Proceedings of Anticancer Research, 2024, Volume 8, Issue 1
http://ojs.bbwpublisher.com/index.php/PAR
ISSN Online: 2208-3553
ISSN Print: 2208-3545

Analyzing the Combination Effects of Repetitive Transcranial Magnetic Stimulation and Motor Control Training on Balance Function and Gait in Patients with Stroke-Induced Hemiplegia

Xiaoqing Ma[1], Zhen Ma[2], Ye Xu[1], Meng Han[1], Hui Yan[1]*

[1]Rehabilitation Hospital of Huishan Wuxi, Wuxi 214181, Jiangsu Province, China
[2]Department of Rehabilitation Medicine, Gansu Province Central Hospital, Lanzhou 730070, China

***Corresponding author:** Hui Yan, skyan123123@163.com

Abstract: *Objective:* To analyze the effects of repetitive transcranial magnetic stimulation combined with motor control training on the treatment of stroke-induced hemiplegia, specifically focusing on the impact on patients' balance function and gait. *Methods:* Fifty-two cases of hemiplegic stroke patients were randomly divided into two groups, 26 in the control group and 26 in the observation group, using computer-generated random grouping. All participants underwent conventional treatment and rehabilitation training. In addition to these, the control group received repetitive transcranial magnetic pseudo-stimulation therapy + motor control training, while the observation group received repetitive transcranial magnetic stimulation therapy + motor control training. The balance function and gait parameters of both groups were compared before and after the interventions and assessed the satisfaction of the interventions in both groups. *Results:* Before the invention, there were no significant differences in balance function scores and each gait parameter between the two groups ($P > 0.05$). However, after the intervention, the observation group showed higher balance function scores compared to the control group ($P < 0.05$). The observation group also exhibited higher step speed and step frequency, longer step length, and a higher overall satisfaction level with the intervention compared to the control group ($P < 0.05$). *Conclusion:* The combination of repetitive transcranial magnetic stimulation and motor control training in the treatment of stroke-induced hemiplegia has demonstrated positive effects. It not only improves the patient's balance function and gait but also contributes to overall physical rehabilitation.

Keywords: Stroke-induced hemiplegia; Repetitive transcranial magnetic stimulation; Motor control training; Balance function; Gait

Online publication: January 26, 2024

1. Introduction

Stroke is a highly prevalent neurological disease among middle-aged and elderly individuals, often resulting in limb dysfunction such as hemiplegia. This condition diminishes the ability to perform daily self-care activities, impacting the overall quality of daily life. Rehabilitation therapy is essential to ensure maximum recovery to pre-disease functional levels [1]. Conventional rehabilitation therapy plays a crucial role in promoting brain plasticity, thereby enhancing limb motor function. Transcranial magnetic stimulation therapy technology is widely utilized in the rehabilitation treatment of neurological injuries. It can be categorized into three types based on the stimulation pulse. Repetitive transcranial magnetic stimulation involves continuously delivering multiple pulses to the brain at a fixed frequency, influencing the excitability of the cerebral cortex to achieve therapeutic effects [2]. Motor control training is a method wherein the central nervous system utilizes available information to convert neural energy into kinetic energy, facilitating the completion of effective functional activities and aiding patients in recovering motor function. This study aims to analyze the rehabilitation effects of the combined application of the aforementioned two intervention methods in hemiplegic stroke patients. A total of 52 patients have been selected for this investigation.

2. Materials and methods

2.1. General information

A total of 52 hemiplegic stroke patients admitted to Wuxi Huishan District Rehabilitation Hospital from May 2022 to May 2023 were selected as subjects for this study. They were divided into two groups using the computer random grouping method, resulting in 26 cases in each group.

The control group had 16 males and 10 females, with their ages ranging from 51 to 73 years and an average age of 62.57 ± 4.15 years. Their disease duration was 1–5 months, with an average duration of 3.11 ± 0.25 months. There were 14 cases of left-sided paralysis and 12 cases of right-sided paralysis in this group.

The observation group had 15 males and 11 females, with their ages ranging from 50 to 75 years and an average age of 62.40 ± 4.27 years. Their disease duration was 1–6 months, with an average duration of 3.32 ± 0.41 months. There were 15 cases of left-sided paralysis and 11 cases of right-side paralysis in this group. Statistical analysis of these data from both groups yielded $P > 0.05$.

Inclusion criteria included: (1) Patients diagnosed with stroke by head MRI or CT scans; (2) First onset of the disease with a duration of < 6 months; (3) Stable vital signs and normal cognitive function; (4) Brunnstrom's stage > stage I; (5) Complete clinical data; (6) Informed about the study and signed the informed consent form.

Exclusion criteria included: (1) Cognitive impairment preventing completion of relevant commands; (2) Presence of a pacemaker or cochlear implant; (3) History of epilepsy; (4) Other diseases impacting lower limb muscle strength; (5) Comorbid immune system disorders or hematological disorders; (6) Comorbid malignant tumors or psychiatric disorders.

2.2. Methods

Both groups underwent conventional treatment and rehabilitation training. The treatment plans for each group were as follows:

(1) Control group: Transcranial magnetic pseudo-stimulation therapy + motor control training. The parameters, stimulation sites, treatment frequency, and treatment time for transcranial magnetic pseudo-stimulation therapy were the same as those for the observation group, with the exception that the magnetic stimulation coil was rotated by 90° during treatment. The gait analysis instrument used was a whole-body three-dimensional gait and movement analysis system (DC-G-100; Jiangsu Dechang Medical Technology Co., Ltd). Motor control training methods included balance bar center of gravity transfer training, elastic band resistance semi-squatting side-steps around the knee joint, lumbar and dorsal twisting muscle group exercise training for the spine and pelvis, and gait adjustment training.

The rehabilitation therapist provided guidance and assistance during relevant training, adjusting the exercise intensity based on the patient's individual situation. The initial training aimed to improve muscle tone, while later training focused on enhancing limb function.

(2) Observation group: Repetitive transcranial magnetic stimulation therapy + motor control training. The method of motor control training was the same as that for the control group. The repetitive transcranial magnetic stimulation treatment instrument used was the YRD CCY type magnetic field stimulator, with a round coil having an 80 mm diameter and a maximum magnetic field strength of 2.2 T (Wuhan Iridium Medical Equipment New Technology Co.). Before treatment, resting motor threshold (RMI) was detected, and the magnetic stimulation coil was positioned with the surface of the skull in a lying position. The coil's center aligned with the representative area of the M1 hand function in the healthy motor cortex, and motor evoked potentials (MEP) were recorded in the position of the contralateral adductor magnus muscle. Recording electrodes were placed on the muscle belly, reference electrodes on tendons, and earth wires on the wrist. The resting motor threshold (RMT) was recorded when the MEP wave amplitude was ≥ 1 in five out of ten stimulations. The RMT was the minimum stimulation intensity that could record the MEP wave amplitude ≥ 50 μV in five out of ten stimulations, and it was re-determined after ten treatments. These stimulation points were located using the international EEG 10-20 system positioning standard ensuring the stimulation points remained the same. The parameters were set as follows: the stimulation intensity at 80% RMT, the stimulation frequency at 1 Hz, the stimulation interval between 6 s and 3 s, and a treatment time of 20 minutes per session. The treatment was administered once a day, five days per week, for four consecutive weeks.

2.3. Observation indexes

(1) Comparison of balance function: The Berg Balance Scale was utilized for assessment [3], comprising 14 items, each rated 0 to 4 points, resulting in a total score ranging from 0 to 56 points. Scores of 0 to 20 points indicated relatively poor balance function, requiring a wheelchair; 21 to 40 points suggested the presence of some balance function but necessitated walking assistance; and 41 to 56 points indicated better balance function, enabling independent walking. A score below 40 indicated a risk of falling.

(2) Comparison of gait parameters: Wuhan Iridium Medical Equipment New Technology Co., Ltd. Whole Body 3D Gait and Motion Analysis System (Model DC-G-100) was used to detect gait parameters, including step speed, step frequency, and step length.

(3) Comparison of intervention satisfaction: A department-designed scale was employed for the survey, with a total score of 100 points. Scores of 80 to 90 points indicated great satisfaction, 60 to 79 points indicated general satisfaction, and scores below 60 points indicated less satisfaction. Total satisfaction encompassed both the great satisfaction rate and the general satisfaction rate.

2.4. Statistical analysis

SPSS 25.0 was used for statistical analyses. Measurement data were expressed as mean ± standard deviation (SD), and an independent sample *t*-test was used. Count data were expressed as [*n* (%)], and the χ^2 test was implemented. A *P* value of < 0.05 indicated a statistically significant difference between the compared data.

3. Results

3.1. Balance function

Table 1 shows that there was no significant difference between the balance function scores of both groups before the intervention (P >0.05). After the intervention, the balance function scores of the observation group were higher than those of the control group (P < 0.05).

Table 1. Balance function score (mean ± SD, points)

Group	Pre-intervention	Post-intervention
Control group (n = 26)	26.35 ± 5.14	32.20 ± 3.15
Observation group (n = 26)	26.17 ± 5.28	40.45 ± 3.17
t	0.125	9.413
P	0.901	0.000

3.2. Gait parameters

Before the intervention, the differences between the gait parameters of both groups were insignificant (P > 0.05). However, after the intervention, the observation group had higher step speed and step frequency as well as longer step length compared to the control group (P < 0.05), as shown in **Table 2**.

Table 2. Gait parameters (mean ± SD)

Group	Pace of step (m/min)		Step frequency (step/min)		Step length (cm)	
	Pre-intervention	Post-intervention	Pre-intervention	Post-intervention	Pre-intervention	Post-intervention
Control group (n = 26)	46.56 ± 8.15	54.23 ± 7.26	70.54 ± 10.13	80.25 ± 12.31	33.27 ± 5.14	38.15 ± 5.29
Observation group (n = 26)	46.30 ± 7.24	59.30 ± 7.18	70.31 ± 10.25	88.14 ± 13.26	33.15 ± 5.29	42.17 ± 6.18
t	0.122	2.532	0.081	2.224	0.083	2.520
P	0.904	0.015	0.935	0.031	0.934	0.015

3.3. Intervention satisfaction

Table 3 shows that the observation group had higher overall satisfaction with the intervention as compared to the control group (P < 0.05).

Table 3. Intervention satisfaction [n (%)]

Group	Very satisfied	Satisfied	Less satisfied	Total satisfaction
Control group (n = 26)	10 (38.46)	9 (34.62)	7 (26.92)	19 (73.08)
Observation group (n = 26)	17 (65.38)	8 (30.77)	1 (3.85)	25 (96.15)
χ^2				4.372
P				0.037

4. Discussion

Stroke is characterized by the "five highs" [4], and while the mortality rate has decreased in recent years, the permanent damage to brain cells and the inability to replace the function of damaged cells with others lead to disability. Hemiplegia is a common limb motor dysfunction, often clinically manifested as balance and walking dysfunction, and in severe cases, reliance on a wheelchair or long-term bedridden status. Loss of self-care ability is a major factor hindering patients from returning to normal life and the community. Strengthening interventions is crucial for promoting the rehabilitation of patients [5].

Data statistics reveal that approximately 83% of stroke patients experience balance dysfunction, and around 70%–80% deal with walking dysfunction [6]. Related research suggests that balance and walking dysfunction increase the risk of falling, leading to bone fracture [7]. Falls can also exacerbate anxiety and fear, reduce physical activity levels, and even contribute to depression and social isolation.

Neurorehabilitation, rooted in central plasticity, involves the release of neurobiological active factors, synaptic function reconstruction, and activation of neural stem cells. Transcranial magnetic stimulation is a non-invasive, painless, convenient, and relatively safe treatment technology widely used in clinical rehabilitation. By inducing high-voltage and high-energy currents, it generates instantaneous discharges in stimulation coils, producing a high-field magnetic field that penetrates the skin without attenuation. This induces microcurrents in nerve tissues, depolarizes nerve cells, and excites peripheral nerve blocks, ultimately affecting the nervous system's excitability. By adjusting the frequency, intensity, and other parameters, this therapy enhances damaged nerve function's reorganization speed, effectively treating central nervous system injuries. Repetitive transcranial magnetic stimulation therapy induces a magnetic field through the coil, passes through the skull to alter the action potential induction current of cortical nerve cells, and subsequently influences brain metabolism and nerve electrophysiological activities through various physiological changes. This process alters the brain's plasticity, gradually enhancing limb function.

Motor control training, combined with modern testing and scientific training, is tailored to the patient's tolerance and other factors to develop a scientific training plan. This involves strengthening monitoring during the training process, making flexible adjustments to training intensity, and preventing secondary injuries [8]. The training program includes quadriceps control training, knee stability training, lumbar and dorsal muscle activation training, squatting muscle group exercises, lumbar and dorsal twisting muscle group exercises, gait adjustment, and other targeted exercises addressing various aspects of function.

The intervention program, combining repetitive transcranial magnetic stimulation with motor control training, seamlessly integrates physical therapy and exercise therapy. For each patient's specific conditions, an individualized rehabilitation training program is established. Utilizing motor control training in rehabilitation allows for real-time monitoring of the patient's training effects and enables flexible adjustments to exercise intensity and duration, ensuring the safety of the rehabilitation exercise [9]. Additionally, continuous attention is essential during the rehabilitation training to monitor the patient's psychological changes, aiming to enhance enthusiasm and initiative in training.

Post-stroke hemiplegic patients experience decreased balance function, and their gait is characterized by reduced step speed, step frequency, and shortened step length, indicating asymmetrical gait characteristics. The results of this study demonstrate that after receiving the combined intervention program, patients in the observation group exhibited higher balance function scores and better gait parameters than those in the control group. This suggests that the combined intervention program is more conducive to patients' recovery. The rationale behind this lies in the fact that good dynamic and static balance of the body is a prerequisite for walking. After a stroke, the central nervous system is damaged, leading to a reduction or complete loss of the central nervous system's role in regulating the limb motor system. This, in turn, results in primitive and coarse reflex activities [10], reduced proprioception, decreased postural regulation, and a swaying of the body's center of gravity, making patients more prone to falls. Repetitive transcranial magnetic stimulation regulates balanced bilateral cerebral cortical excitability, meaning the healthy side of the cerebral cortex has decreased excitability while the affected side has increased excitability [11]. This increased excitability on the affected side improves cerebral blood flow, brain-derived neurotrophic factor synthesis and secretion, and facilitates the proliferation of endogenous neural stem cells. Systematic quantitative exercise training can enhance limb loading force, regulate reflexes, and improve motor control [12,13]. This, in turn, encourages patients to engage in normal exercise. Core muscle group training enhances posture and balance control ability [14], mobilizing the patient's enthusiasm for training and promoting the recovery of limb function. When combined with motor control training, the gradual improvement of motor function becomes more ideal.

Comparing intervention satisfaction between the two groups, the observation group exhibited a satisfaction rate of 96.15%, while the control group showed 73.08% satisfaction. This indicates that the observation group is more content with the intervention program. In summary, stroke-induced hemiplegia is a relatively common functional disorder. Considering the plasticity of the nerve center, the combination of repetitive transcranial magnetic stimulation and motor control training proves beneficial in enhancing the balance function and improving gait. This approach is worth promoting.

Disclosure statement

The authors declare no conflict of interest.

References

[1] Li Z, Lv Y, Zhang Z, et al., 2023, Observation on the Efficacy of High-Frequency Repetitive Transcranial Magnetic Stimulation Combined with Electroacupuncture in the Treatment of Post-Stroke Hemiplegic Shoulder Pain. Chinese Journal of Physical Medicine and Rehabilitation, 45(4): 317–319.

[2] Hao C, Lin B, Ni B, et al., 2023, Study on the Rehabilitation Effect of Repetitive Transcranial Magnetic Stimulation Combined with Motor Control System in Treating Hemiplegic Patients with Stroke. Clinical Journal of Medical Officer, 51(8): 843–845.

[3] Wang H, 2023, Comparative Study on the Application Effect of Different Frequency Repetitive Transcranial Magnetic Stimulation Combined with Comprehensive Rehabilitation Therapy in Hemiplegic Stroke Patients. Reflexology and Rehabilitation Medicine, 4(12): 56–59.

[4] Shan S, Huang X, Zhang M, et al., 2022, Three-Dimensional Gait Analysis of Gait Changes in Hemiplegia After Stroke Treated with Low-Frequency Repetitive Transcranial Magnetic Stimulation. Journal of Clinical Rehabilitative Tissue Engineering Research, 26(5): 762–767.

[5] Zhu Y, Shao M, Sun M, et al., 2023, Analysis of the Efficacy of Repetitive Transcranial Magnetic Stimulation Combined with Rhythmic Motor Training on the Function of Lower Limbs of Hemiplegic Lower Limb Spasticity Patients with Stroke. Modern Practical Medicine, 35(8): 1028–1031.

[6] Liang T, Long Y, Lu L, et al., 2023, Effect of Proprioceptive Neuromuscular Facilitated Cord Training Combined with Repetitive Transcranial Magnetic Stimulation on Upper Limb Motor Function in Stroke Patients with Hemiplegia. Chinese Journal of Rehabilitation Theory and Practice, 29(3): 262–268.

[7] Liu J, Li Y, Ge P, et al., 2023, Effects of Repetitive Transcranial Magnetic Stimulation Combined with Head-Eye Movement on Lower Limb Movement and Balance Function in Post-Stroke Hemiplegic Patients. Chinese Journal of Physical Medicine and Rehabilitation, 45(10): 884–887.

[8] Zhao Q, Fei S, Fang F, et al., 2022, Effect of High-Frequency Repetitive Transcranial Magnetic Stimulation Combined with Task-Oriented Training on the Rehabilitation of Upper Limb Motor Function in Patients with

Hemiplegia After Stroke. Practical Journal of Cardiac Cerebral Pneumal and Vascular Disease, 30(1): 113–116 + 123.
[9] Chen Q, Huang H, Chen Z, et al., 2021, Effects of Low-Frequency Repetitive Transcranial Magnetic Stimulation Combined with MOTOmed Intelligent Motor Training System on Upper Limb Spasticity in Hemiplegic Patients with Stroke. Chinese Journal of Rehabilitation Medicine, 36(4): 437–442.
[10] Liu L, Wei D, Su Q, et al., 2023, Effects of Low-Frequency Repetitive Transcranial Magnetic Stimulation Combined with Bobath Therapy on Neurological Function, Motor Function and Balance in Hemiplegic Patients with Stroke. Progress in Modern Biomedicine, 23(6): 1116–1120.
[11] Wang J, Zhu Y, 2020, Effects of Repetitive Transcranial Magnetic Stimulation on Balance Function in Elderly Hemiplegic Patients with Cerebral Infarction. Journal of Lanzhou University (Medical Edition), 46(4): 45–50.
[12] Huang Z, Zhao J, 2023, Effects of Repetitive Transcranial Magnetic Stimulation Combined with Graded Motor Imagery Training on Motor Function and Neurological Function in Hemiplegic Patients After Cerebral Infarction. Chinese Journal of Neurotraumatic Surgery, 9(2): 102–107.
[13] Tao F, Wang C, Chen B, et al., 2022, Effects of Low-Frequency Repetitive Transcranial Magnetic Stimulation Combined with Mirror Therapy on Lower Limb Motor Function and Balance in Hemiplegic Patients with Stroke. Chinese Journal of Rehabilitation Medicine, 37(5): 611–615 +622.
[14] Ma Z, Chen W, Zhang X, et al., 2022, Effects of Repetitive Transcranial Magnetic Stimulation on Balance Function in Stroke Patients. Chinese Journal of Physical Medicine and Rehabilitation, 44(8): 703–706.