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Original Article

Effect of transcranial direct current stimulation on visual perception function and performance capability of activities of daily living in stroke patients

Ko-Un Kim, MS, OT[1)], Soo-Han Kim, PhD, PT[2)], Tae-Gyu An, MS, OT[1)*]

[1)] *Rehabilitation Science, Daegu University: 201 Daegudae-ro, Gyeongsan-si, Gyeongsangbuk-do 38453, Republic of Korea*
[2)] *Department of Physical Therapy, College of Health Medicine, Kaya University, Republic of Korea*

Abstract. [Purpose] The purpose of this study was to examine the effects of transcranial direct current stimulation (tDCS) on visual perception and performance of activities of daily living in patients with stroke. [Subjects and Methods] Thirty subjects were assigned equally to a tDCS plus traditional occupational therapy group (experimental group) and a traditional occupational therapy group (control group). The intervention was implemented five times per week, 30 minutes each, for six weeks. In order to assess visual perception function before and after the intervention, the motor-free visual perception test (MVPT) was conducted, and in order to compare the performance of activities of daily living, the Functional Independence Measure scale was employed. [Results] According to the results, both groups improved in visual perception function and in performance of activities of daily living. Although there was no significant difference between the two groups, the experimental group exhibited higher scores. [Conclusion] In conclusion, the application of tDCS for the rehabilitation of patients with stroke may positively affect their visual perception and ability to perform activities of daily living.

Key words: Transcranial Direct Current Stimulation (tDCS), Visual perception, Activities of daily living

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INTRODUCTION

Patients with stroke experience overall degradation in visual perception and activities of daily living (ADLs). In particular, damage to visual perception makes it difficult for patients with stroke to perform ADLs due to unilateral neglect and damage to spatial perception abilities. For example, difficulties with dressing, hygiene, and other independent daily living activities, as well as the ability to learn new activities, have a significant impact on patient rehabilitation[1)]. In order to improve visual perception and the performance of ADLs for patients with stroke, plasticity of the brain needs to be supported. As a method to improve plasticity, transcranial direct current stimulation (tDCS) has been suggested. tDCS is used to stimulate the cerebral cortex directly, in order to control the activities of the cortex. tDCS can impact the function of a specific neural structure and augment treatment effects during the rehabilitation process through brain stimulation[2)]. Since tDCS is highly portable and safe, as well as economical, it can be used conveniently for the purposes of research and treatment[3)]. Previous studies have reported that providing tDCS to patients with stroke can help increase hand function, balance, and motor function in addition to improvements in cognition, such as executive function, concentration, short-term memory, and a reduction in depression[4–7)]. However, few studies have been conducted on the effect of tDCS on visual perception and performance of ADLs, which are important indices for improvement in the rehabilitation of patients with stroke. Thus, this study aims to determine

*Corresponding author. Tae-Gyu An (E-mail: rhdnsxorb2016@hanmail.net)

the effect of tDCS on visual perception and performance of ADLs when applied to the affected side of patients with stroke.

SUBJECTS AND METHODS

This study was conducted for six weeks in patients with stroke who were diagnosed by computed tomography (CT) or magnetic resonance imaging (MRI) at M Rehabilitation Hospital in Busan from January 2015 to November 2015. This study was approved by the Institutional Review Board at Kaya University (Kaya IRB-115). Subjects participated in this study after obtaining an understanding of the purpose of the study and providing written consent, in accordance with the ethical principles of the Declaration of Helsinki, good clinical practices, and the applicable laws and regulations. A total of 30 subjects were selected based on the hospitalization date and were divided into the experimental group (15 subjects) and control group (15 subjects) randomly. For the experimental group, traditional occupational therapy treatment and tDCS were applied. For the control group, traditional occupational therapy and sham tDCS were applied. Prior to applying the treatment intervention for the two groups, the visual perception abilities of each subject were evaluated using the motor-free visual perception test (MVPT) and ADL performance was evaluated using the Functional Independence Measure (FIM) scale to test homogeneity.

tDCS was applied by attaching sponge electrodes (4 × 6 cm) that were soaked in saline to the scalp. A current generator, the Phoresor® PM 850 (Phoresor® II Auto Model No. PM 850, IOMED, Inc., Salt Lake City, USA) was used, which generates direct current using a battery. It is certified by the Food and Drug Administration (FDA) and is available commercially. In order to stimulate the occipital lobe, in accordance with the guidelines of the international electroencephalography system, the anode was attached to C3 (central 3) and the cathode was fixed to the required stimulation area by winding a strap around the supraorbital area. A current of 1 mA was applied for 20 min[8–10]. For the control group, electrodes were applied to the same location for the same length of time as above, but the current was discontinued after 30 s. Subjects in the control group were unaware of this until the test was completed.

To compare the general characteristics of the study subjects, frequency analysis was used. A paired t-test was conducted to compare the results of the MVPT and FIM scores before and after the intervention. For data analysis, SPSS 21.0 (IBM Corp., Armonk, NY, USA) was used. The significance level was set to $p<0.05$.

RESULTS

The experimental group had ten males and five females and the control group had nine males and six females. The experimental group had seven subjects with left-sided paralysis and eight subjects with right-sided paralysis. Conversely, the control group had eight subjects with left-sided paralysis and seven subjects with right-sided paralysis. The mean age of the experimental group was 58.7 ± 12.6 years and that of the control group was 51.9 ± 10.7 years. The mean duration of stroke in the experimental group was 14.6 ± 6.0 months and that in the control group was 14.5 ± 6.9 months, with no significant difference between the two groups. With regard to the main causes of paralysis, the experimental group had four subjects and the control group had 10 subjects with cerebral infarction, while the experimental group had 11 subjects and the control group has five subjects with cerebral hemorrhage ($p<0.05$) (Table 1).

For both groups, comparison of the MVPT results before and after the intervention revealed a statistically significant difference ($p<0.05$). Results of the MVPT showed that the experimental group demonstrated a significant improvement of approximately six points, from 21.1 ± 3.6 points to 26.8 ± 3.1 points on average, after the intervention. The control group also improved in visual perception after the intervention, increasing from 21.0 ± 3.9 points to 23.9 ± 3.8 points, which was also statistically significant ($p<0.05$). The total FIM score showed that the experimental group increased by 13 points after the intervention, from 66.8 ± 9.5 points to 79.57 ± 11.3 points. The FIM score of the control group increased by three points, from 65.4 ± 11.4 points to 68.3 ± 18.4 points. Both increases were statistically significant ($p<0.05$) (Table 2).

DISCUSSION

The above study results demonstrate that the group receiving tDCS and traditional occupational therapy simultaneously exhibited greater improvements in visual perception and ADL performance than the group receiving traditional occupational therapy only, although no significant difference was shown between the two groups. Through a number of previous studies, the effects of tDCS have been presented. According to one study, when tDCS was applied to normal healthy subjects, visual perception improved. tDCS was applied over the primary visual cortex for 50 min in 31 normal healthy adults, after which a two-alternative forced choice (2AFC) task was performed, with evidence of an increased accuracy rate for the task following the application of anodal tDCS[11]. Similarly, in a study by Kraft et al.[12], investigators applied tDCS to 12 healthy subjects over the visual cortex for 15 min per day for one week and reported that subjects demonstrated improved perceptual learning upon testing[13]. Basically, tDCS has a positive effect on visual perception in normal healthy adults as well as in patients with stroke. In particular, stimulation of the visual area, which is related to visual perception, plays an important role. Along with the above study results, a study of tDCS in patients with brain damage showed that tDCS, applied twice over the posterior parietal cortex (PPC) on the right side for 20 min, reduced the tendency for unilateral neglect on cancellation and bisection tests in 15 patients with stroke with unilateral neglect[13]. In a single case study, tDCS was applied over the occipital lobe for

Table 1. General characteristics of the subjects (N=30)

Categories	Items	Experimental group		Control group	
		N	%	N	%
Gender	Male	10	66.7	9	60.0
	Female	5	33.3	6	40.0
Age		58.7 ± 12.6		51.9 ± 10.7	
Paretic side	Left	7	46.7	8	53.3
	Right	8	53.3	7	46.7
Time since stroke (month)		14.6 ± 6.0		14.5 ± 6.9	
Cause of disease	Cerebral infarction	4	27.0	10	66.7
	Cerebral hemorrhage	11	73.0	5	33.3

Table 2. Comparison of the changes in visual perception and ADLs between the experimental and control groups

	Experimental group		Control group	
	Pre-test (Mean ± SD)	Pre-test (Mean ± SD)	Post-test (Mean ± SD)	Post-test (Mean ± SD)
Visual perception	21.1 ± 3.6	21.0 ± 3.9**	26.8 ± 3.1	23.9 ± 3.8**
ADLs	66.8 ± 9.5	65.4 ± 11.4**	79.57 ± 11.3	68.3 ± 18.4**

*p<0.05, **p<0.001

30 min per day for three months in a 61-year-old patient with stroke and hemianopsia, resulting in changes in the peri-lesional visual area along with changes in activity on functional MRI[14].

The application of tDCS can affect not only visual perception but also ADL performance. A study on rehabilitation treatment in parallel with tDCS, applied to 14 patients with stroke, showed that the experimental group, to which tDCS was applied for 10 min, five times a week, for two weeks over the primary motor cortex area, improved in physical function (upper and lower extremity function and balance) and ADL performance[15]. A study showed that the experimental group, receiving tDCS over the primary sensorimotor cortex for 20 min, five times a week, for four weeks along with physiotherapy, improved on the Barthel Index, a measurement tool for ADLs, by 20 points more than the control group[16]. The results of these studies are consistent with the results of the present study, in which tDCS and traditional occupational therapy were conducted simultaneously to determine the impact on visual perception and ADL performance.

In the present study, both the experimental group and control group exhibited a significant difference in visual perception and ADL performance after the intervention, although the experimental group, which received tDCS, demonstrated a greater change than the control group, which received only traditional occupational therapy. These results indicate that although traditional occupational therapy can also have a positive impact on visual perception and ADL performance, greater positive effects can be obtained by applying tDCS in parallel.

Despite the above study results, this study has a limitation. The study contained a small number of subjects, if the study was powered by a larger sample size, it would be the possibility of seeing significant differences between the groups. Therefore, a larger study involving more subjects should be conducted in the future.

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