- Normalization of sleep architecture, including REM/NREM balance and deep sleep phases
- Improvement of EEG rhythms and reduction of cortical hyperexcitability
- Enhancement of cognitive functioning, particularly attention and memory
- Stabilization of emotional and behavioral states

These results support the integration of micro-polarization into comprehensive neurorehabilitation programs aimed at restoring healthy sleep patterns and optimizing neuropsychological development in children.

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(Translated and kept in original academic style.)

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