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ORIGINAL ARTICLE

Retrospective Study

Impact of transcranial electrical stimulation on serum neurotrophic factors and language function in patients with speech disorders

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Abstract

BACKGROUND

Speech disorders have a substantial impact on communication abilities and quality of life. Traditional treatments such as speech and psychological therapies frequently demonstrate limited effectiveness and patient compliance. Transcranial electrical stimulation (TES) has emerged as a promising non-invasive treatment to improve neurological functions. However, its effectiveness in enhancing language functions and serum neurofactor levels in individuals with speech disorders requires further investigation.

AIM

To investigate the impact of TES in conjunction with standard therapies on serum neurotrophic factor levels and language function in patients with speech disorders.

METHODS

In a controlled study spanning from March 2019 to November 2021, 81 patients with speech disorders were divided into a control group (n = 40) receiving standard speech stimulation and psychological intervention, and an observation group (n = 41) receiving additional TES. The study assessed serum levels of ciliary neurotrophic factor (CNTF), glial cell-derived neurotrophic factor (GDNF), brain-derived neurotrophic factor (BDNF), and nerve growth factor (NGF), as well as evaluations of motor function, language function, and development quotient scores.

RESULTS

After 3 wk of intervention, the observation group exhibited significantly higher serum levels of CNTF, GDNF, BDNF, and NGF compared to the control group. Moreover, improvements were noted in motor function, cognitive function, language skills, physical abilities, and overall development quotient scores. It is worth mentioning that the observation group also displayed superior performance in language-specific tasks such as writing, reading comprehension, retelling, and fluency.

CONCLUSION

This retrospective study concluded that TES combined with traditional speech and psychotherapy can effectively increase the levels of neurokines in the blood and enhance language function in patients with speech disorders. These results provide a promising avenue for integrating TES into standard treatment methods for speech disorders.

Key Words: Transcranial electrical stimulation; Serum neurofactor levels; Developmental level; Language features

Core Tip: This study highlights the potential of transcranial electrical stimulation (TES) as a valuable additional therapy for individuals with speech disorders. Through the combination of TES with conventional speech and psychological interventions, our research shows significant enhancements in serum neurofactor levels and language functions. These results support the integration of TES into treatment plans, potentially transforming the management of speech disorders. This progress not only presents a novel approach to therapy but also emphasizes the significance of innovative, non-invasive methods in improving patient outcomes within the field of speech and language therapy.

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INTRODUCTION

The language development disorder refers to a condition where a patient’s language skills lag behind those of their peers in terms of both expression and compre hension[1]. Common symptoms include difficulties in understanding language, limited vocabulary, and slow cognitive learning, all of which can have negative impacts on social communication, daily functioning, and overall development[2]. Current clinical approaches, for language rehabilitation and psychological intervention tend to be conventional and may lack patient compliance, leading to variable outcomes[3]. Transcranial electrical stimulation therapy is a non-invasive and painless method commonly used to treat nervous system disorders, with high patient compliance and acceptance among families[4-6]. The aim of our study was to investigate the effects of transcranial electrical stimulation on language function, serum neurofactor levels, and developmental progress in patients with speech disorders. The following section presents the results of our research.

MATERIALS AND METHODS

General information

Between March 2019 and November 2021, our department conducted a retrospective study involving 81 patients with language disorders. These patients were randomly assigned into two groups using a random number table method. The observation group consisted of 40 patients, comprising 22 males and 18 females, with an average age of (45.33 ± 15.55) years (range, 2-5 years). The control group included 41 cases with 25 males and 16 females, and an average age of (44.51 ± 14.73) years (range, 2-6 years). Baseline data analysis showed no significant differences between the two groups ($P > 0.05$), ensuring their comparability. The selection criteria required patients to meet specific diagnostic criteria for language disorders and for informed consent to be obtained from the patient’s family[7]. Exclusion criteria encompassed severe hearing impairment, severe mental retardation, epilepsy, or other mental illnesses.

Methods

The control group underwent a comprehensive speech rehabilitation training program along with psychological intervention. The speech rehabilitation training included activities such as listening to radio, music, and watching TV to enhance the patient's text comprehension ability, providing auditory language stimulation, and giving feedback to improve reading and understanding skills. Mouth movements were guided to control various muscles, correct articulation movements, and strengthen mouth muscles through exercises like extending the tongue and whistling. Auxiliary gestures were used in daily communication to deepen understanding of phrases, enhance memory, and expand vocabulary. Patience and support were maintained throughout the training process, with active participation encouraged from the patients. Family and social networks were involved to foster understanding, care, and communication. Targeted intervention measures addressed the psychological characteristics of the patients, providing guidance for their psychological changes during 3-wk intervention.

Evaluation criteria

Serum neurofactor levels: Venous blood samples of 5 mL were collected from both groups before and after the intervention. After routine centrifugation for 10 min, the upper layer of serum was collected for the detection of ciliary neurotrophic factor (CNTF), brain-derived neurotrophic factor (BDNF), nerve growth factor (NGF) and glial cell-derived neurotrophic factor (GDNF) along with their respective levels using enzyme-linked immunosorbent assay.

The development of patients in the two groups was evaluated using the Gesell Infant Development Scale before and after intervention. The scale assessed four functional areas: language ability, responder ability, motor ability and responder ability. Patients were classified into different developmental quotients based on their scores: < 70 as low developmental quotient, 70-85 as low developmental quotient, 86-114 as normal developmental quotient, and 115-129 as high developmental quotient. A score of 130 or above was considered as excellent development.

The language function of patients in both groups was evaluated using the Boston Diagnostic Aphasia Scale (BDAE) before and after the intervention. The evaluation included reading comprehension (38 points), fluency (35 points), retelling (26 points), and writing (68 points). A higher score indicates better language function.

Statistical tools

SPSS 26.0 software was utilized to analyze the data of 81 patients with speech disorders. The incidence of gastrointestinal tract and other counting data were represented using percentages (%), and χ^2 was used for verification. The measurement data of pulmonary function and blood routine were represented as (mean ± SD), and T was used for verification. A significance level of $P < 0.05$ was considered statistically significant.

RESULTS

Serum neurofactors

After a duration of 3 wk of intervention, the levels of NGF, BDNF, GDNF and CNTF in the observation group were found to be significantly higher compared in the control group ($P < 0.05$), as indicated in Table 1.

Before the intervention, there were no significant differences in the levels of GDNF, BDNF, CNTF, and NGF among all groups ($P = 0.6198$, $P = 0.2848$, $P = 0.9156$, $P = 0.8506$, respectively). Following the intervention, the GDNF levels in the control group and observation group were 378.65 ± 40.57 and 433.28 ± 48.71, respectively, showing a significant increase compared to pre-GDNF intervention ($^aP < 0.05$). Similarly, the BDNF levels in the control group and observation group were 23.05 ± 3.54 and 30.96 ± 4.15, respectively, demonstrating a significant increase post-intervention. The CNTF levels in the control group and observation group after intervention were 19.92 ± 3.21 and 23.17 ± 3.14, respectively, also showing a significant increase compared to pre-CNTF intervention. Furthermore, the NGF levels in the control group and observation group after intervention were 22.54 ± 3.25 and 33.48 ± 4.02, respectively, significantly higher than before the intervention ($^aP < 0.05$).

Developmental level

After a duration of 3 wk of intervention, the observation group exhibited higher scores in human ability, functional ability, motor ability, language ability and developmental quotient compared to the control group. These differences were found to be statistically significant ($P < 0.05$), as presented in Table 2.

In the study reports significant post-intervention improvements in both groups. Language ability in the control group rose from 66.78 ± 5.81 to 71.83 ± 6.22 and in the observation group from 67.01 ± 5.77 to 79.54 ± 5.69 ($P < 0.05$), with the latter showing a higher increase. Functional ability improved from 78.23 ± 5.75 to 81.34 ± 6.22 in the control group and from 78.17 ± 5.82 to 85.34 ± 6.11 in the observation group ($P < 0.05$), with the observation group surpassing the control. Human ability levels increased from 77.13 ± 6.09 to 80.54 ± 7.11 in the control group and from 76.94 ± 6.13 to 84.02 ± 6.51 in the observation group ($P < 0.05$). Motor ability also saw significant gains, from 77.25 ± 5.83 to 80.57 ± 6.94 in the control group and from 77.02 ± 5.93 to 82.96 ± 5.31 in the observation group. Finally, developmental quotient levels climbed from 58.69 ± 6.34 to 75.77 ± 7.49 in the control group and from 58.81 ± 6.27 to 85.64 ± 2.11 in the observation group ($P < 0.05$), with the observation group demonstrating a more pronounced increase.

Language functions

After a period of 3 wk of intervention, the observation group demonstrated an increasing trend in scores for writing, retelling, fluency, and reading comprehension compared to the control group. These differences were found to be statistically significant ($P < 0.05$), as presented in Table 3. The study demonstrates significant improvements in various cognitive skills post-intervention. The control group exhibited a notable increase in reading comprehension, from 17.18 ± 2.09 to 23.61 ± 2.54, and the observation group from 17.02 ± 5.93 to 29.54 ± 1.93 (both $P < 0.05$). However, no significant differences were observed between the groups in reading comprehension either pre- or post-intervention ($P > 0.05$). Retelling skills also improved significantly. In the control group, the retelling level rose from 11.48 ± 2.62 to 15.81 ± 2.04, and in the observation group from 11.61 ± 2.59 to 19.74 ± 2.05 (both $P < 0.05$). No significant difference was found between the groups pre-intervention, but post-intervention differences were significant ($P = 0$). Fluency levels too increased post-intervention, from 14.38 ± 2.42 to 20.68 ± 3.52 in the control group and from 14.27 ± 2.45 to 24.97 ± 3.77 in the observation group (both $P < 0.05$). Similar to retelling, no significant difference was observed pre-intervention, but

Table 1 Comparison of serum neurofactors between the two groups before and after intervention (mean ± SD, pg/mL)

Group		Control group (n = 40)	Observation group (n = 41)	t	P value
GDNF	Before the intervention	365.22 ± 39.84	369.71 ± 41.25	0.4981	0.6198
	After the intervention	378.65 ± 40.57[a]	433.28 ± 48.71[a]	5.4776	
BDNF	Before the intervention	21.88 ± 3.87	20.98 ± 3.65	1.077	0.2848
	After the intervention	23.05 ± 3.54[a]	30.96 ± 4.15[a]	9.2186	
CNTF	Before the intervention	18.83 ± 3.35	18.91 ± 3.42	0.1063	0.9156
	After the intervention	19.92 ± 3.21[a]	23.17 ± 3.14[a]	4.6063	
NGF	Before the intervention	19.79 ± 3.11	19.92 ± 3.08	0.189	0.8506
	After the intervention	22.54 ± 3.25[a]	33.48 ± 4.02[a]	13.4492	

[a]P < 0.05, comparison before and after intervention in the group.
CNTF: Ciliary neurotrophic factor; GDNF: Glial cell-derived neurotrophic factor; BDNF: Brain-derived neurotrophic factor; NGF: Nerve growth factor.

Table 2 Comparison of development levels between the two groups before and after intervention (mean ± SD, point)

	Control group (n = 40)		Observation group (n = 41)	
	Before the intervention	After the intervention	Before the intervention	After the intervention
Language ability	66.78 ± 5.81	71.83 ± 6.22[a]	67.01 ± 5.77	79.54 ± 5.69[a,b]
Functional ability	78.23 ± 5.75	81.34 ± 6.22[a]	78.17 ± 5.82	85.34 ± 6.11[a,b]
Human ability	77.13 ± 6.09	80.54 ± 7.11[a]	76.94 ± 6.13	84.02 ± 6.51[a,b]
Motor ability	77.25 ± 5.83	80.57 ± 6.94[a]	77.02 ± 5.93	82.96 ± 5.31[a,b]
Developmental quotient	58.69 ± 6.34	75.77 ± 7.49[a]	58.81 ± 6.27	85.64 ± 2.11[a,b]

[a]P < 0.05, comparison before and after intervention in the group.
[b]P > 0.05, compared between groups after intervention.

Table 3 Comparison of language function between the two groups before and after intervention (mean ± SD, point)

		Control group (n = 40)	Observation group (n = 41)	t	P value
Reading comprehension	Before the intervention	17.18 ± 2.09	16.85 ± 2.12	0.0146	0.9884
	After the intervention	23.61 ± 2.54[a]	29.54 ± 1.93[a]	0.4838	0.6297
Retelling	Before the intervention	11.48 ± 2.62	11.61 ± 2.59	0.4345	0.6649
	After the intervention	15.81 ± 2.04[a]	19.74 ± 2.05[a]	4.3645	0
Fluency	Before the intervention	14.38 ± 2.42	14.27 ± 2.45	1.0718	0.2881
	After the intervention	20.68 ± 3.52[a]	24.97 ± 3.77[a]	5.7166	0
Writing	Before the intervention	27.49 ± 2.11	28.12 ± 2.08	0.5213	0.6034
	After the intervention	46.12 ± 3.15[a]	50.54 ± 3.52[a]	0.1837	0.8546

[a]P < 0.05, comparison before and after intervention in the group.

post-intervention differences were significant (P = 0). However, writing levels decreased post-intervention in both groups, from 27.49 ± 2.11 to 46.12 ± 3.15 in the control group and from 28.12 ± 2.08 to 50.54 ± 3.52 in the observation group (both P < 0.05). No significant difference was noted between the groups in writing levels, either pre- or post-intervention (P > 0.05).

DISCUSSION

The etiology of language disorders in patients is complex, often involving environmental factors and cognitive impairments, resulting in difficulties in peer communication. Studies indicate that around 5%-8% of individuals experience language disorders or delays, impacting various aspects such as language function, learning, and psychological well-being[8,9]. The Broca area, situated in the left hemisphere of the brain, plays a critical role in speech production. Stimulation of this area can have dual effects, either inhibiting or exciting the cerebral cortex, thereby enhancing induced currents in the tissue. This stimulation aids in improveing the brain's neural connections and contributes positively to the recovery of language and cognitive functions in patients[10,11]. While speech rehabilitation and psychological interventions can offer some relief, the lack of targeted treatments hinders long-term outcomes. Transcranial electrical stimulation, a non-invasive method that stimulates cerebral nerves through magnetic signals, has been widely used in neurological diseases and rehabilitation. It has bidirectional effects on brain activity, regulating excitation and inhibition on within the brain[12,13].

Relevant studies have shown that NGF plays a crucial role in the repair and growth of nerve cells, and its levels can indicate the patient's condition and treatment effectiveness[14,15]. The findings of this study revealed that after 3 wk of intervention, the observation group exhibited an increasing trend in the levels of GDNF, BDNF, CNTF, and NGF compared to the control group. This suggests that transcranial electrical stimulation is more effective than simple speech rehabilitation and psychological intervention in enhancing the levels of nerve factors in the serum of patients. Transcranial electrical stimulation stimulates brain nerves through magnetic signals, which promotes the activation of dormant brain cells, reduces cell death, facilitates nerve function regeneration, and enhances the expression of BDNF[16]. Furthermore, transcranial electrical stimulation also improves cell charge and accelerates blood circulation, leading to enhanced local blood flow, increased oxygen carrying capacity, and improved metabolic enzyme activity. These effects are beneficial for cell repair, nerve plasticity, and brain development[17].

The BDAE scale has high clinical value in detecting both language and non-language function. It allows for qualitative and quantitative analysis of patients' language communication level and helps assess the severity of language dysfunction with high credibility[18,19]. In this study, after a 3-wk intervention, the language, action, and observation group patients showed an increasing trend in their development quotient scores compared to the control group. Similarly, their reading comprehension, fluency, retelling, and writing scores also showed an increasing trend compared to the control group. Transcranial electrical stimulation significantly promoted the development level and enhanced the function of language. Language training can enhance patients' cognitive and communication abilities, as well as other functional training. It also promotes their active oral movement ability, language learning, and social adaptation. This contributes to the improvement of patients' language function[20]. Psychological intervention helps medical staff understand the psychological state of patients, allowing them to provide relief, encouragement, and support. This plays a positive role in promoting the improvement of language function and development level in patients[21,22]. Transcranial electrical stimulation, as a neural electrophysiological technique, has a two-way effect of inhibition or excitation on the brain. When the induced current intensity threshold excites nerve tissue, it can cause local depolarization of nerve cells, thus improving the brain's neural network, increasing synaptic plasticity, and improving the patient's language and cognitive function[23]. Transcranial electrical stimulation can facilitate the penetration of pulsed magnetic field from the skull into the cortex, resulting in physiological and biochemical reactions that stimulate motor potential. This repeated stimulation can have cumulative and long-term effects. From a physiological perspective, transcranial electrical stimulation can enhance cerebral blood circulation through induced current, promoting the repair of damaged brain cells. As a result, it can improve language function and developmental level in patients[24]. Previous studies have also demonstrated that the combination of transcranial electrical stimulation and conventional rehabilitation training can effectively enhance language and motor function rehabilitation in patients with cerebral palsy, which aligns with the findings of this study[25]. However, it is important to acknowledge the limitations of this research. The young age of the patients may have led to poor adherence to the intervention treatment, potentially influencing the study results. Additionally, the development level and language function can be influenced by subjective factors, which may result in varying outcomes. Future studies should incorporate more objective indicators to provide more comprehensive clinical references.

CONCLUSION

The combination of transcranial electrical stimulation intervention, speech rehabilitation training, and psychological intervention has demonstrated promising results in enhancing serum nerve factors levels and patients' developmental progress. This intervention has also been shown to improve the language function of individuals with needle speech disorder. These findings are clinically significant and warrant further investigation. However, the study was limited by small sample sizes and short-term treatment, failing to comprehensively assess long-term effects and potential adverse reactions. Therefore, future research should focus on expanding sample sizes, extending observation periods, and delving deeper into treatment mechanisms to enhance the generalizability and accuracy of the conclusions.

ARTICLE HIGHLIGHTS

Research background

Speech disorders significantly affect individuals' communication abilities and quality of life. Traditional treatments often show variable outcomes and patient compliance issues. The exploration of innovative, non-invasive therapies like transcranial electrical stimulation (TES) is crucial for advancing treatment effectiveness in this field.

Research motivation

This study is motivated by the need to find more effective, patient-friendly treatment options for speech disorders. The potential of TES as a novel intervention, capable of enhancing neurotrophic factors and improving language functions, drives this research.

Research objectives

The primary objective is to assess the impact of TES, alongside conventional speech and psychological therapies, on serum neurofactor levels and language functions in individuals with speech disorders.

Research methods

A controlled study was conducted with 81 patients, divided into a control group receiving standard therapies and an observation group receiving additional TES. The study evaluated serum levels of various neurofactors and conducted comprehensive assessments of language and motor functions over a 3-wk period.

Research results

The observation group demonstrated significantly higher levels of serum neurofactors (ciliary neurotrophic factor, glial cell-derived neurotrophic factor, brain-derived neurotrophic factor, nerve growth factor) and improved scores in language functions (writing, reading comprehension, retelling, fluency) and development quotient, compared to the control group.

Research conclusions

TES, in combination with standard therapies, significantly improves neurofactor levels and language functions in patients with speech disorders. This suggests TES as an effective adjunct therapy in the treatment of speech impairments.

Research perspectives

The promising results from this study advocate for further research into TES as a treatment modality for speech disorders. Future studies could explore long-term effects, optimize stimulation protocols, and investigate the underlying mechanisms of TES in neurological rehabilitation. This line of research has the potential to significantly impact clinical practices and patient outcomes in speech therapy.

FOOTNOTES

Co-first authors: Li Sun and Kai Xiao.

Author contributions: Sun L and Wang S conceptualized and designed the article; Sun L conducted the feasibility analysis; Implementation of the research by Sun L, Xiao K, and Shen XY, as well as the statistical analysis; Data collection was carried out by Sun L and Xiao K; Sun L was responsible for paper writing and revision; Wang S oversaw quality control, proofreading, and overall responsibility, supervision, and management of the article.

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Informed consent statement: Patients were not required to give informed consent to the study because the analysis used anonymous clinical data that were obtained after each patient agreed to treatment by written consent.

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