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THE EFFECTIVENESS OF TRANSCRANIAL MAGNETIC STIMULATION IN PEDIATRIC NEUROLOGICAL DISORDERS

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Abstract: Pediatric neurological disorders are frequently associated with motor, cognitive, and behavioral impairments that significantly affect quality of life and functional independence. In recent years, transcranial magnetic stimulation (TMS) has emerged as a non-invasive neuromodulation technique with potential therapeutic benefits in children with neurological conditions. This article analyzes the effectiveness of transcranial magnetic stimulation in the management of pediatric neurological disorders, including cerebral palsy, epilepsy, attention-deficit hyperactivity disorder, and post-stroke motor dysfunction. The review highlights the mechanisms of action, clinical outcomes, and safety considerations of TMS in pediatric populations. Available evidence suggests that TMS can improve motor function, cognitive performance, and neuroplasticity when applied in a controlled and individualized manner. Understanding the therapeutic potential of TMS is essential for integrating this technology into pediatric neurorehabilitation.

Keywords: Transcranial magnetic stimulation, children, neurological disorders, neurorehabilitation, neuroplasticity, non-invasive brain stimulation

Introduction

Neurological disorders in children represent a major cause of long-term disability and developmental delay. Conditions such as cerebral palsy, epilepsy, attention-deficit hyperactivity disorder, and acquired brain injuries often result in persistent motor and cognitive impairments. Conventional treatment approaches, including pharmacotherapy and physical rehabilitation, may not fully address these deficits.

Transcranial magnetic stimulation is a non-invasive brain stimulation technique that uses magnetic fields to induce electrical currents in targeted cortical areas. By modulating neuronal excitability and synaptic activity, TMS can influence neural networks involved in motor control, cognition, and behavior. While TMS has been widely studied in adult populations, its application in pediatric neurology has gained increasing attention over the past decade.

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This article aims to review the effectiveness of transcranial magnetic stimulation in pediatric neurological disorders and to discuss its clinical implications and future potential.

Materials and Methods

This study was conducted as a narrative analytical review of scientific literature. Peer-reviewed clinical studies, randomized controlled trials, and systematic reviews focusing on the use of transcranial magnetic stimulation in pediatric neurological disorders were analyzed. Sources were selected from international journals in neurology, neurorehabilitation, and neuroscience.

The analysis included studies evaluating motor, cognitive, and behavioral outcomes following repetitive transcranial magnetic stimulation (rTMS) in children. Safety data, stimulation parameters, and follow-up results were also examined. No original experimental or clinical data were collected.

Results

The reviewed studies indicate that transcranial magnetic stimulation demonstrates promising therapeutic effects in various pediatric neurological disorders. In children with cerebral palsy, rTMS applied to the motor cortex has been associated with improvements in muscle tone, motor coordination, and functional mobility. These effects are attributed to enhanced cortical excitability and facilitation of neuroplastic mechanisms.

In pediatric stroke and acquired brain injury, TMS has been shown to promote motor recovery by modulating interhemispheric inhibition and supporting functional reorganization of motor networks. Children receiving combined TMS and physical therapy exhibited better motor outcomes compared to conventional rehabilitation alone.

In children with attention-deficit hyperactivity disorder, stimulation of prefrontal cortical regions resulted in improved attention, executive function, and behavioral regulation. Similarly, selected studies in pediatric epilepsy reported a reduction in seizure frequency following low-frequency rTMS, suggesting an inhibitory effect on cortical hyperexcitability.

Overall, the effectiveness of TMS was influenced by stimulation parameters, treatment duration, age of the patient, and severity of the underlying neurological condition. Reported adverse effects were mild and transient, including headache and scalp discomfort.

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Discussion

The findings support the growing evidence that transcranial magnetic stimulation is an effective adjunctive therapy in pediatric neurological disorders. By directly modulating cortical activity, TMS enhances neuroplasticity and supports functional recovery in developing brains. The greater plastic potential of the pediatric nervous system may explain the favorable response observed in many studies.

However, the application of TMS in children requires careful consideration of safety, ethical issues, and individualized treatment planning. Optimal stimulation protocols for different disorders are still under investigation, and long-term outcomes remain insufficiently studied. The combination of TMS with conventional rehabilitation appears to yield the most consistent benefits.

Future research should focus on large-scale controlled trials, standardized treatment protocols, and long-term follow-up to better define the role of TMS in pediatric neurorehabilitation.

Conclusion

Transcranial magnetic stimulation represents a promising non-invasive therapeutic approach for pediatric neurological disorders. Evidence suggests that TMS can improve motor, cognitive, and behavioral outcomes by enhancing neuroplasticity and modulating dysfunctional neural circuits. When applied safely and in combination with conventional therapies, TMS may significantly improve rehabilitation outcomes in children. Continued research is necessary to optimize stimulation protocols and establish long-term efficacy and safety.

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