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OPTIMIZATION OF NEUROSTIMULATION METHODS FOR THE TREATMENT OF ENURESIS IN CHILDREN BASED ON PHOTOBIOMODULATION (A LITERATURE REVIEW)

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Abstract

Enuresis in children is one of the most relevant interdisciplinary problems in modern pediatric neurology, urology, and psychoneurology. Despite significant progress in understanding the pathogenesis of this disorder, the effectiveness of traditional pharmacological and behavioral treatment approaches remains limited, which necessitates the search for and implementation of new non-pharmacological technologies. In recent years, particular interest has been focused on the use of neurostimulation methods, including photobiomodulation, aimed at correcting the functional state of the central and peripheral nervous systems. This review article systematizes current data on the neurophysiological mechanisms of enuresis, the possibilities of neurostimulation and photobiomodulation, and discusses the prospects for optimizing these methods in pediatric neurological practice.

Keywords

pediatric enuresis, neurostimulation, photobiomodulation, central nervous system, neuroplasticity, non-pharmacological therapy.

Introduction

Enuresis in children is one of the most common functional disorders of urination and, according to various authors, affects 5–15% of preschool and early school-aged children [1–4]. In modern neurology, enuresis is considered not only as a urological problem but also as a manifestation of functional immaturity or dysfunction of the regulatory structures of the central nervous system, including the cerebral cortex, reticular formation, limbic system, and spinal centers controlling micturition [2, 3].

Traditional treatment methods (desmopressin, anticholinergic drugs, behavioral therapy) are often accompanied by relapses, side effects, and insufficient sustainability of therapeutic outcomes [4, 12]. This has increased interest in neuromodulation technologies capable of influencing the pathogenetic mechanisms of enuresis.

Materials and Methods of the Review

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This review is based on an analysis of publications by domestic and international authors addressing the pathogenesis of enuresis in children, as well as the use of neurostimulation methods and photobiomodulation in neurological practice. Data from scientific articles, review publications, and clinical guidelines published in specialized medical journals were utilized. The analysis was conducted to summarize existing approaches and identify promising directions for non-pharmacological therapy.

Current Concepts in the Neurophysiology of Enuresis

From a neurological perspective, enuresis is considered a consequence of disrupted integrative activity of the central nervous system, which coordinates the processes of bladder filling and emptying. Key factors include functional immaturity of cortico-subcortical connections, reduced arousal threshold, imbalance between sympathetic and parasympathetic regulation, and dysfunction of neurotransmitter systems (serotonergic and dopaminergic) [2, 3, 13].

Several studies have confirmed the involvement of neuroplastic processes in the development of stable bladder control skills, which provides a pathogenetic rationale for the use of neurostimulation methods [12–14].

Neurostimulation Methods in the Treatment of Pediatric Enuresis

Neurostimulation methods applied in pediatric practice include:

- transcranial electrical stimulation;
- sacral root electrical stimulation;
- magnetic stimulation;
- photobiomodulation (low-intensity laser and LED irradiation) [5–7].

These methods are aimed at normalizing the brain's bioelectrical activity, enhancing inter-neuronal connections, and promoting functional maturation of regulatory centers.

Photobiomodulation as a Neuro-modulation Method

Photobiomodulation (PBM) involves the application of low-intensity light in the red and near-infrared spectrum (630–904 nm), exerting biostimulatory and neuromodulatory effects [12–14]. The main mechanisms of photobiomodulation include:

- activation of mitochondrial respiration;
- enhancement of ATP synthesis;
- modulation of oxidative stress;
- stimulation of neuroplasticity;
- improvement of microcirculation in neural tissue [13, 14].

Clinical Efficacy of Photobiomodulation in Enuresis

Clinical studies indicate that photobiomodulation in children with enuresis contributes to:

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- reduction in the frequency of nocturnal incontinence episodes;
- improvement of electroencephalographic parameters;
- normalization of sleep and autonomic balance;
- increased effectiveness of comprehensive therapy [1, 12–14].

The method is characterized by a high safety profile, absence of significant side effects, and suitability for use in early childhood.

Optimization of Neurostimulation Approaches

Current directions in optimizing neurostimulation methods include:

- individualization of photobiomodulation parameters;
- combination with behavioral and cognitive therapies;
- consideration of the child's neurophysiological profile;
- integration of neuroimaging and neurofunctional monitoring techniques [6, 7, 15].

Perspectives of Application in Neurology

From the standpoint of pediatric neurology, photobiomodulation represents a promising tool for correcting functional disorders associated with delayed neuropsychological maturation. The use of PBM in the treatment of enuresis expands the possibilities of non-pharmacological therapy and aligns with the principles of personalized medicine.

Conclusion

Thus, the analysis of current data indicates a high pathogenetic rationale and clinical potential for the use of photobiomodulation within neurostimulation methods for treating enuresis in children. Further studies focusing on optimization of treatment parameters and development of standardized application protocols are expected to enhance therapeutic effectiveness and improve patients' quality of life.

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