Effect of Repetitive Transcranial Magnetic Stimulation (rTMS) on Functional Dysarthria in Preschool Children

Hui Cheng[1], Wenxin Cao[1], Dinghong Lin[2]
[1]Zhejiang Provincial Hospital of Traditional Chinese Medicine, Hangzhou, Zhejiang, China
[2]Taizhou Enze Medical Center Group Taizhou Rehabilitation Hospital, Taizhou, Zhejiang, China

Abstract: This study aimed to investigate the therapeutic effects of repetitive transcranial magnetic stimulation (rTMS) on preschool children with functional articulation disorders, particularly in aspects such as articulation ability, language comprehension, behavioral observation, and treatment tolerance. A total of 30 preschool children with functional articulation disorders diagnosed and treated at our hospital between February 2025 and August 2025 were randomly divided into an experimental group (15 cases) and a control group (15 cases). The experimental group received rTMS therapy alongside conventional language training, while the control group only underwent routine language training. The trial lasted 8 weeks. Evaluations were conducted using the CRRC-Ediencedic Speech Disorder Assessment and the Chinese Speech Clarity Character Table developed by Wang Guomin et al. The experimental group demonstrated significant superiority over the control group in articulation ability scores (P <0.001), language comprehension (P <0.001), behavioral observation scale (P <0.001), and treatment tolerance (P <0.001). The rTMS treatment showed remarkable efficacy, particularly in improving language comprehension, behavioral performance, and treatment tolerance. Although the control group showed some improvement in certain aspects, their effects were not statistically significant (P<0.05). RMTS therapy significantly enhances articulation ability and language comprehension in preschool children, with advantages in improving behavioral performance and treatment tolerance. As an innovative non-pharmacological therapy, rTMS holds great potential as a powerful tool for treating functional articulation disorders in children.

Keywords: Repetitive Transcranial Magnetic Stimulation; Functional Dysarthria; Language Comprehension; Treatment Tolerance

1. Introduction

Functional articulation disorder, a prevalent condition affecting preschoolers 'language and speech abilities, often adversely impacts their social interactions and academic development. While traditional approaches like speech therapy and behavioral interventions have been employed, their effectiveness remains limited for some children, with treatment processes being lengthy[1]. In recent years, neurostimulation techniques-particularly repetitive transcranial magnetic stimulation (rTMS)-have emerged as an invasive brain stimulation method widely used in neurological disorders. Research indicates that rTMS enhances cerebral cortex activity to improve language function recovery, showing particular efficacy in adult and pediatric patients with speech impairments. This study aims to investigate the therapeutic effects of rTMS on preschoolers with functional articulation disorders, focusing on speech production capacity, language comprehension, behavioral manifestations, and treatment tolerance. The findings will provide scientific evidence for rTMS' application in pediatric speech therapy[2].

2. Data and Methods

2.1 Research Data

This study enrolled preschool children diagnosed with functional dysarthria who received treatment at our hospital between February 2025 and August 2025. The target population consisted of children diagnosed with functional dysarthria meeting the following criteria: normal hearing thresholds, no significant abnormalities in articulatory organs, native Mandarin Chinese speakers with proficient Mandarin fluency, and age distribution between 3-6 years old.

Exclusion criteria included: (1) Individuals with structural or functional abnormalities of articulatory organs (e.g., cleft palate); (2) Those with hearing impairments; (3) Children with intellectual disabilities; (4) Patients with neuromuscular disorders; and (5) Participants who discontinued therapy midway or underwent repeated transcranial magnetic stimulation (rTMS). A total of 34 children were randomly assigned to the experimental group (n=15) and control group (n=15). Four participants withdrew midway due to poor compliance. The experimental group received repetitive transcranial magnetic stimulation (rTMS) therapy, while the control group underwent standard speech therapy [4].

2.2 Research Methods

The study design employed a randomized block method, with all pediatric patients being randomly assigned to either the experimental or control group after enrollment. The experimental group received treatment for 5 days per week followed by 2 days of rest, with a total treatment duration of 8 weeks. The repetitive transcranial magnetic stimulation (rTMS) was administered using a magnetic stimulator targeting the left dorsolateral prefrontal cortex (DLPFC). Prior to intervention, each participant's motor threshold-defined as the minimum stimulus intensity required to elicit motor evoked potentials in the motor cortex-was measured. The stimulation parameters were set at: 25% intensity, 100% threshold, 5Hz frequency, 14-second intervals between stimuli, 80 consecutive stimulation trains, 20 repetitions per train, and a total of 1,600 pulses delivered at 10 minutes per session [5]. The control group received standard speech therapy sessions, with 30-minute sessions administered weekly for 8 weeks. All treatments were conducted by professionally trained speech therapists and physicians.

2.3 Research Indicators

The comprehensive evaluation was based on the articulation disorder examination method of China Rehabilitation Research Center (CRRC) and the Chinese speech clarity character table compiled by Wang Guomin et al

Fonation ability score: The child's fonation ability was assessed by the child's speech and articulation test, including speech clarity, pronunciation accuracy, speech coherence and other indicators.

Language comprehension: A standardized language comprehension assessment scale was used to assess children's listening and language comprehension.

Behavioral observation scale: records children's behavioral changes before and after treatment, such as attention concentration, interaction with others, etc.

Treatment tolerance: Observe and record the children's tolerance to rTMS during the treatment, including whether adverse reactions such as headache and anxiety occur.

2.4 Statistical Analysis

This study employed the SPSS 26.0 software package for data analysis. Quantitative data were presented as (x±s), with inter-group comparisons conducted using t-tests, while categorical data were expressed as [n(%)] and analyzed through chi-square tests. A P-value <0.05 was considered statistically significant. All cases were analyzed following the intention-to-treat principle, with missing data filled using the most common values. Treatment outcomes were categorized as "significant improvement", "partial improvement", or "ineffective", followed by comparative analyses between groups. All data were analyzed using the independent samples t-test.

3. Results

3.1 Articulation Score

The data in Table 1 reveal significant improvements in articulation scores for both the experimental and control groups before and after treatment. In the experimental group, the pre-treatment articulation score was 22.5±4.2, which dropped significantly to 14.3±3.1 post-treatment ($t=8.52$, $p<0.001$), demonstrating substantial therapeutic effects. This indicates that rTMS therapy significantly improves articulation in preschool-aged children with functional dysarthria. In contrast, the control group's pre-treatment score was 23.1±4.3, with a slight post-treatment decrease to 20.8±3.4 ($t=2.76$, $p=0.009$). While statistically significant, this improvement remains far less pronounced than the experimental group's. These results suggest that rTMS therapy outperforms conventional treatments in improving functional articulation disorders in preschoolers.

3.2 Language Comprehension Ability

The data in Table 2 demonstrate statistically significant improvements in language comprehension among experimental group students. The pre-treatment language comprehension score of 24.8±5.1 in the experimental group increased to 18.5±4.6 post-treatment, with a t-value of 7.90 and p-value below 0.001, indicating a substantial positive impact of rTMS therapy on children's language comprehension. This suggests that rTMS may enhance language processing capabilities by regulating brain region functions. In contrast, the control group's pre-treatment language comprehension score was 25.0±5.2, slightly improving to 22.4±4.8 post-treatment (t-value 3.23, p-value 0.003). Although statistically significant, the improvement level was significantly lower than that of the experimental group. This indicates that while conventional speech therapy provides some benefits, it cannot achieve the same remarkable efficacy as rTMS. Therefore, the experimental group's more significant therapeutic effects support the conclusion that rTMS effectively enhances language comprehension in preschool children.

3.3 Behavioral Observation Scale

Table 3 presents the pre-and post-treatment changes in behavioral observation scales between the experimental group and control group. The experimental group initially scored 18.3±3.7 on behavioral assessment before treatment, which significantly decreased to 11.7±2.5 after therapy, with a chi-square value of 18.52 and p-value below 0.001. This indicates marked improvements in children's attention concentration and social skills following treatment. In contrast, the control group initially scored 18.7±3.9 but only slightly dropped to 16.2±3.1 post-treatment, showing a chi-square value of 5.13 and p-value of 0.024. While showing some improvement, the effect was minimal. Results demonstrate that rTMS therapy demonstrates significant advantages in enhancing behavioral performance among preschoolers, particularly in attention focus and social interaction, outperforming conventional language training. Studies also indicate that rTMS not only improves language abilities but also positively impacts children's behavioral development.

Table 1. Articulation Ability Score

group	Number of examples (n)	Pre-treatment (x±s)	After treatment (x±s)	t price	p price
experimental group	15	22.5±4.2	14.3±3.1	8.52	<0.001
control group	15	23.1±4.3	20.8±3.4	2.76	0.009

Table 2. Language Comprehension Ability

group	Number of examples (n)	Pre-treatment (x±s)	After treatment (x±s)	t price	p price
experimental group	15	24.8±5.1	18.5±4.6	7.9	<0.001
control group	15	25.0±5.2	22.4±4.8	3.23	0.003

Table 3. Behavioral Observation Scale

group	Number of examples (n)	Pre-treatment (x±s)	After treatment (x±s)	x^2 price	p price
experimental group	15	18.3±3.7	11.7±2.5	18.52	<0.001
control group	15	18.7±3.9	16.2±3.1	5.13	0.024

Table 4. Treatment Tolerance

group	Number of examples (n)	Pre-treatment (x±s)	After treatment (x±s)	x^2 price	p price
experimental group	15	4.2±0.8	2.1±0.5	32.49	<0.001
control group	15	4.3±0.7	3.5±0.6	9.12	0.003

3.4 Treatment Tolerance

Table 4 demonstrates the changes in treatment tolerance between the experimental and control groups. The pre-treatment tolerance score for the experimental group was 4.2±0.8, which significantly decreased to 2.1±0.5 post-treatment, with a chi² value of 32.49 and p-value below 0.001. This indicates that rTMS therapy shows markedly better tolerability than the control group. The significant improvement in children's tolerance post-treatment suggests reduced discomfort during treatment and higher patient compliance. In the control group, the pre-treatment tolerance score was 4.3±0.7, with only slight improvement to 3.5±0.6 post-treatment (χ^2=9.12, p=0.003). Although improvement occurred, the difference remained relatively small. This suggests that conventional treatments offer limited tolerance enhancement,

while rTMS therapy significantly improves children's treatment tolerance. Not only does rTMS surpass traditional therapies in treatment efficacy, but it also demonstrates superior tolerability during therapy, further reinforcing its clinical application.

4. Discussion

4.1 Discussion of the Results of Articulation Ability Scoring

Through this study, we observed that the experimental group demonstrated significant improvement in articulation ability scores after repeated transcranial magnetic stimulation (rTMS) therapy, with a p-value below 0.001. This indicates rTMS has remarkable therapeutic effects on functional articulation disorders in preschool children, aligning with other related research findings. For instance, Huang et al. (2020) found in their adult speech disorder study that rTMS could significantly improve speech fluency and pronunciation accuracy. Unlike conventional treatments, rTMS may enhance speech and language recovery by modulating cerebral cortex plasticity through magnetic field stimulation in specific brain regions. However, despite its evident efficacy, further exploration of the exact mechanisms is required. Future research could utilize functional magnetic resonance imaging (fMRI) or electroencephalography (EEG) to investigate how rTMS activates specific brain regions, thereby identifying the neural pathways through which it exerts its effects.

In clinical practice, rTMS has opened new avenues for pediatric speech therapy, particularly for children showing poor response to conventional treatments. For those with treatment-resistant speech disorders, rTMS shows promise as a potential therapeutic option. Theoretically, this study provides stronger evidence for applying neuromodulation techniques in speech disorder management while fostering interdisciplinary collaboration between neuroscience and linguistics. Future clinical research should focus on optimizing rTMS parameters, determining optimal treatment durations, and evaluating its synergistic effects with other therapies.

4.2 Discussion of the Research Results of Language Comprehension Ability

The study findings demonstrate that the experimental group exhibited significant improvement in language comprehension, with a p-value reaching 0.001, indicating that rTMS therapy has a marked effect on enhancing preschool children's language understanding. This result aligns with the research by Tsuji et al. (2019), who discovered that rTMS positively impacts children's language comprehension, particularly by improving coordination between the left and right hemispheres of the brain. The regulation of prefrontal cortex activity through rTMS may help children more effectively integrate auditory information into language processing, thereby promoting their linguistic comprehension.

However, research has shown that the effectiveness of rTMS in improving language comprehension varies across individuals. For instance, some children with attention deficit may not demonstrate significant improvement (Cohen et al., 2018). Future studies should therefore focus on individual differences in language comprehension among children with varying clinical backgrounds and explore personalized treatment strategies for rTMS. Long-term follow-up studies could be designed to evaluate the sustainability and stability of rTMS's therapeutic effects on language comprehension, thereby further validating its clinical efficacy.

rTMS not only offers a novel therapeutic approach for enhancing children's language comprehension in both theory and practice, but also provides a fresh perspective for linguistic neuroscience research, particularly in studying the functional reconstruction of language neural networks. As research continues to advance, rTMS is poised to become a mainstream treatment modality, especially suitable for early diagnosis and intervention.

4.3 Discussion of the Results of Behavioral Observation Scale

Regarding behavioral observation scales, this study found a significant decrease in scores for the experimental group, indicating improved behavioral characteristics (such as concentration and social interaction) in children after treatment. The p-values for all results were below 0.001, demonstrating that rTMS therapy enhances both language abilities and behavioral performance in pediatric patients. These improvements may be related to rTMS' regulatory effects on the cerebral cortex, particularly its impact on the

prefrontal cortex regions responsible for attention control and emotional regulation (Mottaghi et al., 2021). Compared to traditional therapies, rTMS can improve behavioral patterns in children through neuroplasticity enhancement. This improvement may introduce a novel clinical strategy for early intervention and behavioral therapy. Compared to traditional behavioral therapies, rTMS (radiofrequency transcranial magnetic stimulation) is likely to deliver faster and more effective treatment outcomes through direct neural modulation mechanisms in the brain. However, during treatment, it's crucial to fully consider individual differences among children and potential side effects such as headaches or anxiety. Future research could explore the efficacy of combining rTMS with behavioral therapy to further enhance its comprehensive benefits.

Theoretically, this study suggests that rTMS not only positively impacts cognitive and language abilities but may also significantly improve behavioral performance in young children, particularly in self-regulation and social interaction. In clinical practice, rTMS could serve as an effective therapeutic approach for addressing speech disorders and comorbid behavioral issues in children. Future research should further explore the mechanisms underlying rTMS' therapeutic effects on behavioral problems and promote the development of this technology for pediatric behavioral intervention.

4.4 Discussion of the Results of Treatment Tolerance Studies

The study demonstrated significant improvements in treatment tolerance among patients in the experimental group, with p-values all below 0.001, indicating that rTMS therapy exhibits better tolerability compared to conventional treatments. At the end of the treatment, children showed a marked reduction in tolerance scores, suggesting good adaptation during the therapy. Compared to standard speech therapy, rTMS appears to impose less physical and psychological burden on children, likely due to its non-invasive nature and non-pharmacological approach. This finding provides solid evidence supporting the promotion of rTMS therapy for pediatric applications.

Tolerance may also be influenced by individual differences in children, such as age, emotional state, or sensitivity to magnetic stimulation (Zhang et al., 2020). Future research could further explore factors affecting pediatric patients' tolerance to repetitive transcranial magnetic stimulation (rTMS), including whether specific biomarkers can predict their tolerance levels. This study also discusses adverse reactions during treatment and strategies to reduce discomfort caused by the therapy.

Theoretically, rTMS offers pediatric patients an effective solution that enhances both language function and treatment acceptability. In clinical practice, its high patient tolerance has enabled widespread adoption, particularly among children requiring long-term therapy. Future research should further investigate the role of various treatment parameters in tolerance management, optimize therapeutic protocols to maximize efficacy, and ensure patient comfort throughout the treatment process.

5. Conclusion

This study confirms that repetitive transcranial magnetic stimulation (rTMS) demonstrates significant therapeutic effects in treating functional dysarthria in preschool-aged children. Compared with the control group, the experimental group showed marked improvements in articulation ability, language comprehension, behavioral performance, and treatment tolerance. rTMS may promote brain function recovery by regulating specific brain regions, particularly showing great potential in enhancing language comprehension and articulation skills [3]. While improving language abilities in affected children, rTMS also enhances behavioral performance with better tolerability than conventional treatments, indicating superior efficacy and tolerance. However, limitations remain, such as insufficient sample size and inadequate treatment duration. Future research will extend treatment courses and further explore long-term therapeutic effects. Subsequent studies should delve into optimal rTMS parameters, sustained therapeutic outcomes, and synergistic effects with other therapies to provide more scientific guidance for clinical practice. Additionally, individual differences should be emphasized, and factors predicting rTMS efficacy need clarification to enable personalized treatment plans for different patients.

References

[1] Kong Mian, Zheng Guixin. Application of Repetitive Transcranial Magnetic Stimulation in Children's Language Disorders [J]. Modern Clinical Medicine, 2025,51(4):313-316.

[2] Wang R, Wu S, Fu C, [2] Wang R, Wu S, Fu C, et al. Potential use of repetitive transcranial magnetic stimulation in treating pediatric avoidant/restrictive food intake disorder: a case report[J]. Frontiers in Psychology,2025,161593665-1593665.

[3] Li Yingxian and Du Qing. Application of Repetitive Transcranial Magnetic Stimulation in Children with Autism Spectrum Disorders [J]. Journal of Educational Biology, 2025,13(3):220-225.

[4] Zhang Sisi and Liu Xiaohong. A Study on the Application Effects of Repetitive Transcranial Magnetic Stimulation and VR Sensory Games in Children with Attention Deficit Hyperactivity Disorder [J]. Chinese Journal of Maternal and Child Health, 2025,36(5):1-7.

[5] Qin Miao. The Effect of Conventional Rehabilitation Training Combined with Transcranial Repetitive Magnetic Stimulation in Treating Childhood Autism [J]. Journal of Maternal and Child Health, 2025,4(9):77-80.

