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Effect of Transcranial Direct Current Stimulation on Gait of Stroke Patients

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ABSTRACT

Background: *Stroke is the most leading cause to functional disability and gait problems.*

Objectives: *The purpose of this study was to determine the effect of Transcranial direct current stimulation on selected gait kinematics in stroke patients.*

Methods: *Thirty male stroke patients participated in this study. The patients were assigned randomly into two equal groups, (study and control). Patients in the study group received Anodal TDCS in addition to selected physical therapy program for Stroke patients. Patients in the control group received selected physical therapy program only including: strengthening exercises, stretching exercises, weight bearing, balance exercises and gait training.*

The Outcome Measures: *Biodex gait trainer 2 TM was used to assess selected gait kinematics (step cycle, walking speed) before and after four weeks training period (end of treatment) for both groups.*

Results: *There was a statistical significant increase in walking speed and step cycle in both group. The improvement in gait parameters post treatment was significantly higher in the study group compared to the control group*

Conclusion: *Transcranial direct current stimulation is effective in improving selected gait kinematics in stroke patients when added to the selected physical therapy program.*

Keywords: *Stroke, Gait-post stroke, TDCS.*

Introduction

The World Health Organization (WHO) definition of stroke is a focal neurological deficit loss of function affecting a specific region of the nervous system) due to disruption of its blood supply most strokes result from a blood vessel being blocked by a clot, and around one in ten from a ruptured blood vessel causing haemorrhage. This affects the supply of oxygen and nutrients, causing damage to the brain tissue[(1)].

Stroke impairment have an important impact in patient life and considerable costs for health and social services[(2)]. Morever, after completing standard rehabilitation, approximately 50% -60% of stroke patients still experience some degree of motor impairement, and approximately 50% are at least partly dependent in activities of daily living (ADL)[3].

Hemiplegia is one of the most common impairement after stroke and contributes significantly to reduce gait performance. Although the majority of stroje patients achieve an independent gait ,many don't reach a walking level that enable them to perform all their daily activies[4].

Gait impairment is a common cause of disability in patients with stroke although it has been reported that 85% of stroke survivors recovery walking function within six months after the onset, restoring the ability to walk independently symmetry remains one of the major goals for during the chronic phase of illness[5]. Gait in patients after stroke is characterized by reduced preferred walking speed, cadence, and stride length as well as reduced symmetry, prolonged stance duration on the non-paretic side and reduced step length on the paretic side[6].

Restoring functions after stroke is a complex process involving spontaneous recovery and the effects of therapeutic interventions. In fact, some interaction between the stage of motor recovery and the therapeutic intervention must be noticed. The primary goals of people with stroke include being able to walk independently and to manage to perform daily activities. Consistently, rehabilitation programs for stroke patients mainly focus on gait training, at least for sub-acute patient[7].

Transcranial direct current stimulation (TDCS) as a form of noninvasive brain stimulation was defined as weak, direct electric currents could be delivered effectively transcranially as to induce polarity-dependent changes in cortical area. Specifically, anodal direct current stimulation was shown to increase cortical excitability, whereas cathodal stimulation decreased it. In addition, the mechanisms underlying tDCS effects provided on neuroplasticity[8].

Rehabilitation after stroke is among a growing number of potential therapeutic applications of transcranial direct current stimulation (tDCS), which delivers weak electric currents to the brain via scalp electrodes and There is evidence that non-invasive electrical brain stimulation may accelerate and augment the benefits of concurrent therapy through promotion of cortical plasticity or restoration of inter hemispheric balance following stroke[9].

Methodology

Thirty male stroke patients were induced in this study. The patients were selected from outpatient clinic of physical therapy of the faculty of physical therapy cairo university. The patients were diagnosed as having cerebrovascular stroke based on neurological examination, radiological investigation as CT and MRI. The patients were divided into two equal groups (Group A) was the study group that was treated by Transcranial direct current stimulationin addition to Traditional physical therapy and (Group B) was the control group that was treated only by the traditional physical therapy.

The patients were chosen under the following criteria

- Hemiplegia due to ischaemic stroke in the domain of the carotid system
- Patient's age ranged from 50 to 65 years
- Duration of illness not less than six months and not more than 24 months.
- Spastcity of the paretic lower limb ranged from (1,1+,2) according to the Modified aschowrth scale (MAS)
- All patients will receive rehabilitative care with an average length of stay more than six months after the onset till 2years.
- Degree of weakness in the paretic lower limb muscles was not less than (grade 3) according to group muscle testing.
- Ability of the patient to walk over ground ten meters independently with or without assistive devices
- Medically and psychologically stable patients.
- Cooperative patients who had the ability to obey command and follow instructions.

The current study excluded the following patients

- Uncooperative patients.
- Instability of patient's medical condition.
- Association of other medical or neurological problems.
- Presence of any disease that could affect the research results.
- Radiculopathy not result from cervical disc lesion.

A verbal explanation about the important justification and main points of achievement of the study was explained to every patient.

The procedures of the current study were divided into two main categories

Measurement procedures

a) **Initial evaluation procedures (initial phase)**

- Each patient was examined medically in order to exclude any abnormal medical problems which previously mentioned.
- Each patient's history was taken in previously prepared questionnaire to collect information about, name, age, BMI and determination about any functional, social, psychological problems.
- The purpose of evaluation procedures were explained in steps for each patient in each group.

b) **Technical measurements phases**

Patients included in the study were assessed before and after the study using:

Biodex gait trainer 2 TM treadmill: was used for assessment of kinematic gait parameters including walking speed (m/sec) and step cycle (cycle/sec). Each patient was allowed to be familiar with the gait trainer before starting the recording by allowing him to walk over the tread belt of the device for continuous three to five minutes. To start the evaluation process, the tread belt will ramp up slowly to 0.3 m/hour (by default). Then the therapist increases the speed gradually to be comfortable for each patient and allow him to walk for continuous four minutes. The gait parameters values then can be displayed on the display. Each step of the evaluative procedure was practiced three times with a rest period in between and the average was taken.

Therapeutic Procedures:

The procedures of treatment applications were achieved as the following:

Group A

Patients in this group received anodal transcranial direct current stimulation in addition to selected physical therapy program. TDCS was applied via saline-soaked surface sponge electrodes (5 cmx 5cm), connected to a constant current stimulator .The intensity used was 2 mA. The anodal electrode was placed over presumed lower limb area of lesional hemisphere (C3, C4 according to the EEG 10/20 system), while the cathodal electrode was placed above the contralateral supra orbital ridge .The patients received 20 minutes of anodal TDCS three times per week for four successive weeks [10,11].

Group B (control group)

The patients in this group received selected physical therapy program only three times a week for total four successive weeks.

Selected physical therapy program

- Strengthening exercises for weak upper limb muscles mainly (shoulder flexors, elbow extensors and wrist extensors)
- Strengthening exercises for weak lower limb muscles mainly (hip flexors & abductors, knee flexors & extensors and ankle dorsiflexors).
- Stretching exercises for the affected lower limb muscles mainly (hip adductors,knee flexors and ankle planter flexors. Repition of each exercise was ranged from three to five times according to each patient ability.
- Weight bearing on the affected side : the patient stood in front of wall and tried to bear weight on the affected lower limb for ten seconds and then relax. The exercise

repeated from five to ten times according ability of each patient.

- Balance training on balance board.

Statistical Analysis

- Descriptive statistics and t-test for comparison of the mean age, weight, height, BMI, and duration of illness between both groups (A and B).
- Paired t test was conducted for comparison between pre and post treatment measurements in each group.
- T test was conducted for comparison between pre and post treatment measures between group A and B.
- The level of significance for all statistical tests was set at $p < 0.05$.
- All statistical measures were performed through the statistical package for social studies (SPSS) version 19 for windows.

Results

No significant differences in demographical (age and gender) or clinical (duration of illness) variables at inclusion were detected between groups (Table. 1). No statistically significant differences were found in base line measurements between both groups (Table 2). There was significant difference for all variables before and after treatment for both groups table 3,4. However the study group (GA) showed more improvement in proportion to the control group (GB) as shown in table 5.

Table 1. General characteristics of the patients

	Group A	Group B	MD	t- value	p-value	Sig
	$\bar{X}$ ±SD	$\bar{X}$ ±SD				
Age (years)	57.26 ± 4.66	58.66 ± 4.65	-1.4	-0.82	0.41	NS
Weight (kg)	85.6 ± 2.37	86.2 ± 2.78	-0.6	-0.63	0.53	NS
Height (cm)	165.33 ± 2.1	165.6 ± 2.64	-0.27	-0.3	0.76	NS
BMI (kg/m²)	31.32 ± 1.13	31.6 ± 1.49	-0.28	-0.57	0.57	NS
Duration of illness (months)	18 ± 3.25	19.46 ± 3.22	-1.46	-1.24	0.22	NS

$\bar{X}$: Mean SD: Standard Deviation MD: Mean difference
t value: Unpaired t value p value: Probability value NS: Non significant

Table 2. Comparison between pre treatment mean values of gait parameters of group A and B

	Group A	Group B	MD	t-value	p-value	Sig
	$\bar{X}$ ±SD	$\bar{X}$ ±SD				
Walking speed (m/sec)	0.35 ± 0.01	0.36 ± 0.02	-0.01	-0.82	0.41	NS
Gait cycle (cycle/sec)	0.54 ± 0.03	0.53 ± 0.04	0.01	0.67	0.5	NS

$\bar{X}$: Mean SD: Standard Deviation MD: Mean difference
t value: Unpaired t value p value: Probability value NS: Non significant

Table 3. Gait parameters in study group (GA)

	Pre	Post	MD	% of improvement	t-value	p-value	Sig
	$\bar{X}$ ±SD	$\bar{X}$ ±SD					
Walking speed (m/sec)	0.35 ± 0.01	0.46 ± 0.02	-0.11	31.42	-13.82	0.0001	S
Gait cycle (cycle/sec)	0.54 ± 0.03	0.64 ± 0.03	-0.1	18.51	-31.62	0.0001	S

$\bar{X}$: Mean SD: Standard Deviation MD: Mean difference
t value: Paired t value p value: Probability value S: Significant

Table 4. Gait parameters in control group (GB)

	Pre	Post	MD	% of improvement	t-value	p-value	Sig
	$\bar{X}$ ±SD	$\bar{X}$ ±SD					
Walking speed (m/sec)	0.36 ± 0.02	0.4 ± 0.02	-0.04	11.11	-13.71	0.0001	S
Gait cycle (cycle/sec)	0.53 ± 0.04	0.57 ± 0.04	-0.04	7.54	-16	0.0001	S

$\bar{X}$: Mean SD: Standard Deviation MD: Mean difference
t value: Paired t value p value: Probability value S: Significant

Table 5.comparison between post treatment mean values of gait parameters of group A and B

	Group A	Group B	MD	t-value	p-value	Sig
	$\bar{X}$ ±SD	$\bar{X}$ ±SD				
Walking speed (m/sec)	0.46 ± 0.02	0.4 ± 0.02	0.06	6.44	0.0001	S
Gait cycle (cycle/sec)	0.64 ± 0.03	0.57 ± 0.04	0.07	5.2	0.0001	S

$\bar{X}$: Mean SD: Standard Deviation MD: Mean difference
t value: Unpaired t value p value: Probability value S: Significant

Discussion

The current study was conducted to explore the effect of transcranial direct current stimulation on kinematic gait parameter in stroke patients. The patients were assigned randomly into two equal groups; study (group A) and control (group B). The study group received selective physical therapy program as well as transcranial direct current stimulation (TDCs). while the control group received the selective physical program only.

In this study, there was no statistical significant difference in the mean values of ages and duration of illness between the patients of both groups. This indicates that the selection of the patients in two groups were homogenous

The results of the present study revealed significant increase in walking speed post treatment in both group (A and B) especially in the study group. The increase in gait velocity may be due to increased step length and cadence in agreement to that reported by sungkarat et al., (2010)[(12)].

The results of present study revealed a statistical significant increase of step cycles/sec in the study compared to the control group post treatment. This finding agreed with the result of (Giacobbe et al., 2013) who conducted anodal TDCS for 20 minutes for 12 chronic stroke patient (> 6month) before robotic practice and found significant improvement in gait speed by 20% compared to control group who receive robotic practice only[13].

The explanation of improvement of kinematic gait parameter following application of anodal TDCs to ipsilesional hemisphere may be due to increase in spontaneous firing rate and excitability of cortical neurons by depolarizing the membrane[14].

The result of this study contradicted with Geroin et al.,(2011) who examined the combined TDCS and robot assisted gait training in patient with chronic stroke and reported that direct current stimulation had no additional effect on robot-assisted gait training in patients with chronic stroke. Investigators in this study applied 1.5 mA during locomotor training for 7 minutes. In our study we delivered 2.0 mA for 20 minutes before the training. It is possible that the intensity, duration and timing of their tDCS protocol were not optimal for gait rehabilitation in stroke[15].

Conclusions

In view of the results of this study , it can be concluded that transcranial direct current stimulation had a benfical effect on selected gait kinematics in stroke patients, so it is recommended to be added to the physical therapy program for stroke patients who had gait problems.

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