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The Effects of a Low-Frequency rTMS Post-Hand Therapy Program on Upper Limb Function and Antispasticity in Patients with Post-Stroke Hemiplegia

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Purpose: To investigate the effects of a hand therapy program after repetitive transcranial magnetic stimulation (rTMS) on upper limb function and spasticity in stroke cases. Methods: This study divided patients (> 6 months) into two groups. (experimental group: hand therapy program group after rTMS, control group: general hand therapy group, [n=15 per group]). The program was conducted thrice a week for one week, and upper limb function (Manual Function Test, [MFT]) and muscle tone (Myotone muscle tester) were evaluated before and after the experiment. Results: Both groups showed significant improvements in upper limb function and decreased muscle tone. In a between-group test after the intervention, the experimental group showed statistically significant improvements in upper limb function and decreased muscle tone compared with the control group. Conclusion: rTMS and hand therapy programs are potential therapeutic approaches for brain injury cases and impaired motor function, improving neurophysiological and kinesthetic functions. In the future, we plan to conduct a follow-up study using a hand therapy program and rTMS for stroke patients to prove its effectiveness.

Keywords : 1 Hz repetitive transcranial magnetic stimulation, cerebral magnetic field, upper extremity function, muscle tone, stroke

1. Introduction

Stroke is a condition in which the blood supply to the brain tissue through the bloodstream is continuously insufficient because of an abnormality in the cerebrovascular system, resulting in local brain tissue abnormalities and neurological dysfunction [1]. Common symptoms of stroke include unilateral motor and perceptual impairments, aphasia, and spasticity [2]. Particularly, many patients with stroke experience movement disorders of the upper limbs and hands on the contralateral side of the damaged cerebral hemisphere due to damage to the corticospinal tract [3]. The corticospinal tract primarily controls the distal muscles in the body, controlling distal movements such as finger and toe movements. Damage to the corticospinal tract affects the dexterity of distal body parts [4]. Spasticity is a major disability associated with upper motor neuron damage [5]. Spasticity is an abnormal muscle tone clinically recognized as resistance to passive muscle stretching that increases with stretching velocity [6]. The reported prevalence of spasticity in the chronic phase of stroke, >6 months after onset, is approximately 20% [7, 8]. Spasticity can result in motor weakness and clumsiness in the affected limb, causing pain and other complications. Consequently, the development of spasticity after stroke is associated with a detrimental influence on quality of life [8] and may further impair motor function, cause pain, and lead to secondary complications [9].

Spasticity in patients with stroke is treated with oral anti-spastic medications, selective peripheral nerve block with phenol, intramuscular injection of botulinum toxin, and intrathecal administration of baclofen [10, 11].

Recent studies have reported that repetitive transcranial magnetic stimulation (rTMS) has a positive effect on the upper limb function and alleviates spasticity in patients with stroke. rTMS utilizes the principle of placing an

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electromagnetic coil on the outer skin of the head to generate a magnetic field for a short time, which is then converted into an electric field within the tissue. When the electric field wave reaches an appropriate intensity and duration, it causes depolarization of neurons located in the cerebral cortex [12, 13]. Treatments combining rTMS with other rehabilitation therapies have also been introduced. Shim and Lee (2023) reported that when high-frequency rTMS (10 min) was applied to the affected side three times a week for 4 weeks, along with motor learning (10 min) related to upper limb and hand movements in patients with subacute stroke, finger grip strength significantly improved compared to the control group [14]. Valle *et al.* (2007) found that activation of the cerebral motor cortex through TMS increases the inhibitory effect on spinal excitability through the corticospinal tract and thus reduces the hyperactivity of gamma and alpha neurons, resulting in stiffness [15]. A study by Pawan *et al.* (2023) also reported that a decrease in post-stroke spasticity was observed after rTMS treatment [16]. Of the patient groups provided, 5 Hz, 1 Hz, and sham stimulation for 5 days, the 5-Hz application group reported a significant decrease in spasticity [15].

Furthermore, according to a study by Thut and Pascual-Leone (2010), when the average stimulation intensity of low-frequency rTMS was 101% MT (80-110% motor threshold), the average stimulation duration was 31 min [17]. There have not been many studies on applying hand therapy programs concurrently during the residual effect period after low-frequency rTMS treatment. Therefore, based on the results of these previous studies, this study aimed to investigate the effects of a hand therapy program on the function and anti-spasticity of the upper limb of patients with stroke on the function of the injured side and anti-spasticity within the residual effect duration after low-frequency (1 Hz) rTMS of the motor cortex of the non-injured side of patients with stroke within the residual effect duration.

2. Theoretical Background

2.1. Principles and Effects of TMS (Low-frequency-rTMS [LF-rTMS])

TMS utilizes the principle of placing an electromagnetic coil on the outer skin of the head to generate a magnetic field for a short time, which is then transformed into an electric field within the tissue. When the electric field reaches an appropriate intensity and duration, it depolarizes neurons in the cerebral cortex [18]. TMS magnetic stimulation is not attenuated by high-resistance objects, such as the skull or scalp, and does not generate high current densities on the scalp, resulting in minimal pain and allowing for safe and effective noninvasive brain modulation [19].

Repeated TMS, also known as rTMS, produces effects that last beyond the initial stimulation period. Depending on the intensity, coil orientation, and frequency of stimulation, rTMS can increase or decrease corticospinal tract excitability. Although the mechanism of these effects is unclear, they are thought to induce changes in synaptic efficacy similar to long-term potentiation (LTP) and long-term depression (LTD). High-frequency rTMS ($\geq$ 5 Hz) can increase the excitability of neurons in primary motor cortex (M1), while stimulation frequencies below 5 Hz (low-frequency rTMS) can suppress excitability [20].

The theoretical basis of TMS is transcallosal inhibition (TCI), which posits that under normal conditions, each cerebral hemisphere controls the other. This control is called TCI, because it inhibits the other through the corpus callosum. Neurons that control TCI are located in the primary motor area and project to the contralateral side via the corpus callosum, locally stimulating the inhibitory neurons in the primary motor area of the contralateral cerebral hemisphere [21]. After a stroke, increased activity in the primary motor area of the uninjured cerebral hemisphere and disruption of the corpus callosum inhibitory balance lead to strong inter-hemispheric inhibition of the lesioned hemisphere from the uninjured hemisphere, contributing to motor impairment [22]. Therefore, when rTMS is applied to restore motor function after a stroke, low-frequency (1 Hz) stimulation of the motor cortex of the uninjured hemisphere reduces excitability, whereas high-frequency (5 Hz or higher) stimulation of the motor cortex of the lesioned hemisphere increases excitability [23].

The mechanism of LF-rTMS has been reported to be that stimulation of the uninjured cerebral cortex suppresses activation of the uninjured cerebral cortex, thereby enhancing brain activity on the lesioned side. This, in turn, can positively affect the recovery of upper limb function and motor learning [24]. A study on the duration of the effect of TMS reported that when LF-rTMS was performed at an average stimulus intensity of 101% MT (80–110% motor threshold), the average duration of the effect of stimulation was 31 min [17].

3. Research Method

3.1. Research Participant

This study, conducted from March to May 2025, targeted adult patients with stroke receiving rehabilitation treatment at the Department of Rehabilitation Medicine of

Hospital B in Gyeonggi Province. Thirty-four participants were selected, of whom four were excluded because they did not meet the selection criteria, leaving 30 participants. The selected participants were randomly assigned through a lottery and divided into two groups of 15 participants each. The study selection criteria were as follows:

The patients were diagnosed with hemiplegia due to stroke (cerebral infarction or cerebral hemorrhage) by a rehabilitation medicine specialist or neurologist.

2) Patients whose stroke occurred >6 months ago.

3) Patients with a Korean Mini-Mental State Examination (K-MMSE) score of ≥24 who were able to express their thoughts accurately.

4) Those who voluntarily participated after receiving an explanation of the study and obtaining consent.

The exclusion criteria for this study were as follows, in accordance with the recommendations of Wassermann *et al*. (1998), to prevent adverse effects of rTMS [25].

First, those with a pacemaker or implanted intracardiac wires or metal.

Second, those with metal objects within the head.

Third, those with a clinically unstable medical disorder, such as seizures.

Fourth, those with damage to the internal carotid artery.

Furthermore, those with aphasia or cognitive impairment that would impede assessment, hemineglect or visual field defects, or psychiatric or orthopedic conditions were excluded.

3.2. Intervention program

After assessing the general information of the 30 patients who met the inclusion criteria, 15 patients were assigned to each group by lottery. The selected participants were divided into an experimental group (Hand therapy after rTMS group, hereafter HT-rTMS group) and a control group (General Hand therapy group, hereafter GHT group).

The HT-rTMS group received 20 minutes of 1 Hz rTMS and a 20-minute hand therapy program for 40 minutes. The control group (GHT group) underwent only the hand therapy program for 40 minutes (Table 1).

Each group received the same intervention three times per week for 30 minutes per session. The study period lasted for eight weeks, from March to May 2025. To assess pre-intervention spasticity, muscle tone testers (MyotonPRO, MyotonAS, Tallinn, Estonia) were used, and a Manual Function Test (MFT) was used to assess upper limb function. The intervention was administered for eight weeks. A post-intervention evaluation was conducted, and the final week was devoted to data collection and statistical analysis.

To ensure the accurate application of rTMS, the intervention was conducted by a therapist currently providing rTMS treatment at a hospital with at least five years of clinical experience.

This study was conducted as a preliminary study from January to February 2025. After revising and supplementing the results, two patients hospitalized at Hospital B in Gyeonggi Province were selected for a two-week pilot study, starting in January 2025. After revising and supplementing the results during the study, the intervention was conducted from March to May 2025, and the statistical data and results were compiled from June to July 2025.

3.2.1. LF-rTMS(experimental group)

This study used an ALTMS (Remed, Korea, 2018) equipped with a 70-mm figure-of-eight coil to apply LF-rTMS (Fig. 1). The participant was positioned relaxed on the machine's chair with their head fixed on a headrest, both upper arms and elbows extended, wrists in a neutral position, forearms supinated, and fingers extended (Fig. 2). To assess MEP thresholds, the participant wore a hood with preprinted coordinates. The coordinates were drawn from the nasion to the inion and marked at the intersection of the midsagittal and interaural lines. A grid pattern was created by intersecting lines at 1-cm intervals around this line. The coil stimulator was positioned tangentially to the head over the noninjured hemisphere, with the handle facing posteriorly and at a 45-degree angle from the midline. The purpose of stimulating the cerebral cortex on the uninjured side was to activate the cerebral cortex on the injured side by suppressing it

Table 1. Treatment program for each group.

HT-rTMS group(40min)		GHT group (40min)
1. 1Hz rTMS(20 min)	1 Hz, 1200pulse, 120% MT	Hand therapy program
2. Hand therapy program (20min)	1. Elbow, wrist, and finger flexor muscles stretching exercise 2. Specific activation of lumbricals 3. Specific activation of abductor digiti minimi 4. Press a computer keyboard 5. Grip the cup	1. Elbow, wrist, and finger flexor muscles stretching exercise 2. Specific activation of lumbricals 3. Specific activation of abductor digiti minimi 4. Grip the small ball 5. Grip the cup

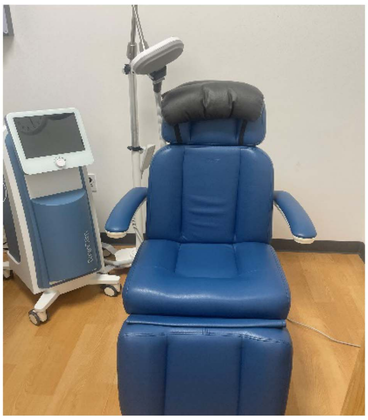

Fig. 1. (Color online) rTMS device (ALTMS, Remed, Korea). 70 mm figure-8 coil and main body and chair for applying LF-rTMS.

Fig. 2. (Color online) rTMS sitting position. A participant is seated comfortably with the head stabilized on a headrest during 1 Hz rTMS using the ALTMS® system.

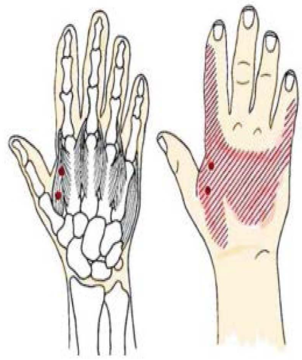

Fig. 3. (Color online) Attached surface electrodes: first dorsal interosseous. (When measuring the MEP in the hand, the first dorsal interosseous (FDI) was measured as the target muscle).

during LF-rTMS stimulation of the uninjured side.

The first dorsal interosseous (FDI) muscle was targeted for MEPs (Fig. 3).

To identify the location of the FDI in the primary motor area (M1), stimulation was performed by slightly shifting the muscle position on the patient's scalp. Before the study, a silver electrode (silver chloride electrode) was attached to the FDI muscle to measure MEPs. A ground electrode was attached to the arm for electromyography (EMG). EMG data were recorded using the mobile KEY POINT®.NET software. The signal was amplified to 100 mV/div and filtered at 2 Hz–10 kHz.

The point at which the largest MEP appeared in the recorded potential of the FDI was determined as the motor cortex area of the corresponding muscle. The resting motor threshold is defined as the minimum stimulus intensity at which an MEP of ≥50 μV is recorded in at least 5 out of 10 stimulations. To suppress the motor cortex on the noninjured side, 1200 pulses with an intensity of 120% of the motor threshold were applied to the noninjured cerebral hemisphere for 20 min at a frequency of 1 Hz [26]. The participant underwent 18 sessions in total, 24 times for 20 min per session, 3 times a week for 8 weeks. To ensure the accurate application of rTMS, the intervention was performed by a therapist with >5 years of clinical experience and currently in charge of rTMS treatment at the hospital.

3.2.2. Hand therapy program (experimental group)

In this study, the hand therapy program was modified and supplemented to suit the participant, referring to the finger intrinsic muscle therapy program proposed by Sue Raine *et al.* (2013) [27]. The hand therapy program lasted for 20 minutes and consisted of the following: 1) Elbow, Wrist, Finger flexor muscles stretching exercise (Fig. 4), 2) Specific activation of lumbricals (Fig. 5), 3) Specific

Fig. 4. (Color online) Elbow, Wrist, Finger flexor muscles stretching exercise. The experimental and control groups underwent a stretching exercise program to relax the flexor muscles, with the sequence being elbow extension, wrist extension, and finger extension.

Fig. 5. (Color online) Specific activation of lumbricals. Lumbricals strengthening exercises for functional grip in the hand therapy program of the experimental and control groups.

Fig. 6. Specific activation of abductor digiti minimi. Strengthening exercises for the abductor muscles of the little finger during the hand therapy program for the experimental and control groups.

Fig. 7. Press a computer keyboard. Individual finger exercises in the experimental group's hand therapy program.

Fig. 8. Grip the cup. Functional hand tasks performed using tasks in the experimental group's hand therapy program.

Fig. 9. Grip the small ball. Hand functional task performance using tasks in the hand therapy program of the control group.

activation of abductor digiti minimi (Fig. 6), 4) Press a computer keyboard (Fig. 7), and 5) Grip the cup (Fig. 8), and was performed for 10 minutes.

3.2.3. GHT group (control group)

The patients in the GHT group underwent hand therapy without rTMS. The hand therapy program consisted of: 1) elbow, wrist, and finger flexor muscle stretching exercise (Fig. 4), 2) specific activation of lumbricals (Fig. 5), 3) specific activation of abductor digiti minimi (Fig. 6), 4) grip the cup (Fig. 8), and 5) grip the small ball (Fig. 9), and was performed for 40 minutes.

3.3. Assessment

3.3.1. Muscle tone assessment

After the intervention was applied to the experimental and control groups, the MyotonePRO muscle tone assessment tool (MyotoneAS, Estonia) was used to evaluate the muscle tone of the upper limbs. The small cylindrical probe (polycarbonate probe, 3 mm) of the MyotonPRO system contacts the skin surface with 0.18 N and stimulates the skin surface with a force of 0.40 N for 15 ms. Based on the muscle vibration and acceleration generated at this time, three biomechanical indices representing the characteristics of the muscle, namely stiffness, muscle tone (frequency), and elasticity (decrement), were measured (Fig. 10). During measurement, the probe was always positioned perpendicular to the center of the muscle belly of the measurement site, and all measurements were performed in multi-scan mode, with the number of tap repetitions set to three, mechanical impulse transmission time (tap time) set to 15 ms, and transmission interval set to 0.8 s. The unit of measurement for muscle tone was Hz, with a higher value indicating higher muscle tone [28]. Therefore, this study selected the long head of the biceps brachii from among the upper limb flexor muscles of patients with stroke. The measurement method for the muscle tone test was used according to Louise *et al.* (2013), and the test method was as follows [29].

First, the participant was placed in a supine position with the forearm aligned in a neutral position and supported with a pillow or the like to support the posture. Second, a rolled towel was placed under the wrist to ensure that the elbow was flexed by approximately 10 ° to 15 °to check for excessive biceps brachii muscle

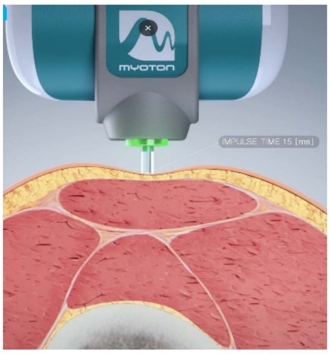

Fig. 10. MyotonPRO (muscle tone tester). MyotonePRO's muscle tension measurement scene.

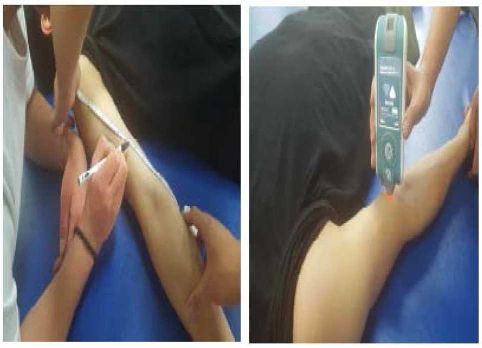

Fig. 11. Location of testing site for biceps brachii. (Measurement was taken by maintaining a right angle to themuscle using a tape measure and tape, and a non-toxic marker to mark the skin).

Fig. 12. Manual Function Test(MFT). Upper limb function assessment tool.

tension. Blocking the kidney. The measurement location of the top needle of the muscle tension device was the midpoint between the outer point of the acromion of the scapula and the inner surface of the elbow socket to identify the location of the muscle belly of the long branch of the biceps brachii. This was measured using a tape measure and a nontoxic marker on the skin. Third, the device was placed upright and measured perpendicular to the muscle (Fig. 11).

3.3.2. MFT

The MFT was developed to assess upper extremity motor dysfunction in patients with stroke and statistically analyze the potential recovery process during rehabilitation [30]. It measures hand and arm movements and consists of 32 items in three domains: upper extremity, grip, and finger movements (Fig. 12). Each item was scored 1 point if performed and 0 points if not, resulting in a maximum score of 32 points. The test-retest reliability and inter-examiner reliability of the MFT are r=0.95, and Cronbach's α is 0.95 [31].

3.4. Statistical processing

The collected data were statistically analyzed using SPSS (version 28.0) for Windows. The following statistical analysis methods were used.

First, descriptive statistics and frequency analyses were conducted to determine the general characteristics of the study participants.

Second, the data collected in this study were tested for normality using the Shapiro-Wilk test, and all variables were found to be normally distributed.

Third, a paired-samples t-test was conducted to examine within-group differences before and after the intervention, and an independent-samples t-test was conducted to examine between-group differences before and after the intervention.

4. Results

4.1. General characteristics of study participants

The general characteristics of the participants are presented in Table 1. As shown in Table 2, there was no significant difference between the muscle tone and MFT in terms of the homogeneity of the participants in this study (Table 3). Therefore, the homogeneity of the participants was ensured before data collection began.

4.2. Comparison of pre- and post-intervention effects within the HT-rTMS group

In the HT-rTMS group, muscle tone significantly decreased from 22.32 Hz before the intervention to 18.45

Table 2. General characteristics of participants.

Variables		HT-rTMS group (N=15)	GHT group (N=15)
Gender	Male	9	8
	Female	6	7
Age		44.76±2.34	46.03±5.46
Lesion type	Hemorrhage	7	6
	Infarction	8	9
Hemiplegic side	Right	8	7
	Left	7	8
Time from stroke to rehab (months)		24.67±3.97	23.45±5.32

M±SD
M: mean
SD: standard deviation
HT-rTMS group: Hand Therapy after 1Hz rTMS group
GHT group: General Hand Therapy group

Table 3. Homogeneity test of variables.

	HT-rTMS	GHT	*t*	*p*
	M±SD	M±SD		
Muscle tone (Hz)	22.32±2.24	21.45±3.56	0.953	.754
MFT (score)	14.63±4.42	15.56±5.73	1.620	.134

M±SD
M: mean
SD: standard deviation
MFT : Manual Function Test(Upper extremity function test)
HT-rTMS group: Hand Therapy after 1Hz rTMS group
GHT group: General Hand Therapy group

Table 4. Comparison of results before and after with the HT-rTMS group.

	Pre-test	Post-test	*p*
	M±SD	M±SD	
Muscle tone (Hz)	22.32±2.24	18.45±6.31	.000***
MFT (score)	14.63±4.42	16.87±5.08	.000***

***p<.001
M±SD
M: mean
SD: standard deviation
MFT : Manual Function Test(Upper extremity function test)
HT-rTMS group: Hand Therapy after 1Hz rTMS group
GHT group: General Hand Therapy group

Hz after the intervention (p<.001). In the upper limb function evaluation, muscle tone significantly increased from 14.63 points before the intervention to 16.87 points after the intervention (p<.001) (Table 4).

4.3. Pre- and Post-Intervention Comparison within the GHT Group

The GHT group showed a significant decrease in muscle tone (p<.01) from 21.45 Hz pre-intervention to 20.02 Hz post-intervention. The upper extremity function assessment showed a significant increase (p<.05) from 14.63 points pre-intervention to 16.87 points post-intervention (Table 5).

4.4. Pre- and Post-Intervention Comparison Between the Two Groups

A comparison of pre- and post-intervention changes between the two groups revealed that muscle tone decreased by 3.87 Hz in the HT-rTMS group and by 1.43 Hz in the GHT group. Therefore, the HT-rTMS group showed a statistically significant decrease (p<.05) in muscle tone after the intervention compared with the GHT group.

In the upper extremity function assessment, the HT-rTMS group showed a 2.24-point increase after the intervention, whereas the GHT group showed a 1.06-point increase. Therefore, the HT-rTMS group showed a statistically significant increase (p<.05) in upper extremity function after the intervention compared with the GHT group (Table 6).

Table 5. Comparison of results before and after with the GHT group.

	Pre-test	Post-test	*p*
	M±SD	M±SD	
Muscle tone (Hz)	21.45±3.56	20.02±4.62	.004**
MFT (score)	15.56±5.73	16.62±7.38	.024*

*p<.05, **p<.01
M±SD
M: mean
SD: standard deviation
MFT : Manual Function Test(Upper extremity function test)
HT-rTMS group: Hand Therapy after 1Hz rTMS group
GHT group: General Hand Therapy group

Table 6. Comparison of results between the two groups.

	HT-rTMS group (N=15)	GHT group (N=15)	*p*
	M±SD	M±SD	
Muscle tone (Hz)	-3.87±0.38	-1.43±3.75	.040*
MFT (score)	2.24±2.34	1.06±0.61	.019*

*p<.05
M±SD
M: mean
SD: standard deviation
MFT : Manual Function Test(Upper extremity function test)
HT-rTMS group: Hand Therapy after 1Hz rTMS group
GHT group: General Hand Therapy group

5. Discussion

This study's results showed that LF-rTMS followed by a hand therapy program significantly reduced muscle tone in the hemiplegic upper limbs of patients with stroke, and that upper limb function also significantly increased. Specifically, the experimental group that received LF-rTMS followed by the hand therapy program showed a statistically significant difference compared with the control group that received only hand therapy. The significance of these results is that, according to the TCI theory of rTMS, under normal conditions, the right and left cerebral hemispheres control and compete with the opposite hemisphere. This inhibition occurs through the corpus callosum, a white matter fiber of the cerebrum, and is called TCI. However, damage to one cerebral hemisphere, such as in a stroke, disrupts this balance, leading to a strong inhibition of the uninjured hemisphere, which in turn affects the motor function of the injured hemisphere. In the case of TMS, LF-rTMS has a motor inhibitory effect; therefore, this study applied LF-rTMS to the motor area of the non-damaged cerebral hemisphere, and it is thought that this was able to reduce the inhibition of the damaged cerebral hemisphere by the non-damaged cerebral hemisphere. Because the inhibition of the non-damaged cerebral hemisphere by the damaged cerebral hemisphere was reduced, the motor area of the damaged cerebral hemisphere was activated. Then, a hand therapy program was applied to actively induce movements of the damaged upper limb. Therefore, these active movements are thought to alleviate the tone of the stiff muscles of the damaged upper limb due to hemiplegia, resulting in increased upper limb function and decreased muscle tone. In a previous study similar to the present study, Kakuda *et al.* (2011) reported that 15 days of rTMS followed by task training in patients with stroke with upper limb spasticity on the Brunnstrom scale of grades 3 to 5 resulted in statistically significant reductions in muscle tone and improvements in upper limb motor function and that the therapeutic effects were maintained 4 weeks after the end of treatment [32]. Furthermore, Mally and Dinya (2008) reported that repeated consecutive applications of 1 Hz rTMS to the non-lesional hemisphere for 1 week significantly reduced the spasticity of the affected limbs in patients with poststroke [33]. Because inhibitory (1 Hz) LF-rTMS applied to the non-lesioned hemisphere can increase neural activity in the lesioned hemisphere, it can be speculated that neural activation in the lesioned hemisphere can reduce spasticity in the affected upper limb. Subsequently, it was reported that increased neural activity in the motor cortex of the lesioned cerebral hemisphere increased the descending inhibitory input through the corticospinal tract, which decreased the excitability of gamma and alpha neurons [34, 35]. Park *et al.* (2023) also reported that shoulder-upper arm exercise after low-frequency rTMS improved upper limb function [36]. Based on these reports, it is believed that the anti-spastic effect observed in this study was mainly produced by LF-rTMS applied to the non-lesioned hemispheres. LF-rTMS applied to the non-lesioned cerebral hemisphere has two beneficial effects in patients with post-stroke hemiplegia. The first is a facilitating effect on functional reorganization of the lesioned cerebral hemisphere and an anti-spastic effect on the lesioned upper limb.

However, this study had several limitations. First, although the participating patients had varying degrees of upper limb spasticity at baseline, this study targeted patients with Modified Ashworth Scale (MAS) grades of 1+ to 2. Future research is recommended to confirm the anti-spasticity effects of this intervention in patients with varying degrees of spasticity. Second, to our knowledge, no neurophysiological studies have investigated the excitability of motor neurons. Further studies examining electromyographic activity are needed to establish the effects of LF-rTMS and hand therapy on motor neuron excitability in the affected hemispheres.

6. Conclusions

These results suggest that a hand therapy program following rTMS is a useful treatment approach for reducing tension in the injured upper limb, resulting in anti-spasticity effects and improved upper limb function.

Currently, various therapeutic approaches are used to improve spasticity and motor function in patients with various brain injuries, including stroke. Treatments such as rTMS, which promote brain plasticity in the damaged cerebral hemisphere when combined with exercise therapy and tasks, are gaining attention. Since rTMS and hand therapy programs can improve neurophysiological and kinesthetic functions, they are considered potential treatment approaches for patients with brain injury who have impaired motor function.

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