ORIGINAL RESEARCH

Effects of Transcranial Direct Current Stimulation and Neuromuscular Joint Facilitation on Upper Limb Motor Disorders for Stroke Patients

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ABSTRACT

Context • Approximately 1.5- to 2-million new patients suffer from stroke annually in China. 60% of patients suffering from stroke will sustain different degrees of upper limb dysfunction at six months after onset. Recovery of upper limb function after stroke is of great significance in improving patients' quality of life.

Objective • The study intended to explore the rehabilitative the effects of transcranial direct current stimulation combined with neuromuscular joint therapy on the rehabilitation of patients with upper-limb motor disorders after strokes to provide new ideas for rehabilitative treatment.

Design • The study was a paired control test.

Setting • The study took place in the Department of Rehabilitation Medicine at Heping Hospital of Changzhi Medical College in Changzhi, Shanxi, China.

Participants • Participants were 80 stroke patients with upper-limb motor disorders who were treated at the hospital between January 2020 and December 2020.

Intervention • According to the natural grouping method, the research team divided participants into an intervention group (n = 42) and a control group (n = 38). The control group received transcranial direct-current stimulation, and the intervention group received transcranial direct-current stimulation combined with neuromuscular joint therapy.

Outcome Measures • The measurements included the scores on the Fugl-Meyer Assessment (FMA) scale, the Action Research Arm Test (ARAT), activities of daily living (ADL), and National Institutes of Health Stroke Scale (NIHSS) as well as the serum levels of brain-derived neurotrophic factor (BDNF), nerve growth factor (NGF), and superoxide dismutase (SOD). The team also measured the maximum isometric torque of flexion and extension of the elbow joint. The research team compared the differences in the scores between the groups for all variables.

Results • Postintervention, the FMA, ARAT, and ADL scores, the torques of elbow flexion and extension maximum isometric contraction, the amplitude, and the serum BDNF, NGF, and SOD levels were significantly higher in the intervention group than those in the control group, while the NIHSS score and the incubation period of evoked potential were significantly lower than those in the control group.

Conclusions • Transcranial direct current stimulation combined with the neuromuscular joint method demonstrated good rehabilitative effects on upper-limb movement disorders for stroke patients and significantly improved their upper-limb function and promoted recovery of nerve functions. (*Altern Ther Health Med.* 2023;29(2):120-124)

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Stroke has a high incidence, high disability rate, and high mortality and involves cerebral thrombosis, vascular occlusion, and brain and subarachnoid hemorrhage. Although the application of medical technology has gradually reduced stroke patients' mortality, most still have motor dysfunction and other sequelae to varying degrees after treatment, especially upper limb motor dysfunction, which can seriously affect patients' quality of life.[1] Therefore, it's crucial to develop appropriate recovery programs after stroke.

Neurological dysfunction is a common manifestation in patients with stroke. For patients with ischemic stroke, it's difficult for the brain center to plan and start an action due to the decline in the body's ability to control the motor system, and the somatosensory-evoked potential is abnormal, resulting in blockade of sensory conduction and then leading to dysfunction. Additionally, a blood clot can form space-occupying lesions, compressing the surrounding large blood vessels, making the blood vessels contract, inducing a large amount of calcium influx, and further leading to abnormal brain and somatosensory activities.[1]

Jiang et al's found that the incidence of stroke in China has significantly increased over the past ten years. Approximately 1.5- to 2-million new patients suffer from stroke annually in China.[2] Approximately 60% of patients suffering from stroke will sustain different degrees of upper limb dysfunction at six months after onset.[3] Improvement in their daily living ability mainly depends on the recovery of upper limb function. Therefore, the recovery of upper limb function after stroke is of great significance in improving patients' quality of life.

Neuromuscular Joint Method

Rehabilitation medicine commonly uses the neuromuscular joint method, which has the effect of improving the function of nerves, muscles, and joints. It has the potential to promote the recovery of neuromuscular function, expand limited joint activity, enhance muscle strength, and alleviate pain in patients with CNS diseases.[4]

The neuromuscular joint method combines massage therapy with the science of trigger points to reduce pain and improve performance. This type of therapy can expand cerebral vessels, promote the early establishment of collateral circulation of damaged lesions, activate nerve cells and nerve fibers with low function in damaged areas, improve neurological deficits caused by cerebral cell ischemia, and promote the repair of sensory and motor function areas.[5]The method can promote normal joints and intracapsular movement through active movement and resistance movement, expand joint activity, loosens shoulder joints, and play a synergistic role with transcranial direct current stimulation.

results indicated that the intervention group's Fugl-Meyer (FMA) score, action research arm test (ARAT) score, elbow flexion, and extension maximum isometric contraction moment were significantly higher than those of the control group postintervention.

The neuromuscular joint method is a type of exercise therapy for proprioceptive neuromuscular facilitation and joint mobilization. Harciarek and Mankowska found that it can strengthen the movement ability of deep muscle groups around the joint, improve joint activity, fundamentally improve the joint function of the body, and help to promote the recovery of upper limb and arm functions.[6]

Transcranial Direct Current Stimulation

Transcranial direct current stimulation is a clinically effective, noninvasive, stimlation of the central nervous system (CNS) that regulates its neuronal activity through a constant current, effectively changing the polarization state of the cell membrane and regulating the plasticity of synapses. Transcranial direct current stimulation is a widely used therapy with high patient acceptance.[7]

Transcranial direct current stimulation uses 1-2 mA of constant and weak direct current, and can improve the excitability of the cortex. Doria and Forgacs found that the anode stimulation of the cerebral cortex for hand function and other specific areas can regulate the activity of cerebral cortical neurons, thereby improving the finger's motor ability.[8]

Current Study

The current study intended to explore the rehabilitative effects of transcranial direct current stimulation combined with neuromuscular joint facilitation on the rehabilitation of patients with upper-limb motor disorders after stroke to provide new ideas for rehabilitative treatment.

METHODS

Participants

The study was paired control test. The study took place in the Department of Rehabilitation Medicine at Heping Hospital of Changzhi Medical College in Changzhi, Shanxi, China. Potential participants were patients with upper-limb motor disorders after stroke who were treated at the hospital between January 2020 and December 2020.

Potential participants were included in the study if they: (1) had received a diagnosis conforming to the criteria in the *Guidelines for the Diagnosis and Treatment of Acute Ischemic Stroke in China*[9] for stroke of the internal carotid-artery system[10]; (2) had hemiplegia in one side, in line with the Brunnstrom Stages of Stroke Recovery 1-3[11]; (3) had a stroke at first onset; and (4) had a stable condition that would allow them to cooperate with treatment.

Potential participants were excluded from the study if they: (1) had had a hemorrhagic stroke; (2) had liver or kidney dysfunction, hematopoietic system diseases, malignant tumors, or other serious diseases; (2) had neurodegenerative diseases such as Parkinson's disease; or (4) had post-stroke depression or aphasia.

Participants and their families signed informed consent forms. The hospital's ethics committee approved the study's protocols.

Procedures

Groups. The research team divided the participants into an intervention group (n = 42) and a control group (n = 38) according to the odd-even number at the end of the patient's medical record number. Grouped by medical record system according to nature grouping.

Symptomatic treatments. All participants received symptomatic treatment with antiplatelet agents, lipid regulation, plaque stabilization, blood-pressure regulation, circulation improvement, and nutritional support.

Direct current stimulation. Both groups group received transcranial direct current stimulation. The treatment used electromyography, with the motor area being the electrode's target. The team used Dantec Keypoint electromyography (Nihon Kohden, Denmark).

The research team placed the anode in the representative area of a participant's hemiplegic upper limb in the primary motor cortex of the side of the brain with the lesion and placed the cathode in the contralateral shoulder. The current was set to 1.5-2.0 mA for 20 min daily for 8 weeks.

Table 1. Comparison of Demographic and Clinical Characteristics Between the Intervention and Control Groups at Baseline

Group	n	Gender		Age	Upper Limb Dyskinesia Side		Onset Time	Brunnstrom Staging		
		Male n (%)	Female n (%)	Mean ± SD	Left Side n (%)	Right Side n (%)	Mean ± SD	Phase 1 n (%)	Phase 2 n (%)	Phase 3 N (%)
Intervention group	42	28 (66.67)	14 (33.33)	60.46 ± 9.95	19 (45.24)	23 (54.76)	4.50 ± 1.00	8 (19.05)	24 (57.14)	10 (23.81)
Control group	38	22 (57.89)	16 (42.11)	58.98 ± 11.03	15 (39.47)	23 (60.53)	4.42 ± 0.98	7 (18.42)	21 (55.26)	10 (26.32)
t/χ^2		0.655		0.631	0.271		0.361	0.067		
P value		.418		.530	.602		.719	.967		

Outcome measures. At baseline and postintervention after 8 weeks of treatment, the research team: (1) collected a 5-ml, fasting, venous blood sample from participants in both groups; (2) after centrifugation at 3000 rpm for 10 min, separated the serum; and (3) detected the levels of serum, brain-derived neurotrophic factor (BDNF), nerve growth factor (NGF), and superoxide dismutase (SOD) using an enzyme-linked immunosorbent assay (ELISA). The team purchased the ELISA kit from the BD Company (Franklin Lake, State, New Jersey National, United States) Purchased the ELISA kit. ramsayrd brookhavenr dplazashirley

The team also measured the maximum isometric torque of flexion and extension of the elbow joint at baseline and postintervention using the American multijoint isokinetic test and rehabilitation system (BIODEX USA, Ramsey City, North Dakota, USA,) and its supporting elbow flexion and extension accessories.

The team also tested participants using: (1) the FMA,[12] (2) the ARAT,[13] (3) the activities of daily living (ADL),[14] and (4) the National Institutes of Health Stroke Scale (NIHSS).[15]

Intervention

The intervention group also received neuromuscular joint facilitation. Training occurred twice a day, in the morning and afternoon, for 30-60 min each time, with continuous training for 8 weeks.

The neuromuscular joint method follows the principle of passive first, active second, and resistance third, from trunk to limbs, from simple to complex, and weight reduction first and then resistance third, which can effectively improve the motor function and neurological function of the hemiplegic limbs of hemiplegic patients, so the serological indices improve.

Patients were supine, lateral position, sitting resistance, passive, active exercise, joint surface movement according to upper limb mode. Namely, stretching, adduction, internal rotation, buckling, abduction, external rotation, buckling, adduction, external rotation, stretching, abduction, internal rotation. After the opposite traction joint movement, the patients Change to patients pulled the contralateral bone to expand the joint surface movement.

Outcome Measures

BDNF. Elevated after treatment represents effective treatment, increase is proportional to the therapeutic effect.

NGF. The increase after treatment indicates that the treatment is effective, and the increase is proportional to the treatment effect.

SOD. The increase after treatment indicates that the treatment is effective, and the increase is proportional to the treatment effect.

Statistical Analysis

The research team performed the statistical analysis using the SPSS 23.0 software (IBM, Manufacturer, Amunk, City, New York, State, USA). The team: (1) expressed the measurement data conforming to normal distribution as means ± standard deviations (SDs), and used the independent sample *t* test to analyze the differences between the two groups, and (2) expressed the counting data as n (%), and compared the differences in indicators between the two groups using the χ^2 test. The significance level was set to $P<.05$.

RESULTS

Participants

Table 1 shows the comparison of demographic and clinical characteristics between the intervention and control groups at baseline. No significant differences existed between the groups at that time.

Fugl-Meyer and ARAT scores

Table 2 shows that the Fugl-Meyer and ARAT scores of both groups significantly increased between baseline and postintervention ($P < .05$). The intervention group's Fugl-Meyer and ARAT scores were significantly higher than those of the control group postintervention ($P<.05$).

Elbow Flexion and Extension

Table 3 shows that the elbow joint flexion and extension maximum isometric contraction torque significantly increased for both groups between baseline and postintervention ($P < .05$). The intervention group's elbow joint flexion and extension maximum isometric contraction torque were significantly higher than those of the control group postintervention ($P<.05$).

Latency and Amplitude

Table 4 shows that the incubation period and amplitude of the evoked potentials significantly improved for both groups between baseline and postintervention ($P<.05$). The intervention group's incubation period was significantly lower ($P<.05$) and its amplitude was significantly higher than those of the control group postintervention ($P<.05$).

Table 2. Comparison of the Changes in the Fugl-Meyer and ARAT Scores Between Baseline and Postintervention for the Intervention and Control Groups

Group	n	Fugl-Meyer Score Baseline Mean ± SD	Fugl-Meyer Score Postintervention Mean ± SD	ARAT Score Baseline Mean ± SD	ARAT Score Postintervention Mean ± SD
Intervention group	42	31.16 ± 3.98	45.51 ± 6.68[a]	21.03 ± 3.32	40.03 ± 5.03[a]
Control group	38	32.03 ± 4.10	37.89 ± 7.11[a]	22.40 ± 3.51	32.28 ± 3.85[a]
t		-0.962	4.942	-1.794	7.677
P value		.339	.000[b]	.077	.000[b]

[a]$P < .05$, indicating that the Fugl-Meyer and ARAT scores for both groups significantly increased between baseline and postintervention.
[b]$P = .000$, indicating that the intervention group's Fugl-Meyer and ARAT scores were significantly higher than those of the control group postintervention

Abbreviations: ARAT, action research arm test.

Table 3. Comparison of the Changes in Elbow Joint Flexion and Extension Torque During Maximum Isometric Contraction Between Baseline and Postintervention for the Intervention and Control Groups

Group	n	Torque at Maximum Isometric Contraction in Buckling, N·m Baseline Mean ± SD	Torque at Maximum Isometric Contraction in Buckling, N·m Postintervention Mean ± SD	Torque During Extension Maximum Isometric Contraction, N·m Baseline Mean ± SD	Torque During Extension Maximum Isometric Contraction, N·m Postintervention Mean ± SD
Intervention group	42	7.14 ± 1.03	12.59 ± 1.14[a]	5.19 ± 1.09	11.40 ± 2.12[a]
Control group	38	7.06 ± 1.05	10.78 ± 1.22[a]	5.27 ± 1.01	9.17 ± 1.81[a]
t		0.344	6.859	-0.339	5.033
P value		0.732	0.000[b]	0.735	0.000[b]

[a]$P < .05$, indicating that the elbow joint flexion and extension torque for both groups significantly increased between baseline and postintervention.
[b]$P = .000$, indicating that the intervention group's elbow joint flexion and extension torque were significantly higher than those of the control group postintervention

Table 4. Comparison of the Changes in Incubation Period and Amplitude Between Baseline and Postintervention for the Intervention and Control Groups

Group	n	Incubation Period, ms Baseline Mean ± SD	Incubation Period, ms Postintervention Mean ± SD	Amplitude, mv Baseline Mean ± SD	Amplitude, mv Postintervention Mean ± SD
Intervention group	42	26.68 ± 2.35	22.03 ± 1.97[a]	0.98 ± 0.22	1.80 ± 0.28[a]
Control group	38	26.80 ± 2.19	24.15 ± 2.00[a]	0.93 ± 0.20	1.68 ± 0.22[a]
t		-0.236	-4.772	1.060	2.116
P value		.814	.000[b]	.293	.038[b]

[a]$P < .05$, indicating that the incubation period significantly decreased and the amplitude significantly increased for both groups between baseline and postintervention.
[b]$P < .05$, indicating that the intervention group's incubation period was significantly lower and its amplitude was significantly higher than those of the control group postintervention

Table 5. Comparison of the Changes in Serum BDNF, NGF, and SOD Between Baseline and Postintervention for the Intervention and Control Groups

		BDNF, ng/ml		NGF, ng/ml		SOD, U/ml	
		Baseline	Postintervention	Baseline	Postintervention	Baseline	Postintervention
Group	n	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Intervention group	42	11.45 ± 1.84	20.16 ± 2.03[a]	120.46 ± 32.35	155.97 ± 21.16[a]	42.26 ± 9.94	70.06 ± 10.42[a]
Control group	38	11.97 ± 1.68	17.65 ± 1.87[a]	124.13 ± 28.16	132.25 ± 24.06[a]	43.38 ± 9.16	61.15 ± 9.88[a]
t		-1.315	5.732	-0.539	4.692	-0.522	3.914
P value		.192	.000[b]	.592	.000[b]	.603	.000[b]

[a]$P < .05$, indicating that the BDNF, NGF, and SOD scores for both groups significantly increased between baseline and postintervention.
[b]$P < .05$, indicating that the intervention group's BDNF, NGF, and SOD scores were significantly higher than those of the control group postintervention

Abbreviations: BDNF, brain-derived neurotrophic factor; NGF, nerve growth factor; SOD, superoxide dismutase

ADL and NIHSS Scores

The ADL and NIHSS scores (data not shown) significantly improved for both groups between baseline and postintervention ($P < .05$). The intervention group's ADL score, at 86.64 ± 5.56 points, was significantly higher ($P < .05$) and its NIHSS score, at 16.80 ± 2.21 points, was significantly lower than those of the control group postintervention ($P < .05$).

BDNF, NGF, SOD

Table 5 shows that the serum BDNF, NGF, and SOD significantly increased for both groups between baseline and postintervention ($P < .05$). The intervention group's serum BDNF, at 20.16 ± 2.03 ng/ml; NGF, at 155.97 ± 21.16 ng/ml; and SOD, at 70.06 ± 10.42 U/ml, were significantly higher than those of the control group postintervention ($P < .05$).

DISCUSSION

The current study's results suggested that the intervention group's incubation period of the evoked potential postintervention was significantly lower than that of the control group, while the amplitude was significantly higher. Thus, transcranial direct current stimulation combined with neuromuscular joint therapy can effectively improve the somatosensory current activity of patients.

Compared with the control group in the current study, the intervention group's ADL scores were significantly higher and its NIHSS scores were significantly lower postintervention. Hence, transcranial direct current stimulation combined with neuromuscular joint may improve daily living ability and nerve function recovery.

The intervention group's serum BDNF, NGF, and SOD levels were significantly higher than those of the control group postintervention, which suggests significant improvement in patients' neurological function and oxidative stress levels.

In the current study, the effects of transcranial direct current stimulation combined with neuromuscular joint therapy were evaluated from multiple perspectives, which was the study's advantage. However, the study had some limitations as well. The sample size was small, and research team performed the study in only one center, which might have affected the results. Further prospective studies with a large cohort from multiple centers are required.

CONCLUSIONS

Transcranial direct current stimulation combined with neuromuscular joint therapy demonstrated good rehabilitative effects on upper-limb movement disorders for stroke patients and significantly improved their upper-limb function and promoted recovery of nerve functions.

AUTHORS' DISCLOSURE STATEMENT

The research team Scientific Research Project of Shanxi Health and Family Planning Commission (Effect of rehabilitation therapy on electrophysiology and morphology of peripheral nerves in patients with Hemiplegia after stroke No. 2017161).

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