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Original Article

Effects of dynamic neural mobilization on cerebral cortical activity in patients with stroke

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Abstract. [Purpose] The current study aimed to identify the effects of dynamic neural mobilization on cerebral cortical activity in patients with stroke, and to present efficient intervention methods for stroke management. [Subjects and Methods] A total of 20 hemiplegic patients diagnosed with stroke over the past 6 months were sampled, and randomly divided into groups I (n=10) and II (n=10). Groups I and II underwent neural mobilization and dynamic neural mobilization, respectively, on the paralyzed arm. Both interventions were administered for 30 min, once a day, for 4 days a week, over a course of 4 weeks. β-waves and μ-rhythms in the C3 and C4 areas of the cerebral cortex were measured using electroencephalography, both before and after the intervention. [Results] After the intervention, both groups showed significant changes in the β-waves and μ-rhythms in the C3 area alone. Further, significant inter-group differences in the β-waves and μ-rhythms were only present in the C3 area. [Conclusion] Dynamic neural mobilization is an efficient intervention because it increases β-waves and μ-rhythms in the cerebral cortex. Therefore, the effects of continuous intervention programs involving dynamic neural mobilization in patients with stroke should be investigated in the future.

Key words: Cerebral cortex activity, Dynamic neural mobilization, Stroke

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INTRODUCTION

In patients, arm-related symptoms of stroke include palsy, motor loss, abnormal movement, changes of physical sensation, and functional limitations[1)], which substantially limit their daily living activities[2)]. Interventions for arm functional recovery include motor therapies, such as stimulation of proprioceptive nerve root, functional electric stimulation, mirror therapy, and neural mobilization[3)]. Neural mobilization, in particular, has been suggested to be more effective than other motor therapies in patients with stroke, as it can indirectly stimulate the nervous system[4)]. However, even though many motor therapies have benefits, the distal area of the paralyzed arm exhibit slow recovery of delicate functions due to problems with mechanical receptors and functional impairment, which often persists in patients with stroke[5)]. To address this issue, Robson et al.[6)] suggested the need to incorporate novel techniques into existing motor therapies or advance current techniques. Accordingly, the current study aimed to apply dynamic neural mobilization, an advanced version of the existing neural mobilization technique. To do this we implemented dynamic movement in the distal area of the paralyzed arm and analyzed changes in

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Table 1. Characteristic of subjects

Items	Experimental group I (n=10)	Experimental group II (n=10)
Age (years)	62.4 ± 8.4	58.1 ± 6.1
Height (cm)	158.3 ± 11.5	161.9 ± 5.6
Weight (kg)	63.3 ± 7.5	66.1 ± 8.2
MMSE-K (scores)	26.2 ± 2.2	25.8 ± 2.0

Data are presented as mean ± SD obtained using the Shapiro-Wilk test.

cerebral cortical activity in patients with stroke, in an ultimate attempt to provide clinical data related to effective functional recovery for patients with stroke.

SUBJECTS AND METHODS

The current study was approved by the Institutional Review Board at Sehan University (approval no. SH-IRB 2016-12). A total of 20 stroke patients who visited the M hospital located in the South JeollaNamdo between February and October 2017 were enrolled in the present study. All patients provided informed consent prior to starting the study. In order to objectify the research subjects, we selected as follows. Only patients who were diagnosed with right hemiplegia between the past 3–6 months, without other neurological or orthopedic history and without restriction of passive range of motion on the paralyzed arm, and sensory impairment on the affected side or vision or hearing problems, were included in the current study. In addition, patients with a Korean Mini Mental Status Exam score of 24 or greater and modified Ashworth scale of G II or lower (to ensure that they can understand and comply with the instructions (Table 1)) were also included. There was no significant difference between the subjects. Therefore, the homogeneity between groups was achieved.

After sampling, the 20 stroke patients were randomly divided into the neural mobilization group (treatment group I, n=10) and dynamic neural mobilization group (treatment group II, n=10). The patients underwent 30-min sessions, once a day, 4 days a week, over a period of 4 weeks. β-waves and μ-rhythm in the C3 and C4 areas of the cerebral cortex were measured using electroencephalography (EEG), before and 4 weeks after the intervention to analyze changes.

For dynamic neural mobilization of the radial nerve, the patient was in the supine position. The therapist lowered the shoulder toward the closer leg while internally rotating the upper arm shoulder joint, extending the elbow joint, and pronating the lower arm. The patient laterally flexed the neck to the opposite side. The therapist performed dynamic hyper-inner rotation of the patient's wrist every 2 s, for a total of 20 s using a metronome. For the dynamic neural mobilization of the median nerve, the patient was in the supine position with the shoulder joint open at approximately 90°, the elbow joint flexed at 90°, and the wrist joint in dorsal flexion. The therapist fixed the patient's shoulder with one arm while externally rotating the patient's shoulder, extending the elbow joint, supinating the lower arm, and completely extending the fingers and wrist. The patient's neck was laterally flexed to the opposite side. The therapist performed dynamic hyperextension of the distal area of the patient's arm, once every 2 s, for a total of 20 s, using a metronome. For ulnar nerve mobilization, the patient was in the same position as the median nerve mobilization. The therapist externally rotated the patient's shoulder joint as much as possible while pronating the lower arm, completely extending fingers and wrist, and the patient laterally flexed the neck to the opposite side. The therapist performed dynamic hyperextension of the patient's wrist, once every 2 s, for a total of 20 s using a metronome. Neural mobilization of the arm was performed using the same position as that for the dynamic neural mobilization, but without the dynamic movement. Further, the distal area of the arm was continuously extended for 20 s.

This study was intervened by one physical therapist to improve objectivity. The therapist has 8 years of clinical experience. And I completed nerve mobilization education in Korea.

Data were analyzed using Windows SPSS version 20.0 software package. Changes in β-waves and μ-rhythms within each group was compared using the paired t-test, while changes in β-waves and μ-rhythms between groups was compared using analysis of covariance (ANCOVA). Statistical significance was set at $\alpha=0.05$.

RESULTS

After the intervention, changes in β-waves were only significant in the C3 area in both groups ($p<0.01$). Further, the β-waves only significantly differed between the two groups in the C3 area ($p<0.05$) (Table 2). Further, there were significant changes in μ-rhythms in the C3 area alone in both groups after the intervention ($p<0.001$). The μ-rhythms changes also significantly differed between the two groups in the C3 area alone ($p<0.001$) (Table 2).

DISCUSSION

Motor therapies alter brain plasticity in stroke patients[7]. As Nowak et al.[8] stated, neural plasticity demonstrates the

Table 2. Comparison of β-wave, μ-rhythm changes within and between group

Domain		Groups	Pre-test	Post-test	
β-wave	C3	Experimental group I	0.26 ± 0.04	0.29 ± 0.05**	*
		Experimental group II	0.32 ± 0.06	0.37 ± 0.06**	
	C4	Experimental group I	0.25 ± 0.04	0.27 ± 0.07	
		Experimental group II	0.32 ± 0.05	0.35 ± 0.06	
μ-rhythm	C3	Experimental group I	2.7 ± 0.24	2.78 ± 0.46***	***
		Experimental group II	2.29 ± 0.17	1.69 ± 0.31***	
	C4	Experimental group I	2.53 ± 0.27	2.37 ± 0.39	
		Experimental group II	2.57 ± 0.34	2.3 ± 0.35	

*p<0.05, **p<0.01,***p<0.001.
Data are presented as mean ± SD, paired t-test, analysis of covariance.

brain's ability to regenerate, causing reorganization through axonal sprouting and dendritic sprouting, which lead to changes in the central nervous system. Among several existing methods for observing changes in the central nervous system, measuring brain waves is beneficial in that it enables the confirmation of therapeutic efficacy of exercise learning[9)]. By examining cerebral cortical changes after intervention, Kim et al.[10)] found positive changes in EEG signals of stroke patients after passive exercise. Repeated passive exercise led to an increase in β-waves in the C3 and C4 areas, i.e., the primary motor areas in the brain, confirming that passive movement is effective[11)]. This exercise method was reported to be also effective among patients with palsy, such as stroke, as it can stimulate the body sensations of patients[12)]. In the present study, interventions involving the concept of passive mobilization were administered to stroke patients by a therapist. These interventions led to significant changes in β-waves in the C3 area alone in both groups. Such an increase in β-waves suggests that patients with stroke exhibited smooth body movement during the task. This result is attributable to the fact that both interventions were effective exercise methods that promote functional recovery by indirectly stimulating the peripheral nervous system[13)]. The between-group comparison showed that dynamic neural mobilization was more effective in increasing β-waves. This outcome could be attributed to the fact that dynamic movement more efficiently stimulates neural viscoelasticity in the distal area of the paralyzed arm[13)].

Many studies use μ-rhythms, which reflect the state of recovery after intervention, to assess the degree of functional recovery in the arm[14)]. These waves occur when performing a task or imitating the behaviors of others. In particular, μ-rhythms are substantially decreased as finger functions recover[15)]. Shahid et al.[16)] measured μ-rhythms in the C3 and C4 motor areas after intervention in stroke patients with right palsy and found that μ-rhythms in the C3 area, on the opposite side of the paralyzed arm, were significantly decreased. Another study applied imaginative training in stroke patients and found that the group that underwent intensive finger training showed a more efficient reduction in μ-rhythms, suggesting that μ-rhythms are more intimately related to recovery of finger functions[17)]. We administered interventions based on these previous findings and demonstrated significant reductions in μ-rhythms of both groups in the C3 area alone, after the corresponding interventions. This suggested that both interventions were effective in promoting recovery of arm functions in patients with stroke. One speculation is that both interventions indirectly stimulate the nervous system, at the same time stimulating the activities of muscle spindles and tendon organs of Golgi[13)]. Further, dynamic neural mobilization led to a greater decrease in μ-rhythms than the conventional neural mobilization, presumably because providing dynamic movement in the distal area of the paralyzed arm induces greater changes in viscoelasticity in the peripheral nervous system and capsular pressure of the mechanical receptors in the distal area of the arm[13, 18)].

Application of neural mobilization and dynamic neural mobilization was effective in increasing β-waves and decreasing μ-rhythms in the C3 area, on the opposite side of the paralyzed side, in patients with stroke and hemiplegia. Dynamic neural mobilization was particularly more efficient at increasing the β-waves and decreasing μ-rhythms. Therefore, dynamic neural mobilization should be utilized more often to promote smooth body movement and recovery of arm functions for stroke patients. Additional clinical studies are warranted to investigate the effects of dynamic neural mobilization on other parts of the body.

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Conflict of interest

None.

REFERENCES

1) Kim BY, Choi WH: The effects of interferential cuttent therapy on spasticity, range of motion, and balance ability in stroke patient. J KorSocPhysTher, 2013, 25: 187–194.
2) Vanroy C, Vissers D, Cras P, et al.: Physical activity monitoring in stroke: SenseWear Pro2 activity accelerometer versus Yamax Digi-Walker SW-200 pedometer. Disabil Rehabil, 2014, 36: 1695–1703. [Medline] [CrossRef]
3) Stinear C, Ackerley S, Byblow W: Rehabilitation is initiated early after stroke, but most motor rehabilitation trials are not: a systematic review. Stroke, 2013, 44: 2039–2045. [Medline] [CrossRef]
4) Godoi J, Kerppers II, Rossi LP, et al.: Electromyographic analysis of biceps brachii muscle following neural mobilization in patients with stroke. Electromyogr Clin Neurophysiol, 2010, 50: 55–60. [Medline]
5) Boyd BS, Wanek L, Gray AT, et al.: Mechanosensitivity during lower extremity neurodynamic testing is diminished in individuals with Type 2 Diabetes Mellitus and peripheral neuropathy: a cross sectional study. BMC Neurol, 2010, 10: 75. [Medline] [CrossRef]
6) Robson N, Faller II KJ, Ahir V, et al.: Creating a virtual perception for upper limb rehabilitation. Stroke, 2017,12:15.
7) Pruitt DT, Schmid AN, Kim LJ, et al.: Vagus nerve stimulation delivered with motor training enhances recovery of function after traumatic brain injury. J Neurotrauma, 2016, 33: 871–879. [Medline] [CrossRef]
8) Nowak DA, Grefkes C, Ameli M, et al.: Interhemispheric competition after stroke: brain stimulation to enhance recovery of function of the affected hand. Neurorehabil Neural Repair, 2009, 23: 641–656. [Medline] [CrossRef]
9) Wiers RW, Gladwin TE, Hofmann W, et al.: Cognitive bias modification and cognitive control training in addiction and related psychopathology: mechanisms, clinical perspectives, and ways forward. Clin Psychol Sci, 2013, 1: 192–212. [CrossRef]
10) Kim B, Kim L, Kim YH, et al.: Cross-association analysis of EEG and EMG signals according to movement intention state. Cogn Syst Res, 2017, 44: 1–9. [CrossRef]
11) Pittaccio S, Zappasodi F, Tamburro G, et al.: Passive ankle dorsiflexion by an automated device and the reactivity of the motor cortical network. EMBC, 2013:6353–6356.
12) Calabrò RS, Naro A, Russo M, et al.: Do post-stroke patients benefit from robotic verticalization? A pilot-study focusing on a novel neurophysiological approach. Restor Neurol Neurosci, 2015, 33: 671–681. [Medline]
13) Kang JI, Moon YJ, Jeong DK, et al.: The effect of rhythmic neurodynamic on upper extremity nerve conduction velocity and function of stroke patients. J Kor Phys Ther, 2017, 29: 169–174.
14) Mohamed EA, Yusoff MZ, Malik AS, et al.: Comparison of EEG signal decomposition methods in classification of motor-imagery BCI. Multimedia Tools Appl, 2018, 1: 1–23.
15) Oberman LM, Hubbard EM, McCleery JP, et al.: EEG evidence for mirror neuron dysfunction in autism spectrum disorders. Brain Res Cogn Brain Res, 2005, 24: 190–198. [Medline] [CrossRef]
16) Shahid S, Sinha RK, Prasad G: Mu and beta rhythm modulations in motor imagery related post-stroke EEG: a study under BCI framework for post-stroke rehabilitation. BMC Neurosci, 2010, 11: 127. [CrossRef]
17) Kasashima Y, Fujiwara T, Matsushika Y, et al.: Modulation of event-related desynchronization during motor imagery with transcranial direct current stimulation (tDCS) in patients with chronic hemiparetic stroke. Exp Brain Res, 2012, 221: 263–268. [Medline] [CrossRef]
18) Scott M, Taylor S, Chesterton P, et al.: Motor imagery during action observationincreases eccentric hamstring force: an acute non-physical intervention. Disabil Rehabil, 2017, 21: 1–9. [CrossRef]