Journal of Critical Reviews

ISSN- 2394-5125 Vol 7, Issue 8, 2020

Article

INFLUENCE OF CEREBELLAR TRANSCRANIAL DIRECT CURRENT STIMULATION ON REACHING KINEMATICS IN CHRONIC STROKE PATIENTS: A CONTROLLED RANDOMIZED STUDY

BASMA HUSSIEN MOHAMED[1], NAHED AHMED SALEM[1], EBTESAM MOHAMED FAHMY[2], RASHA MOHAMED EL REWAINY[1]

[1]Department of Physical Therapy for Neuromuscular Disorder and its Surgery, Faculty of Physical Therapy, Cairo University, Giza, Egypt.

[2]Neurology Department, Faculty of Medicine, Cairo University, Giza, Egypt.

*Corresponding author E-mail:Hussienbasma800@yahoo.com

Received: 11.03.2020 *Revised: 12.04.2020* *Accepted: 28.05.2020*

Abstract: Background: Cerebellar transcranial may be a promising manner for the reconstitution of reaching coordination deficits for stroke patients. Objective: To research the result of cerebellar direct current stimulation on reachingcoordination in Egyptian chronic stroke Patients & Methods: Randomly dividing for Thirty chronic stroke patients to a pair of groups; Group A: exposed to cerebellar Transcranial direct current stimulation with physiotherapy program and B: exposed to selected physical therapy program solely. Treatment sessions were performed three times/week for five sequential weeks. Arm reaching function and coordination was assessed using the Fugl-Meyer arm section scale (FMUA) and Action Research Arm Test (ARAT), wheres analysis of acceleration and movement time of reaching was done using video processing by Kinovea software system program. Results: Significant increase of Fugl-Meyer arm section scale and Action Research Arm Testpost-treatment in group A only. A extremely significant increasein the mean accelerationwas found post-treatments, with a tendency towards the significant distinction between each groups post-treatment in favor of group A. Significantly decreasing in movement time of specific reaching phase in post-treatment for the group (A). Moreover, a significant distinctionin movement time was detected between both groups post-treatment Conclusion: Cerebellar transcranial direct current stimulation is beneficial in improving reaching perform and coordination deficits in chronic stroke patients.

Key Words: Cerebellar Transcranial direct current stimulation, stroke, reaching

1 INTRODUCTION

Stroke is a harmful disease and conjiontly the leading reason of incapacity in adults. There are over six million have disabilities as a result of stroke [1]. Stroke causes specific deficits of coordination movements in between the hand and thearm which is principal components for successful reach to grasp (RTG). After stroke reaches to grasp (RTG) movements is also restricted and seem clumsy. Treatment of upper limb coordination deficits in reaching and effectiveness could improve recovery of reach to grasp performance [2].

Increase using for cerebellar transcranial direct current stimulation (tDCS) neuroscience laboratories and conjointly for clinical investigations in last few years [3]. C-tDCS investigationscould improve motor performances for the youngest on 2-dimensional arm movement tasks within the horizontal plane[4]. Cerebellar transcranial direct current stimulation (tDCS) induces neurophysiological changes in cerebellar-brain interaction, wherever might influence gait coordination, motor learning, and cognition. Cerebellar transcranial direct current stimulation (tDCS) was very useful by varied disorders [5].

Investigated of cerebellar transcranial effects direct current stimulation in improving coordination deficits reaching in chronic stroke in Egypt.

2 MATERIAL AND METHODS

The study was applied on thirty patients with first-ever cerebrovascular stroke. Patients were chosen from the outpatient clinic of BeniSwef University Hospitals with in the amount from Jan 2017 to Decr2018. The aim and procedure illustrate to all participants and inform them by written consent obtained before being enrolled. The ethical committee was accepted for our investigation (Registration number: P.-T.REC/012/001769). physical therapy in Neuromuscular Disorders and its Surgery, Physical Therapy Faculty/ Cairo University

Randomly dividing into thirty Patients into two equal groups, Group (A) received cerebellar transcranial direct current stimulation and a selected physiotherapy program and Group (B) received the selected physiotherapy program only.

Inclusion criteria were: Patients with first-ever ischemic cerebrovascular stroke who had arm reaching coordination problems, age ranged from forty to sixty years old, (illness a minimum of six month from stroke and ten years of traditional education, grade of spasticity(

1 to 1+) accord to modified Ashworth scale, grade of muscle power ≥ 3 (manual muscle), Fugl-Meyer arm section scale (FMUA) score ranged between 30 and 49, Mini-Mental State Examination score ≥ 25 and normal hearing and vision.
Exclusion criteria were: Recurrent cerebrovascular stroke or different concomitant neurological disorders, medical sickness as the stiffness of arm, peripheral nerve injuries and shoulder pain, seizure disorders, and wounds in skull skin.

3 Methods:
Instrumentations:
1) FuglMeryer arm section Assessment Scale (FMUA):could be a well-designed, comprehensive scale widely used to evaluate motor control reflex activity, muscle strength. The arm section (4 sub-items). Each one rate for 3 scales (cannot perform =0 ; partly perform =1; Perform fully=2) / 66-point maximum [6].
2) Action Research Arm is ordinal scale measured upper-extremity (arm and hand) function, coordination, and hand -dexterity consists of 4 fundamental movements: grasp, grip, pinch, and gross movements [7].
3) Kinovea software system program is software for analysis movements. It consists of a digital video camera and a digitizing software program. The camera was placed 1.5 m far away from the participants on a stand at a height of 80 cm [8]. To keep the identical distance between the camera and therefore the patients; the stand was placed on taped markers on the ground. All images were imported into portable computer and analyzed using Kinovea software system , Subjects were asked to perform a reaching task while seated in a straight-back chair or their wheelchair. Their trunks were stabilized to the back of a chair to reduce compensatory movements of the trunk, the shoulders were in just about 0° flexion and extension and 0° of internal rotation and threrfore elbows were in 75° to 90° flexion, with wrists in apalm down position , and finger joints were in slight flexion. The start, reaching, and ending position components of the event were determined through the velocity measurement reading **(Table 1)**[9].

Table (1): Phase movement definitions in reaching.(Bahria., et al ,2018)

Detect by	Activity	Phase
Velocity value equal zero	Hand position were horizontal with the target object	Rest Position
Velocity value positively increased	Hand begin to move towards the target object	Move Forward
Velocity value equal zero/nearly zero	Hand will reach the target object and stop for a second	Reaching target
Velocity value negatively decreased	From the target object hand will move back ward to rest position	Move Backward
Velocity value equal zero	Hand position were horizontal with the target object	Rest Back

Instrumentations for Treatment:
- Transcranial direct current stimulation (tDCS) device: Gymna- uniphy (PHY-action 787) is an advanced Electro-therapeutic appliance. It can give every form of electro-therapy from low frequency to medium frequency currents coursing through one or two output channels, with or without making use of the constitutional vacuum unit.

Procedures:
1) Cerebellar transcranial direct current stimulation: Scalp skin inspected for irritation, cuts, or lesions to avoid transcranial direct stimulation (tDCS). Hair removed from the stimulation site and skin cleaned. Applied transcranial stimulation through two electrodes (5 x 5 cm) incased in saline-soaked sponges to decrease electric resistance. The anode was put on the cerebellum and cathode put on ipsilateral shoulder. Session must be stopped if the patient feels headache, severe itching sensation, or severe numbness under the electrode areas, dizziness, or sense of vomiting [10].
2) A selected physical therapy program of reach to grasp training for an hour 3/ week for 5 weeks (15 sessions). It included: stretching exercise, graduated active exercises, proprioceptive neuromuscular facilitation technique (PNF), and repetitive task training.
Treatment sessions were performed three times per week for five sequential weeks.
Statistical analysis
Data were analyzed by SPSS /22. Comparing data pre and post treatment within the group using paired *t*-test. And in between groupsby unpaired t-test. $P < 0.05$.

4 RESULTS:

Subjects:
The average ages were 55.68±8.65 years for the first exponential group (A) and 56.86±8.28 years for the second group (B). The mean duration of illness was 10.23+2.07 months for group A and 9.34±3.1 months for B. No significant difference was observed between A and B in average age and illness duration.
In A, where 6 patients had right hemiparesis(40%) and 9 left hemiparesis(60%), In group B, 8 patients had right hemiparesis(53.3%) and 7 left hemiparesis(46.7%).
Fugl-Meyer arm Scores section scale (FMUA):
Significant increase in FMA scores for post-treatment in A (p= 0.008), while no significant difference was noted between A and B in mean FMUA scores either pre or post-treatment (P= 0,444, 0.245 respectively). **(Tab. 2)**.

Table (2) : Comparison of mean values of fugl- meryer scale test pre and post treatment within and between groups.

FMUA test	Mean±SD	Mean±SD	% of improvement	t-value	p-value
	Pre test	Post test			
Group A	**52.2±4.4**	**56.46±3.81**	**4.2**	**2.835**	**0.0084***
Group B	**50.3±8.4**	**53.8±7.8**	**3.5**	**1.183**	**0.2469**
t-value	**-0.776**	**-1.187**			
p-value	**0.4442**	**0.2451**			

SD: standard deviation**highly significant differences

Action research arm test Scores (ARAT):
Significant increase in mean ARAT scores post-treatment for A, in contrast, no significant difference between A and B in mean ARAT scores either pre or post-treatment. **(Tab. 3)**

Table (3): Comparison of mean scores of action research arm test pre and post treatment within and between groups

ARAT	Mean±SD	Mean±SD	% of improvement	t-value	p-value
	Pre test	Post test			
Group A	37.5±5.19	42.13±6.07	4.6	2.241	0.0331*
Group B	38.13±6.09	39.13±5.3	1.000	0.480	0.6351
t-value	0.305	-1.401			
p-value	0.7627	0.1606			

*significant at p<0.05SD: standard deviation

Reaching phase acceleration:
Acceleration values were increased Significantly in both A and B post-treatment (p= 0.0003, 0.0004 respectively, a tendency towards significantly for acceleration in all experimental groups post-treatment, in favor of group A(P= 0,05).. **(Tab. 4)**

Table (4) Comparison of mean values of acceleration pre and post treatment within and between group

Acceleration test (m/sec)	Mean±SD	Mean±SD	% improvement	t-value	p-value
	Pre test	Post test			
GroupA	2.50±0.5	3.12±0.3	0.6	4.118	0.0003**
Group B	2.22±0.37	2.82±0.5	0.6	3.985	0.0004**
t-value	-1.868	-1.993			
p-value	0.0723	0.0561~			

~:trend wise significant **highly significant differences

Movement Time of reaching phase:
significantly decreasing in movement time for a specific reaching phase in A post-treatment (p= 0.04). Also, there was a significant difference in movement time between groups post-treatment (P= 0,038), being significantly lower in group A **(Tab. 5)**

Table (5):Comparison of mean values of movements time pre and post treatment within and between groups.

MT Test (sec)	Mean± SD	Mean±SD	% of improvement	t-value	p-value
	Pre test	Post test			
Group A	5.3±1.28	4.4±0.8	0.8	-2.053	0.0496*
Group B	6.13±1.09	5.2±1.18	0.9	-1.712	0.0980
t-value	1.912	2.173			
p-value	0.0662	0.0384*			

*significant at p<0.05

5 DISCUSSION

Reach and grasp ability are the most component of several daily life functionally task. Residual upper extremity motor impairment is commonly posted stroke and could restrict functional abilityand participating in many functional activities [11].
Significantly increasing post-treatment for FMUA scores in group A and that in agreement with results of Kim [12] and Baker and colleagues [13] who rumored a significant improvement in motor function with electrical stimulation of ascending cerebellar output of supra-tentorial stroke combined with motor training of the forelimb.
Moreover, Kaminski and colleagues [14] declared that cerebellar tDCS had not improved complex body dynamic balance tasks for young which could help learning of elderly patients and cerebellar deficits cases .
In contradistinction, Giacomo[15] found that no significant differences in fugl-Meyer assessment after 3 weeks of treatment with cerebellar intermittent burst stimulation applied over the cerebellar hemisphere. Summers [16]also notice that ctDCS applied during task training is able of modifying or interfering in corticospinal excitability without disrupting performance improvement.
Significantly increasing action research arm test (ARAT) scores for post-treatment in group A indicating an improvement in performance (coordination, dexterity, and functioning) which is similar to observation of Elsner and colleagues [17] and Antal and colleagues [18]. Also, Allman & colleagues [19]checked the influence of anodal tDCS with pairing a 9-day motor training program and discovered an improvement in the ARAT scale .
On the contrary, Kang and colleagues [20] found little to null effects of TDCs on recovery of upper limb motor tasks after stroke. Also, Sadnicka[21] had not found any effects of Appling rightcerebellar transcrainal stimulation on inhibition of motor surround brain areas in healthy individuals.,Gironell[22] reported that transcrainal stimulation of cerebellum alone was not specific enough to modify and improve functional tasks.
Significantly increasing in acceleration in groups A and B post-treatment moreover, a tendency towards significant difference in acceleration between A and B/ post-treatment. The results come in agreement with Chothia[23] andManto[24] they found cerebellar stimulation followed

by anodal stimulation of the contralateral motor cortex causes reduction of upper limb tremor and decrease hypermetria in two patients with dominant ataxia. On the contrary, Grimaldi and colleagues [25] reported that anodal ctDCS did not improve upper limb manual dexterity and coordination deficits with using a mechanical counter test. Also, Hulst[26]discovered that patients do not gain any improvement in coordinated reaching tasksfrom the cerebellar or motor area (M1) transcranial direct current stimulation during force-field reaching coordination test .

The tendency towards a significant difference in acceleration values between both groups post-treatment may be due to modulated cerebellar-thalamic cortical pathways and enhanced Purkinje cell firing as a primary effect of ctDCS[27].

Significant improvement in movement duration of specific reaching phase in experimental groups in agreement Galea and colleagues [28] and Cantarero[29] who found ctDCS caused faster reaching movement adaptation to the visuomotor transformation. Also, Block and colleagues [30]found that cerebellar stimulation has polarity effect when adapting to force field perturbations device . Ivry&colleagues [31] suggested that ctDCS restores the property of the cerebellar-thalamocortical pathway and internal representation of temporal information modified. However, Jayaram and colleagues [32] reported that Anodal ctDCS could improve reaching adaptation.

6 CONCLUSION

Cerebellar stimulation is safe and effective neuro-rehabilitation modality which could improve motor function in several domains such as coordination, performance, and motor learning. Moreover, cerebellar transcranial direct current stimulation combined with training has a positive outcome on performance for activities. We recommend that using it in rehabilitation for post-stroke dysfunctions.

FUNDING:

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

7 REFERENCES

1. Lakhan SE, Kirchgessner A, Hofer M. Inflammatory mechanisms in ischemic stroke: therapeutic approaches. J Transl Med. 2009; 7(1):97.
2. Wu CY, Chou SH, Kuo MY, Chen CL, Lu TW, Fu YC. Effects of object size on intralimb and interlimb coordination during a bimanual prehension task in patients with left cerebral vascular accidents. Motor Control. 2008; 12(4):296-310.
3. Ferrucci R, Brunoni AR, Parazzini M, Vergari M, Rossi E, Fumagalli M, et al. Modulating human procedural learning by cerebellar transcranial direct current stimulation. The Cerebellum. 2013; 12(4):485-92.
4. Celnik P. Understanding and modulating motor learning with cerebellar stimulation. The Cerebellum. 2015; 14(2):171-4.
5. Dutta A, Paulus W, Nitsche MA. Facilitating myoelectric-control with transcranial direct current stimulation: a preliminary study in healthy humans. J NeuroengRehabil. 2014; 11(1):13.
6. Fugl-Meyer AR, Jääskö L, Leyman I, Olsson S, Sterling S. The post-stroke hemiplegic patient. 1. amethod for evaluation of physical performance. Scand J Rehabil Med. 1975; 7(1):13-31.
7. Lyle RC. A performance test for assessment of upper limb function in physical rehabilitation treatment and research. Int J Rehabil Res. 1981; 4(4):483-92.
8. Mahmud J, Holt CA, Evans SL. An innovative application of a small-scale motion analysis technique to quantify human skin deformation in vivo. J Biomech.2010; 43(5):1002-6.
9. Abidin SB, Jusoh WN, Beng GK. Kinematic analysis on reaching activity for hemiparetic stroke subjects using a simplified video processing method. Malaysian Journal of Fundamental and Applied Sciences. 2018 Sep 3;14(3):386-90.
10. Lum PS, Mulroy S, Amdur RL, Requejo P, Prilutsky BI, Dromerick AW. Gains in upper extremity function after stroke via recovery or compensation: potential differential effects on the amount of real-world limb use. Top Stroke Rehabil. 2009; 16(4):237-53.
11. Grimaldi G, Argyropoulos GP, Bastian A, Cortes M, Davis NJ, Edwards DJ, et al. Cerebellar Transcranial Direct Current Stimulation (ctDCS) a novel approach to understanding cerebellar function in health and disease. Neuroscientist. 2016 ;22(1):83-97.
12. Kim DY, Lim JY, Kang EK, You DS, Oh MK, Oh BM, et al. Effect of transcranial direct current stimulation on motor recovery in patients with subacute stroke. Am J Phys Med Rehabil. 2010 ;89(11):879-86.
13. Baker KB, Schuster D, Cooperrider J, Machado AG. Deep brain stimulation of the lateral cerebellar nucleus produces frequency-specific alterations in motor evoked potentials in the rat in vivo. Exp Neurol. 2010 ;226(2):259-64.
14. Kaminski E, Hoff M, Rjosk V, Steele CJ, Gundlach C, Sehm B, et al. Anodal transcranial direct current stimulation does not facilitate dynamic balance task learning in healthy old adults. Front Hum Neurosci. 2017;11:16.
15. Koch G, Bonnì S, Casula EP, Iosa M, Paolucci S, Pellicciari MC, et al. Effect of cerebellar stimulation on gait and balance recovery in patients with hemiparetic stroke: a randomized clinical trial. JAMA Neurol. 2019;76(2):170-8.
16. Summers RL, Chen M, Hatch A, Kimberley TJ. Cerebellar transcranial direct current stimulation modulates corticospinal excitability during motor training. Front Hum Neurosci. 2018;12:118.
17. Elsner B, Kwakkel G, Kugler J, Mehrholz J. Transcranial direct current stimulation (tDCS) for improving capacity in activities and arm function after stroke: a network meta-analysis of randomized controlled trials. J NeuroengRehabil. 2017;14(1):95.
18. Antal A, Bikson M, Datta A, Lafon B, Dechent P, Parra LC, et al. Imaging artifacts induced by electrical stimulation during conventional fMRI of the brain. Neuroimage. 2014;85:1040-7.
19. Allman C, Amadi U, Winkler AM, Wilkins L, Filippini N, Kischka U, et al. Ipsilesional anodal tDCS enhances the functional benefits of rehabilitation in patients after stroke. SciTransl Med. 2016 ;8(330):330 re1-.

20. Kang N, Summers JJ, Cauraugh JH. Transcranial direct current stimulation facilitates motor learning post-stroke: a systematic review and meta-analysis. J NeurolNeurosurg Psychiatry. 2016;87(4):345-55.
21. Sadnicka A, Kassavetis P, Saifee TA, Pareés I, Rothwell JC, Edwards MJ. Cerebellar transcranial direct current stimulation does not alter motor surround inhibition. Int J Neurosci. 2013;123(6):425-32.
22. Gironell A, Martínez-Horta S, Aguilar S, Torres V, Pagonabarraga J, Pascual-Sedano B, et al. Transcranial direct current stimulation of the cerebellum in essential tremor: a controlled study. Brain Stimul. 2014 ;7(3):491-2.
23. Chothia M, Doeltgen S, Bradnam LV. Anodal cerebellar direct current stimulation reduces the facilitation of propriospinal neurons in healthy humans. Brain Stimul. 2016 ;9(3):364-71.
24. Manto M, Marmolino D. Cerebellar ataxias. CurrOpin Neurol. 2009 ;22(4):419-29.
25. Grimaldi G, Manto M. Anodal transcranial direct current stimulation (tDCS) decreases the amplitudes of long-latency stretch reflexes in cerebellar ataxia. Ann Biomed Eng. 2013;41(11):2437-47.
26. Hulst T, van der Geest JN, Thürling M, Goericke S, Frens MA, Timmann D, Donchin O. Ageing shows a pattern of cerebellar degeneration analogous, but not equal, to that in patients suffering from cerebellar degenerative disease. Neuroimage. 2015 ;116:196-206.
27. Ferrucci R, Priori A. Transcranial cerebellar direct current stimulation (tDCS): motor control, cognition, learning, and emotions. Neuroimage. 2014 ;85:918-23.
28. Galea JM, Vazquez A, Pasricha N, Orban de Xivry JJ, Celnik P. Dissociating the roles of the cerebellum and motor cortex during adaptive learning: the motor cortex retains what the cerebellum learns. Cerebral cortex. 2010; 21(8):1761-70.
29. Cantarero G, Spampinato D, Reis J, Ajagbe L, Thompson T, Kulkarni K, et al. Cerebellar direct current stimulation enhances on-line motor skill acquisition through an effect on accuracy. J Neurosci. 2015;35(7):3285-90.
30. Block H, Celnik P. Stimulating the cerebellum affects visuomotor adaptation but not inter manual transfer of learning. The Cerebellum. 2013;12(6):781-93.
31. Iyer MB, Mattu U, Grafman J, Lomarev M, Sato S, Wassermann EM. Safety and cognitive effect of frontal DC brain polarization in healthy individuals. Neurology. 2005;64(5):872-5.
32. Jayaram G, Tang B, Pallegadda R, Vasudevan EV, Celnik P, Bastian A. Modulating locomotor adaptation with cerebellar stimulation. J