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Original Article

Effects of adjustment of transcranial direct current stimulation on motor function of the upper extremity in stroke patients

Dong-Geol Lee, PT, PhD[1)], Dong-Yeop Lee, PT, PhD[2)*]

[1)] *Rheumatoid and Degenerative Arthritis Center, Chungnam National University Hospital, Republic of Korea*
[2)] *Department of Physical Therapy, Sunmoon University: Galsan-ri, Tangjeong-myeon, Asan-si, Chungcheongnam-do 336-708, Republic of Korea*

Abstract. [Purpose] The purpose of this study was to examine the effects of transcranial direct current stimulation (tDCS) applied to the cerebral cortex motor area on the upper extremity functions of hemiplegic patients. [Subjects and Methods] Twenty four Patients with hemiplegia resulting from a stroke were divided into two groups: a tDCS group that received tDCS and physical therapy and a control group that received only physical therapy. A functional evaluation of the two groups was performed, and an electrophysiological evaluation was conducted before and after the experiment. Statistical analyses were performed to verify differences before and after the experiment. All statistical significance levels were set at 0.05. [Results] The results showed that functional evaluation scores for the elbow joint and hand increased after the treatment in both the experimental group and the control group, and the increases were statistically significantly different. [Conclusion] tDCS was effective in improving the upper extremity motor function of stroke patients. Additional research is warranted on the usefulness of tDCS in the rehabilitation of stroke patients in the clinical field.
Key words: TDCS, Upper extremity and hand motor function, Stroke patients

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INTRODUCTION

Improvement in the standard of living and changes in diet have led to an increase in the prevalence of hypertension, arteriosclerosis, and diabetes mellitus. Moreover, the incidence rate of stroke and the risk for these diseases have increased. Cerebrovascular diseases are the second-highest cause of death, followed by cancer, in Korea[1)]. Among the cerebrovascular diseases, stroke is one of the most common causes of disability in adults. The prognosis of stroke after the age of 65 years is usually poor, and more than 80% of patients experience neurological damage[2)]. The rate of disability that affects activities of daily living after a stroke, compared to other chronic diseases, is very high. Long-term rehabilitation is necessary because of the loss of function in the upper and lower extremities, speech impairment, and cognitive disorders that accompany a stroke[3, 4)].

With regard to the recovery of neurological motor functions after a stroke, patients show 80% and 95% recovery of the upper and lower extremity function within 3 months, respectively[5)]. Despite intensive, long-term treatment, most stroke patients fail to show complete recovery of the function of their upper limbs[6, 7)]. Among the upper extremity functions, hand function is usually the most severely impaired[8)]. Various treatments, including drugs and exercise, are available to enhance motor functions after a stroke. Other methods include neurological physical therapy focusing on neurodevelopment therapy and proprioceptive neuromuscular facilitation, occupational therapy, ischemic nerve block, functional electrical stimulation, constraint-induced movement therapy[9, 10)], and robot-assisted therapy for upper limb rehabilitation[11)]. These treatment methods may speed up the recovery of patients' upper limb functions but require long-term efforts, and continuous treatment may be difficult for various reasons. Recent research suggests that transcranial direct current stimulation (tDCS) of the brain can improve physical functions in stroke patients[12–15)]. Therefore, we investigated the effects of tDCS on the recovery of upper limb functions in stroke patients.

SUBJECTS AND METHODS

The study included 24 patients with stroke diagnosed by a specialist at C hospital located in D Metropolitan City who were receiving rehabilitation treatment for functional recovery. In all the participants, hemiplegic patients were composed of at least 6 months after the onset. Participants with a history of stroke, with a personal or family history of

*Corresponding author. Dong-Yeop Lee (E-mail: kan717@hanmail.net)

epileptic seizure, who underwent implantation of an artificial cardiac pacemaker, or who showed severe upper extremity contracture and deformity were excluded, because participation of such patients was difficult. Patients with hemiplegia who were diagnosed with a stroke were randomly assigned to either an experimental or a control group. Data were collected from patients who agreed to participate after they fully understood the research procedures. All procedures were approved by the Institutional Review Board committee of C National University Hospital in the Korea.

Fugl-Meyer assessment (FMA) was performed before the experiment for all the patients to determine the function of their upper limbs[16]. The experimental group received tDCS and physical therapy, whereas the control group received only physical therapy. After 4 weeks, the FMA was performed again, and the intervention was performed 5 times per week for 4 weeks.

Kolmogorov-Smirnov single-sample test was performed to examine the general characteristics of the participants and the normality of each item. An analysis of covariance was conducted to identify differences between the 2 groups. The data were analyzed with SPSS 18.0 SPSS Inc, Chicago, IL, USA) for Windows, and the significance was set at $p < 0.05$.

RESULTS

With regard to shoulder function, the mean ± standard deviation (SD) FMA scores were 22.44 ± 5.64 before and 21.00 ± 6.08 after the treatment in the control group, and they were 22.64 ± 6.02 before and 26.82 ± 4.92 after the treatment in the experimental group; the changes were statistically significant ($p < 0.01$). The mean ± SD FMA scores for the elbow joint were 5.00 ± 3.74 before and 5.11 ± 3.72 after the treatment in the control group, whereas they were 7.09 ± 2.34 before and 8.45 ± 1.92 after the treatment in the experimental group; the changes were statistically significant ($p < 0.05$). In the control group, the mean ± SD FMA scores for hand function were 8.44 ± 5.22 before and 8.89 ± 5.16 after the treatment. In the experimental group, the mean ± SD FMA scores were 10.45 ± 2.62 before and 12.45 ± 2.16 after the treatment. The changes in both the groups were statistically significant ($p < 0.05$)(Table 1).

Table 1. Changes score of FMA items in a stroke patients of before and after transcranial direct current stimulation

	Group	Pre	Post	(%)
Shoulder	Experiment (n=12)	22.64±6.02	26.82±4.92	**
	Control (n=12)	22.44±5.64	21.00±6.08	
Elbow	Experiment (n=12)	7.09±2.34	8.45±1.92	*
	Control (n=12)	5.00±3.74	5.11±3.72	
Hand	Experiment (n=12)	10.45±2.62	12.45±2.16	*
	Control (n=12)	8.44±5.22	8.89±5.16	

Values are mean ± SD, * $p<0.05$, ** $p<0.01$
FMA: Fugel-Mayer Assessment
Experiment: Transcranial direct current stimulation + Standard physical therapy group
Control: Standard physical therapy group

DISCUSSION

In this study, we applied tDCS, which activates the motor areas in the cerebral cortex, in combination with physical therapy for patients with a stroke and who experienced hemiplegia for ≥6 months. This study focused on the effects of tDCS on upper extremity functions.

The changes in the FMA scores for the shoulder joint, elbow joint, and hand functions were greater in the group that received tDCS than in the group that received only physical therapy. The FMA is considered the best tool for the assessment of a patient's motor functions. Park and Choi[17] reported that FMA was more effective than other methods for the assessment of the recovery of upper extremity motor functions. In addition, a correlation between the effects of tDCS on upper extremity functions and FMA scores was verified, and FMA was found to be a valid method for the evaluation of upper limb functions. Hummel et al.[18] and Harvey et al.[19] applied tDCS for chronic stroke patients and observed that the extent of improvement in the motor function performance, including FMA scores, was greater in the tDCS group than in the non-tDCS group.

Hummel et al.[18] reported that tDCS applied for chronic stroke patients reduced the reaction time of the paretic hand and improved the pinch force. In the present study, the shoulder joint, elbow joint, and hand function scores in the experimental group increased significantly, and these findings support the findings of Hummel et al[18].

A limitation of the present study was the small study population. Therefore, the results cannot be generalized to all female patients with stroke. Studies in a larger number of participants would generate results that are more meaningful. The validity of the study would also be improved by clarifying the criteria for the selection of participants.

The intervention that included tDCS improved upper limb motor function. However, previous studies did not clarify these changes. Therefore, additional research needs to focus on elucidation of the association between changes in the motor areas in the cerebral cortex and improvement in muscle performance of the upper limbs.

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