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The Effects of Simultaneous Application of Peripheral Nerve Sensory Stimulation and Task-Oriented Training to Improve Upper Extremity Motor Function After Stroke: Single Blinded Randomized Controlled Trial

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Abstract

Objective : This study aimed to investigate the effect of simultaneous application of peripheral nerve sensory stimulation and task-oriented training on the improvement of upper extremity motor function after stroke.

Methods : This study included 29 patients with hemiplegia. The 14 subjects were in the peripheral nerve sensory stimulation and task-oriented training group for 4 weeks (30 min/d, 5 d/wk), while the 15 control group subjects underwent only task-oriented training for the same duration. The outcome measures were the percentage of voluntary baseline muscle contractions of the wrist and shoulder and Box and Block Test, grip and pinch strength, and Action Research Arm Test.

Results : After 4 weeks, muscle activity of extensor carpi radialis, flexor carpi radialis and grip strength and Action Research Arm Test were significantly higher in the experimental group.

Conclusion : Simultaneous application of the peripheral nerve sensory stimulation and task-oriented training was found to be superior to task-oriented training for improving upper extremity motor function of adults with stroke.

Key Words : Peripheral nerve sensory stimulation, Stroke, Task-oriented training, Upper extremity

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I. Introduction

Stroke is a neurological disorder that affects the arteries leading to and within the brain. It occurs when a blood supply to part of the brain is ruptured or reduced. Sudden consciousness loss and paralysis occur when brain cells die during a stroke (Chang, Tung, Wu, & Su, 2006). Most stroke patients experience upper extremity dyskinesia due to abnormalities in muscle tone or motor paresis. This is a main problem that affects performance of everyday activities (Raghavan, 2007).

There have been various studies to induce efficient movement, including using more of the upper extremity on the contralesional hemisphere for recovery of upper limb movement disorder in stroke patients. Previous studies have reported that recovery of the central nervous system in stroke patients is facilitated by neuroplasticity, and that it changes the functional connectivity of brain to promote functional recovery (Gerloff et al., 2006). Based on this understanding of neuroplasticity, various electrical stimulation treatments such as electromyogram-triggered neuromuscular stimulation (EMG-stim), functional electronic stimulation (FES), and peripheral nerve sensory stimulation (PNS) have been applied to promote the recovery of the upper extremity motor function in stroke patients (Bolton, Cauraugh, & Hausenblas, 2004; Celnik, Hummel, Harris-Love, Wolk, & Cohen, 2007; Mangold, Schuster, Keller, Zimmermann- Schlatter, & Ettlin, 2009).

PNS is a treatment that induces the reorganization of the sensory motor cortex by providing low-frequency stimulation at a constant interval (at which muscle contraction does not occur) in the peripheral nerve territories (Deuchert et al., 2002). Previous studies have reported that this repetitive low-frequency electrical stimulation is effective in activating cortical motor activity as well as in improving hand function and sensory function in stroke patients. The advantage of PNS is that there is no fatigue, pain, or discomfort in the muscles (Celnik et al., 2007; Conforto et al., 2010; Ikuno et al., 2012; Sullivan & Hedman, 2004). It is also low cost and easy to apply in clinical practice. It is useful as a supplementary treatment to promote upper extremity motor function recovery because it does not require the patient's voluntary participation or concentration during stimulation, unlike other electro-stimulation treatments (Klaiput & Kitisomprayoonkul, 2009). Recent studies of upper extremity function in stroke have been conducted with interventions such as task-based training using PNS, which requires less exercise and cognition than EMG-stim and FES, and its effectiveness has been reported (Ikuno et al., 2012).

Task-oriented training (TOT) has been widely used in clinical practice. It is based on neuroplasticity through brain activation, which combines motor control and motor learning for functional recovery and motor improvement in patients with neurological impairment (Thieme et al., 2012).

When TOT and PNS are combined, there is a synergy that enhances activation of the corticospinal tract, as the peripheral afferent input from the sensory nerve-branching skin is stimulated (Lin et al., 2012; Saito et al., 2013). Ikuno et al. (2012) investigated this approach in 22 stroke patients by combining peripheral sensory stimulation of the median and ulnar nerves with task-oriented training for one week. As a result, there was a significant improvement of hand function in the group in which the peripheral sensory nerve stimulation was performed compared to that in the group with only task performance training. Fleming et al. (2015) reported a positive effect on upper extremity function in an experimental group that underwent TOT and PNS to the median, ulnar, and radial nerves compared to the effects in a control group that only performed the task-oriented training.

However, studies considering the clinical usefulness of combined PNS and task-oriented training are limited. Most studies have validated the effectiveness of the PNS-only intervention, and studies that combine PNS and TOT have limitations in clinical application with intervention times that are too long because the interventions were applied sequentially (Conforto, Cohen, dos Santos, Scaff, & Marie, 2007; Fleming et al., 2015; Ikuno et al., 2012; Koesler, Dafotakis, Ameli, Fink, & Nowak, 2009; Wu, Seo, & Cohen, 2006). In addition, there were limitations to generalization due to the lack of RCT studies or short intervention periods. In conclusion, studies on peripheral sensory nerve stimulation in korean stroke patients are insufficient, and studies that simultaneously conducted two interventions to reduce the intervention time are also insufficient.

This study aimed to investigate the effect of simultaneous application of PNS and TOT on the improvement of upper extremity motor function after stroke.

II. Methods

1. Participants

29 patients who met the criteria for the study were selected from 41 patients who were admitted to Y hospital

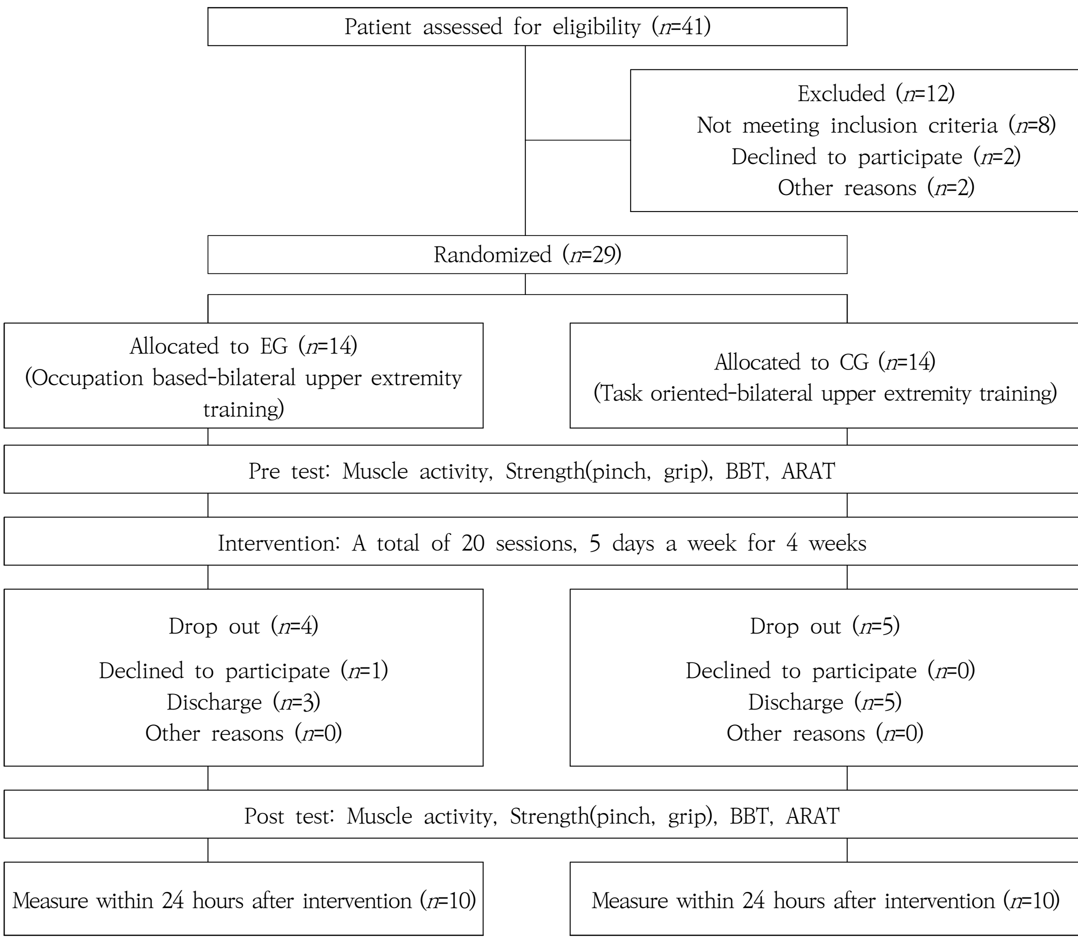

Figure 1. Flow Diagram of Subjects in the Study

ARAT=Action Research Arm Test; BBT=Box and Block Test; CG=Control group; EG=Experimental group; PNS=Peripheral nerve sensory stimulation; TOT=Task-oriented training who were considered to be able to participate in the study.

The inclusion criteria and exclusion criteria for this study were as follows. They were screened by a assessor. The inclusion criteria were as follows: Patients diagnosed with stroke via MRI/CT medical record; Patients aged 20 years and older; Patients with an onset at least 12 months prior to the study; Patients without cognitive impairments (MMSE-K ≧24) (Folstein, Folstein, & McHugh, 1975); Patients who have a Brunnstrom stage of the shoulder and hand of 3 or more; Patients who understand the study's purpose and can provide consent for participation.

Exclusion criteria were as follows: Patients who have had previous strokes or have other neurological or surgical conditions; Patients who recently participated in other rehabilitation research or drug experiments; Patients who had seizures repeatedly during treatment; Patients with visual perception problems (severe unilateral or visual field defects); Patients with contraindications to electrical stimulation.

This was a single-blind study, and subjects were allocated randomly to the experimental or control group using a random number generated by computer software. The study was conducted after approval from the Ethics Committee of Yonsei University School (Approval number.: 1041849-201608-BM-042-02).

All subjects provided informed consent before study inclusion according to the Declaration of Helsinki 2004. Selected patients were randomly assigned to 14 patients in the experimental group (EG) and 15 in the control group (CG). During the intervention, 4 patients in the EG and 5 in the CG were dropped out because of the reasons such as rejection of treatment, discharge. The results of the final 20 patients were analyzed (Figure 1).

2. Protocol

This study was conducted from September 2017 to August 2018 and recruitment took place from September 1 to 30. A simple randomization method using a computer randomization program was used to assign 14 subjects to experimental group, and 15 to control group. All sessions were conducted by one occupational therapist with six years of clinical experience.

EG performed PNS combined with TOT, and the training was conducted a total of 20 sessions, 5 days a week for 4 weeks. In the CG, only TOT was performed, and the training was conducted similarly to the EG. During the study period, all participants in the EG and CG continued to receive conventional physical therapy, occupational therapy, and medication. Physical therapy included central nervous system exercise therapy such as NDT. Occupational therapy performed fine motor control training, strength exercise, and did not include exercise similar to this study intervention.

The assessments were conducted one-on-one within the hospital's occupational therapy room.

Pre-assessment was conducted within 24 hours before the intervention and post-assessment was performed within 24 hours after the intervention. Two occupational therapists with more than three years of experience conducted all the assessments in a fixed order. muscle activity, hand dexterity and hand strength, functional level of the affected upper extremity were assessed at pretreatment, post treatment.

3. Intervention

In this study, we used FES-1000-FES EMG (Cyber Medic, Seoul, Korea) to provide PNS to the participants. It has two channels in total, and can be controlled with frequency of 1–200 Hz, output current of 0–99 mA, and pulse width of 20㎲-50㎲. It is also possible to set the treatment mode, output waveform (monophasic/biphasic), and treatment time from 0–60 min. It has an independent channel method that can control the intensity of each channel's stimulation according to the stimulation site. Peripheral sensory nerve stimulation was provided to the affected upper extremity of each stroke patient using a neuromuscular electrical stimulation therapy device. The location of the electrode was attached to the median nerve and ulnar nerve on the affected side (Kim & Park, 2016). The electrode for the median nerve was attached to the wrist branch of the flexor carpi radialis and the palmaris longus wrist tendon. The electrode for the ulnar nerve was attached to the flexor carpi ulnaris, branching from the ulnar nerve and attaching to the wrist (Burridge & Ladouceur, 2001). The electrode used was a square disposable electrode of 5 x 5 cm. The stimulus was provided for 30 min at a frequency of 10 Hz, a pulse width of 10 ㎲, and an on-off duty cycle to ensure that there was no pain or visual contraction of the muscle (Ikuno et al., 2012).

Task-oriented training (TOT) was performed simultaneously for 30 min to provide peripheral sensory nerve stimulation. TOT used in this study involved a total of six items, including "Press the bell 1-3", "Moving a rubber ball", "Moving the plastic bottle", and "Moving a peg". The intervention method was based on the study by Kim, Park, Jung, & Yoo (2016) (Table 1). The difficulty of the task was controlled by the number, direction, size, and distance of the target, according to the ability of the participant. TOT was performed in a sitting position in a chair with a backrest, and both legs were flexed at 90° in the hip, knee, and ankle joints.

4. Outcome measures

1) Mini-Metal State Examination (MMSE-K)

MMSE-K was used to assess the cognitive abilities required to perform tasks when enrolling the participants. MMSE was developed by Folstein et al. (1975). In 1989, it was translated into Korean and standardized. MMSE-K is widely used in clinical practice to easily assess the cognitive level of patients with brain damage and older adults. It consists of 12 items from a total of 6 categories, and less than 24 points out of 30 points is considered an indication of cognitive impairment. In this study, patients with score of 24 or more were enrolled.

2) Percentage of reference voluntary muscle contractions (% RVC)

The surface electromyography equipment was an ME6000 (Mega Electronics Ltd., Kuopio, Finland), with

Table 1. Content of Task-Oriented Training

Task	Methods
Press the bell	1. The task involved pressing two bells with the palm of the hand. Two bells were spaced 30 cm apart and 50 cm in front of the center of the participant's body.
	2. The task involved pressing five bells with the palm of the hand. The bells were placed 50 cm in front of the center of the participant's body .
	3. The task involved reaching the bell target in the upper, lower, left, and right positions while in the sitting position and pressing the bell with the palm.
Moving a rubber ball	The task involved taking a 6.5 cm diameter rubber ball and putting it in a basket with a diameter of 10 cm (the basket location was moved in various directions).
Moving the plastic bottle	The task involved reaching and moving five plastic bottles of different thickness, height, and weight (the range of movement did not extend past the desk).
Moving a peg	The task involved taking a cylindrical peg with a diameter of 2.5 cm and a height of 7 cm and putting it in a basket placed on the box, while in a sitting position.

a total of eight channels. In this study, five channels were used. The EMG signal sampling rate was 1000 Hz, and a band pass filter of 10–500 Hz and a notch filter of 60 Hz were used. The EMG signals collected on the ME6000 were converted into digital signals and then filtered and signal processed using the MegaWin software 3.0 on connected personal notebooks. Surface electromyography (sEMG) is a test that measures the electrical activity of muscles by using electrodes that are attached to the skin. In this study, it was used to measure muscle activity of the flexor carpi radialis (FCR), extensor carpi radialis (ECR), and anterior fibers of the deltoid (AD).

An electrode was attached to the ECR, which caused the wrist and fingers to extend. The placement was on the muscle belly with supination and pronation of the elbow at 90˚, with the participant in a sitting position, where there was maximal contraction of the wrist. An electrode was attached to the FCR, which caused bending of the wrist and fingers. Similar to the ECR, this electrode was attached to the muscle belly with supination and pronation of the elbow at 90˚, with the participant in a sitting position, where there was maximal flexion of the wrist. An electrode was attached to the AD where it attaches to the posterior surface of the triceps nodule, at a point one finger wide (Riek, Carson, & Wright, 2000).

In this study, the percentage of reference voluntary muscle contractions (% RVC) was used as the muscle activity. The measurements were taken with the participants sitting in a comfortable chair sitting in a separate, quiet space without noise interference. The posture for taking measurements was such that the waist was bent back and maintained at 90 degrees, and the subjects were cushioned on the knee so that they would feel comfortable. In this state, the muscle activity was measured in the resting position for a period of 15 s, and finger flexion and extension, and the reaching position were measured for 10 s. This procedure was repeated three times and the muscle activity was calculated as the mean value (Cook, Burgess-Limerick, & Papalia, 2004). This value was entered into a text file and normalized to % RVC using MATLAB software. The % RVC values were compared before and after the intervention, based on the muscle activity in the resting position, when the specific actions (finger extension and bending, and arm lifting) were performed. Muscle activity was considered to increase as the % RVC values increased.

3) Box and Block Test (BBT)

Box and Block Test (BBT) was used to evaluate the dexterity of the affected upper extremity of the participant in this study. BBT measures the number of blocks that are successfully moved from one side of the subject to the other over a period of 60 s (Chanubol et al., 2012). The test-retest reliability was high at overall 0.98, right to left at 0.94, and right to left at 0.94. The inter-reliability was high at 1.00 on the right side and 0.99 on the left side. Concurrent validity has also been reported to be high (Mathiowetz, Volland, Kashman, & Weber, 1985).

4) Strength

Hand grip strength was measured using a Jamar dynamometer (Sammons Preston, Inc., Bolingbrook, IL, USA) to determine the change in grip strength in the affected extremity. The lateral pinch was measured using pinch gauze (SAEHAN, Korea) (Mathiowetz et al., 1985). The Jamar dynamometer range can be adjusted from 3.45 to 8.57 cm and can measure up to 90 kg. The pinch gauze can measure up to 20 kg. The measurement posture involved the patients sitting in a chair with a 90˚ elbow flexion, with the forearm and wrist in a neutral position.

5) Action Research Arm Test (ARAT)

Action Research Arm Test (ARAT) was used to evaluate the upper extremity functional level in this study. Tools such as cylinders, cups, and rods were used to score tasks according to the degree to which they were performed on grasp, grip, pinch, and gross movements. ARAT consists of 19 items and 4 categories, an uses a 4-point scale consisting of 0~3 points. The reliability by category was grasp=0.98, grip=0.99, pinch=0.99, and gross movement=0.98 (Lang, Wagner, Dromerick, & Edwards, 2006).

5. Data analysis

The collected data were analyzed using SPSS 21.0 (IBM Corp., Armonk, NY, USA). The homogeneity of the experimental group and the control group before the intervention was verified using the chi-squared (χ^2) and Mann-Whitney U tests. The Wilcoxon signed rank test was used to test for significance before and after intervention. An analysis of covariance was used to compare changes between the groups, and the covariance was set as a pre-assessment of each group. Statistical significance was set at $p<.05$.

III. Results

1. Characteristics and baseline assessment results of study participants

Table 2 shows the results of the homogeneity test for the general characteristics and baseline assessment results of the EG and CG in this study. There was no significant difference in general characteristics between the two groups. However, in the pre-assessment, there was a significant difference between the EG and the CG in the FCR (p=.028), pinch strength (p=.037), and ARAT score (p=.028) (Table 2).

Table 2. Characteristics and Baseline Assessment Results of Study Participants

		EG (n=10)	CG (n=10)	p
Age (mean (SD))		57.3 (9.01)	61.7 (7.41)	.363
Time since injury (months; mean (SD))		16.9 (6.1)	19.5 (7.89)	.377
MMSE-K (mean (SD))		29.4 (0.70)	29.4 (1.07)	.605
Brunnstrom stage (mean (SD))				
	Shoulder	4.6 (0.52)	4.8 (0.63)	.483
	Hand			.483
Gender, n (%)				
	Male	4 (40)	4 (40)	1.000
	Female	6 (60)	6 (60)	
Paresis, n (%)				
	Right	5(50)	5 (50)	1.000
	Left	5(50)	5 (50)	
Dominant hand, n (%)				
	Right	9 (90)	9 (90)	1.000
	Left	1 (10)	1 (10)	
Stroke type, n (%)				
	Infarction	7 (70)	4 (40)	.369
	Hemorrhage	3 (30)	6 (60)	
Baseline	Muscle activity (%RVC) (mean (SD))			
	ECR	1088.09 (251.39)	1183.1 (272.27)	.364
	FCR	1391.24 (282.34)	1889.41 (626.61)	.028*
	AD	2921.82 (442.77)	2881.82 (476.2)	.850
	Pinch strength (lbs) (mean (SD))	9.9 (2.92)	13.7 (4.42)	.037*
	Grip strength (lbs) (mean (SD))	24.73 (4.3)	26.68 (3.59)	.364
	BBT (mean (SD))	24.8 (3.08)	24.9 (3)	.938
	ARAT (mean (SD))	27 (6.16)	34.3 (7.8)	.028*

2. Changes in muscle activity, hand strength, BBT, ARAT.

In the EG, muscle activity was increased in the ECR and the FCR. In the CG, muscle activity was significantly increased in the ECR, FCR, and AD (Table 3).

The differences between the two groups were analyzed using an ANCOVA because of the differences in muscle activity before the intervention. After the intervention, there was a significant difference (p=.041) between the two groups, with 695.60% RVC and 511.20% RVC increase in the muscle activity of the ECR. The muscle activity of the FCR also showed a significant difference (p=.008) between the two groups, with 955.54% RVC in EG and 510.64% RVC in CG after the intervention (Table 4).

The grip and pinch strength tests of the hand showed significant changes both before and after the intervention only in the grip strength (Table 3), and the difference between the two groups was also significant only in the grip strength (p=.015) (Table 4). In both groups, significant changes were observed in the ARAT results before and after the intervention (Table 3), and EG showed a significant improvement (p=.018) (Table 4).

The BBT also showed a significant change in the pre-and post-intervention groups (Table 3), but the difference between the two groups was not significant (Table 4).

Table 3. Changes in Muscle Activity, Hand Strength, BBT, ARAT Within Group

		Baseline Mean (SD)	Post intervention Mean (SD)	Z	p
ECR (%)	EG	1088.09 (251.39)	1783.69 (190.74)	-2.803	.005*
	CG	1183.10(272.27)	1694.31 (370.87)	-2.803	.005*
FCR (%)	EG	1391.24 (282.34)	2346.78 (321.47)	-2.803	.005*
	CG	1889.41 (626.61)	2400.041 (556.59)	-2.803	.005*
AD (%)	EG	2921.82 (442.77)	3015.50 (441.52)	-1.784	.074
	CG	2881.82 (476.20)	3025.50 (440.73)	-1.988	.047*
Pinch strength (lbs)	EG	9.9 (2.92)	10.6 (1.96)	-1.734	.083
	CG	13.7 (4.42)	13.9 (3.81)	-0.707	.480
Grip strength (lbs)	EG	24.73 (4.30)	29.88 (4.17)	-2.803	.005*
	CG	26.68 (3.59)	29.32 (3.59)	-2.652	.008*
BBT (sec)	EG	24.8 (3.08)	25.7 (2.90)	-2.041	.041*
	CG	24.9 (3.00)	25.4 (3.17)	-2.236	.025*
ARAT (score)	EG	27.0 (6.16)	34.1 (8.20)	-2.818	.005*
	CG	34.3 (7.80)	36.9 (6.62)	-2.825	.005*

*p<.05

AD=Anterior deltoid; ARAT=Action Research Arm Test; BBT=Box and Block Test; CG=Control Group; ECR=Extensor carpi radialis; EG=Experimental group; FCR=Flexor carpi radialis; SD=Standard Deviation

Table 4. Difference Between Groups

		Mean (SD)		Mean difference	Covariate	CI		F	$d.f.$	p
		EG (n=10)	CG (n=10)							
Muscle activity (% RVC)	ECR	695.60 (146.85)	511.20 (194.13)	175.56 (95.64)	1135.60	7.77	345.35	4.871	1	.041*
	FCR	955.54 (266.55)	510.64 (210.29)	352.89 (154.23)	1640.33	107.18	598.61	9.182	1	.008*
	AD	93.68 (139.97)	143.68 (225.97)	-42.06 (85.92)	2901.82	-213.23	129.10	.298	1	.592
Grip strength(lbs)		5.15 (2.02)	2.64 (1.66)	2.64 (1.66)	11.80	0.47	3.90	7.261	1	.015*
Pinch strength(lbs)		0.70 (1.25)	0.20 (0.92)	0.20 (0.92)	25.71	-1.14	0.49	.69	1	.417
BBT (sec)		7.10 (4.12)	2.60 (1.51)	2.60 (1.51)	24.80	-0.43	1.23	1.02	1	.328
ARAT (score)		0.90 (1.10)	0.50 (0.53)	0.50 (0.53)	30.65	0.82	7.66	6.828	1	.018*

*p<.05

AD=Anterior deltoid; ARAT=Action Research Arm Test; BBT=Box and Block Test; CG=Control group; CI=Confidence Interval; d.f=degree of freedom; ECR=Extensor carpi radialis; EG=Experimental group; FCR=Flexor carpi radialis

Ⅳ. Discussion

This pilot study demonstrated the feasibility of simultaneous use of PNS and TOT for recovery of upper limb dysfunction in stroke patients. The results of this study showed that muscle activity, hand grip strength, and upper limb function were significantly higher in the PNS plus TOT group than the TOT group. These results are consistent with the results of previous studies that combined prior PNS and TOT. In addition, these results show that when spontaneous and active training (such as TOT) PNS are combined, the peripheral afferent input from the sensory nerve-branching skin stimulates the activation of the corticospinal tract (Fleming et al., 2015; Ikuno et al., 2012; Lin et al., 2012; Saito et al., 2013).

The results of this study showed that the muscles activity of the ECR and FCR in the experimental group and the control group was significantly increased before and after the intervention, and the muscle activity of experimental group was significantly greater than that of control group. Changes in the motor unit due to stroke will modify the pattern of muscular activation, making the muscles unable to selectively move (Wagner, Dromerick, Sahrmann, & Lang, 2007). In this study, there was a difference between the groups of muscle activity because the PNS in experimental group stimulated the direct nerve root which could affect the grasping and releasing function of the hand. This increase in muscle activity implies an increase in the number of muscle fibers forming the exercise unit and induces the growth of muscle fibers through neurological plasticity and changes in myofibrils. This is consistent with previous findings that peripheral nerve stimulation promotes paralyzed wrist muscles and may support the results of this study in that changes in muscle activity in groups that provided additional PNS were greater than TOT (Castel-Lacanal et al., 2009). On the other hand, TOT, which was a common intervention in this study, included shoulder movements without electrical stimulation in that area, so there was no difference between groups in the AD, despite the improvement effect in each group.

This change in muscle activity may lead to improvement of motor recovery. In this study, hand grip improvements were significant only in grip strength, not in pinch strength. TOT used in this study affected the plasticity of the cerebral cortex, but did not provide a direct challenge to improve hand muscle strength during tasks, and the location where the PNS was applied was also not significant. It seems that pinch and fine motor are not directly related to the tasks involved in the training. Although TOT used in this study affects cerebral cortex plasticity, it does not provide a direct challenge to improve hand muscle strength during task training, and the location where PNS is applied is also not directly related to pinch and fine motor; therefore, it is considered that the results were not significant in this aspect because there was no direct involvement.

These results support the hypothesis that excitability of the corticospinal tract connected to the hand muscles via PNS is not directly related to the fine motion of the hand (Liu & Au-Yeung, 2017).

In this study, simultaneous application of PNS and TOT was effective in improving upper extremity function in stroke patients. As a result of evaluating upper limb function with ARAT, both groups showed significant changes based on the pre and post interventions, and the score increased significantly in EG. PNS improves the ability to control movement by reducing muscle tone in stroke patients, allowing for spontaneous movement. In addition, when task training is provided at the same time, it significantly increases the activity of the corticospinal tract (Lin et al., 2012; Saito et al., 2013). Based on previous studies, it is suggested that TOT with PNS activated the corticospinal tract and affected the restoration of upper extremity motor function after stroke.

The clinical significance of this study is that it can be applied in clinical situations to improve upper limb function of stroke patients. PNS is relatively safe and less fatigue inducing than FES, and can be easily applied with upper extremity training such as TOT. In addition, this approach makes it easier to induce patients to participate in stroke treatment.

There were several limitations in this study. First, the sample size was small. Second, the participants were chronic stroke patients, and shoulder and hand function loss was mild, with a Brunnstrom stage average of 4 or more. In the future, it is necessary to investigate the effect of providing PNS and TOT in patients with severe upper extremity function impairment. Third, it is difficult to confirm whether the treatment effects were maintained because they were evaluated within 24 hours of the intervention. Future studies are needed to confirm that treatment effects are maintained through at least 1-2 weeks of follow-up.

V. Conclusion

This study investigated the effect of TOT on stroke patients while providing PNS to induce changes in muscle activity, hand grip, and upper extremity function. These variables are meaningful to the clinician because they are important for rehabilitation goals of stroke patients, including a return to daily life activities. In the future, it is necessary to study the amplification intensity and the delivery time, which can appropriately and efficiently provide the peripheral nerve stimulation to stroke patients. In addition to the TOT, studies on the effects of various upper extremity functional treatments, such as bilateral upper extremity training and robotic therapy, are needed.

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국문초록

뇌졸중 환자의 상지기능 개선을 위한 말초감각신경자극과 과제 지향적 훈련의 동시 적용 효과: 단일 맹검 무작위대조군실험

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목적 : 본 연구는 뇌졸중 환자들의 상지기능 개선을 위해 말초신경감각자극과 과제지향적 훈련의 동시적용하여 효과를 알아보는 것이다.

연구방법 : 본 연구는 29명의 편마비 환자를 대상으로 수행하였다. 말초신경감각자극과 과제지향적 훈련을 동시에 적용한 실험군은 14명, 과제지향적 훈련만 실시한 대조군은 15명으로 주5회, 회기당 30분씩, 총 4주간 진행하였다. 결과측정은 손목과 어깨근육의 자발적 근수축 비율과 상자와 나무토막 검사, 잡기와 쥐기의 근력, Action Research Arm Test를 사용하여 중재 전·후로 측정하였다.

결과 : 4주간의 중재 후 짧은노쪽손목폄근, 노쪽손목굽힘근의 근 활성도와 잡기 근력, Action Research Arm Test에서 실험군은 대조군 보다 유의한 개선을 나타냈다.

결론 : 말초신경감각자극과 과제지향적 훈련의 동시적용은 과제지향적훈련만 하는 것보다 뇌졸중 환자의 상지기능 개선에 보다 효과적이었다.

주제어 : 과제 지향적 훈련, 뇌졸중, 말초신경감각자극, 상지