academicresearchJournals

Vol. 3(4), pp. 122-126, April 2015
DOI: 10.14662/IJELC2015.035

ISSN: 2360-7831
http://www.academicresearchjournals.org/IJELC/Index.htm

International Journal of English Literature and Culture

Full Length Research

Effect of different approaches of task oriented training on sensory area excitability in chronic stroke patients

***Walaa M Ragab [1], Mohamed S El Tamawy [2], Moshera H Darwish [1], Ann A Abd El Kader [3], Mye A Basheer[3]**

Physical Therapy for Neuromuscular Disorders and Its Surgery[1], Departments of Neurology[2], Clinical Neurophysiology [3], Cairo University.
*Corresponding Author's E-mail: Ragab_walla@yahoo.com

Accepted 1 May 2015

Background and Purpose: The aim of this study was to assess the effect of different approaches of task oriented training on sensory area excitability (i.e. neuroplasticity) in the chronic stroke patients. Methods: Forty five male chronic stroke patients with moderate impairment of function of the left UE were assigned into three equal groups. The changes of sensory area excitability were assessed before , immediately and long term(retention effect after two months of stopping training program) after arm training by spectral analysis of digital Electroencephalography (d-EEG). Patients in group 1 (G1) received task oriented in form of unilateral arm training , patients in group 2 (G2) received task oriented in form of bilateral weighted arm training and patients in group 3 (G3) received task oriented in form of bilateral arm training without weight . Results: A significant immediate and long term increase was seen in excitability at P4 area in G3 and G2 compared to G1 (*P≤ .001 and P≤ .002* respectively) *.* Conclusion: Task oriented arm training in form of bilateral arm training with and without weight is superior to task oriented arm training in form of unilateral arm training and are recommended methods to enhance the neuroplasticity at sensory area in chronic stroke patients.

Key words: Chronic Stroke -Task Oriented- Neuroplasticity-Brain Electrical Activity Mapping

Cite This Article As: Ragab WM, El Tamawy MS, Darwish MH, El Kader AAA, Basheer MA (2015). Effect of different approaches of task oriented training on sensory area excitability in chronic stroke patients*.* Inter. J. Eng. Lit. Cult. 3(4): 122-126

INTRODUCTION

Sensory abnormality is a common problem after stroke. Impairment of sensation affects the motor recovery of stroke patients (Bayona et al., 2005). The abnormality of movement in the chronic stroke patients is due to depleted movement execution pathways. The movement execution centers depend on sensory information and input from sensory area (Mudie and Matyasoe, 2000). According to Kwakkel et al. 30–66% of all individuals after six months post-stroke have persistent arm impairment (Kwakkel et al., 2003). This poor recovery of motor and sensory function is due to plateau of motor and sensory areas plasticity (Dobkin, 2004). The therapeutic approaches that exploit the plasticity of the nervous system are needed to decrease stroke disability (Stoykov and Corcos, 2009).

Task oriented enhances the recovery in the stroke patients. The task oriented training uses tasks which are meaningful to the patient and involves repetition and practice (Langhammer and Stanghelle, 2000). It has been found to be effective in cognitive neural rehabilitation, sensory retraining, gait retraining, sit-to-stand retraining and motor training of the upper limb (Winstein and Campbell, 2006). Bilateral therapy involves the use of both ULs either simultaneously or not (McCombe et al., 2006). The intact UL facilitates relearning of the spatial and temporal parameters required for motor and sensory recovery in the paretic UL (Cauraugh and Summers, 2005). Task oriented training in form of bilateral arm training with and without weight augments sensory recovery in chronic stroke patients. The synchronous bilateral UL movements result in increase in ipsilesional hemisphere excitability, transcallosal inhibition from ipsilesional to contralesional hemispheres and intracortical inhibition within the contralesional hemisphere (Carey et al., 2002).

Spectral analysis of d-EEG can be quantified in terms of its amplitude, power, frequency, and rhythmicity in order to generate numerical values, ratios, or percentages. These values can then be compared between different regions (Lopes, 2010).

Aim of work

This study was conducted to assess the effect of using Effect of task oriented training on sensory area excitability (neuroplasticity) in chronic stroke patients as it is very important area for motor recovery of stroke patients. Also it was conducted to find the best approaches of training (unilateral or bilateral brain and arm training)to enhance brain plasticity especially at sensory areas in chronic stroke patients whose brain plasticity is usually slowed or stopped after two years of stroke.

SUBJECTS AND METHODS

All the patients were referred from a neurologist. The diagnosis was confirmed by MRI and/or CT scan. The patients were selected from the Outpatient Clinic of Kasr El Aini, Teaching Hospital, Cairo University and from the Out-Patient Clinic, Faculty of Physical Therapy, Cairo University. The study has been reviewed by the appropriate ethics committee (Shrestha, 2012). It was applied in the period between 2012-2014.

The study was conducted on 45 right handed males having left chronic stroke. The age of the patients ranged from 45-60 years old. The patients were allocated to three groups; G1, G2 and G3; each containing 15 patients. The patients from both groups were matched for age as well as stroke duration. Task oriented unilateral arm training was assigned to G1 patients, while task oriented bilateral weighted arm training was assigned to G2 patients and task oriented bilateral arm training was assigned to G3 patients.

The study included patients with sustained single cerebro-vascular accident (CVA) of an ischemic type at the right hemisphere that started since twelve to twenty four months at the time of involvement to this study. The patients had the ability to follow the simple instructions, volitional control of the non- paretic arm, and at least minimal antigravity movement in the shoulder of the paretic arm. All the patients had a moderate impairment for the upper extremity according to Fugle –Myer assessment scale (FMAS). The scores of upper limb impairment ranged from 19-40 (Gladstone et al., 2002). While it excluded patients with aphasia, significant orthopedic or chronic pain conditions, significant musculotendinous or bony restrictions of the affected upper limb. Also, patients with an affected sided neglect, perceptuo-motor or visual field deficits, apraxia and shoulder subluxation.

All the patients were subjected to complete neurological examination; detailed medical history, motor, sensory and activity of daily living (ADL) examination. The spectral analysis of d-EEG was used to assess the neuroplasticity at the sensory area of the affected hemisphere before and after arm training.

***Training procedures:**

The patient received inhibitory techniques in form of prolonged stretch first for the spastic muscles then from a sitting position and in front of mirror the training program was applied to enhance specific muscles. The course of training was applied three times per week for six weeks (eighteen sessions). The researcher helped the patient to complete the task as needed. The speed and the level of the task maintained and not increased until the patients managed to perform it alone without any assistant or synergy. Five continuous minutes of exercise with ten minutes rest was considered as one repeation.

Reaching forward to a level of 90° with elbow extension then retracting the scapula backward with elbow flexed was repeated two times for shoulder flexion. Shoulder abduction with elbow flexion then extension as trying to touch the head and to reach to the level of shoulder respectively was applied for one repeation for each exercise. Trying to reach to the lower back was applied for two repeations. Supination –pronation as trying to open the door from a flexed elbow then from an extended elbow and trying to extend wrist were applied in form of one repeation for each exercise. The patients in G3 performed this program of training by moving both limbs synchronously so the affected limb reached to the same level of the non affected one. While the patients in G2

Table 1: The mean values of d-EEG spectral analysis from the affected sensory area P4:

Alpha+Beta1+Beta2 (fast waves) / Delta+Theta (slow waves)	Pre test	Post test	Retention test	F1 test	P value
	Mean± SD	Mean± SD	Mean± SD		
G1	45±2	45±1	45±1	.649	.477
G2	46±1	48±1	48±1	22.677	.004*
G3	46±1	49±2	48±2	20.666	.001*
F2 test	1.028	11.899	9.885		
P value	.382	.001*	.002*		

SD =Standard deviation * significant at P ≤ .05
F1 test= repeated measure ANOVA F2 test= One Way ANOVA

performed it bilaterally with weight on non affected limb and the patients in G1 performed it unilaterally by the affected limb only.

*__Spectral analysis of d-EEG:__

Spectral analysis of d-EEG was conducted on a Digital EEG-EP Multifunction System 10-20 Channel (Wide Band). It is EBNeuro - FLORENCE –ITALY. MIZAR-PC PERIPHERAL SYSTEM CE version - B9800037800. The Galileo Mizar system “digital electroencephalograph” realize the new EBNeuro DIGITAL EEG/EP line.

EEGs were recorded three times for each patient; before and after- the six weeks of- the training procedure and long term after stopping training by two months (pre test , post test and long term or retention effect). They were recorded according to the International 10–20 system, using a unipolar montage, using derivations F4, T4, C4, P4, O2, F3, F4, C3, P3 and O1. Delta, theta, alpha, beta1 and beta2 waves were recorded. Then these waves were transformed to the Standard Mean spectrum view to make spectral analysis by measuring average ranges of each wave at P4 sensory area of the affected hemisphere.

The equation which was used to detect the neural plasticity and the changing at sensory area excitability was dividing the fast wave/ slow waves or detecting the ratio of mean frequency of (beta 2+ beta 1+alpha/ theta+ delta). Increasing the ratio indicates increasing the fast waves or decreasing the slow waves that means learning ability of sensory area or neuroplasticity (Sheorajpanday et al.,2010) and physical therapy training is based on robotic bilateral training (Ching-yi et al., 2012).

***Data analysis and statistical design:**

One way ANOVA was used to assess the significant difference between the three groups on pre and post and long term (retention) tests. The repeated measure ANOVA was used for each group to assess the significant changes from pre to post and long term (retention) tests on the sensory area excitability (neuroplasticity). The data was coded and entered using statistical package SPSS Version 22 .All statistical procedures were two-tailed with significance set at α level= 0.05 **.**

RESULTS

Comparison between the groups for the mean values of d-EEG spectral analysis from the affected sensory area at pre test in G1, G2 and G3 showed no significant difference (Table 1).

Comparison of the mean values of d-EEG spectral analysis from the affected sensory area (P4) in G2 showed significant increase at post and retention tests (table 1). Comparing the mean values of the post and retention tests to the pre test showed significant increased (P≤.016) and (P≤.006) respectively.

Comparison of the mean values of d-EEG spectral analysis from the affected sensory area (P4) in G3 showed significant increase at post and retention tests (table 1). Comparing the mean values of the post and retention tests to the pre test showed significant increased (P≤.009) and (P≤.05) respectively.

Comparison of the post mean values of brain excitability from sensory area (P4) at G1, G2 and G3 showed a significant difference of brain excitability from sensory area (P4) between the three groups (table 1). Comparing the mean values of G2 and G3 to G1 by post hoc test showed a significant increased of G2 (P≤.003) and significant increased of G3 (P≤.002).

Comparison of the long term (retention) mean values of brain excitability from sensory area (**P4**) at G1, G2 and G3 showed a significant difference of brain excitability from sensory area (**P4)** between the three groups **(table 1).** Comparing the mean values of G2 and G3 to G1 by post hoc test showed a continuous significant increased of G2 (P≤.004) and G3 (P≤.002) with more evident for G3.

The mean values of d-EEG spectral analysis from the affected sensory area **(P4**) in G1 at pre test , post and retention (long term effect) tests showed no significant changes over three period of assessment in G1 (Table 1).

DISCUSSION

The results of the present study proved significant effect of task oriented arm training in form of (bilateral arm training and bilateral weighted arm training) on sensory area excitability (i.e. neuroplasticity) in the chronic stroke patients. Task oriented training was associated with normalization of sensorimotor cortex laterality. Bimanual arm training with and without are supposed to increase sensory area excitability after stroke by exploiting uncrossed pathways and intercallosal connections. It contributes to the normalization of inhibitory influences between the hemispheres. This normalization is the cause of increasing excitability of the sensory area and producing neuroplasticity in the affected hemisphere. Bimanual training leads to activation of extensive networks in both hemispheres, comprising a stronger involvement of the supplementary motor, cingulate gyrus and sensory areas. The result is agreed with other previous studies (Gerloff and Andres, 2002), (French et al., 2008), (Cauraugh et al., 2010) and (Timmermans et al., 2010)

Chronic stroke patients had poor recovery because the non affected hemisphere is the most working one. Chronic stroke patients learned non use of the affected one that increases the inhibition from the contra -lesion site to the lesion site but with bilateral arm training this inhibition decreases which leads to increase sensory and motor areas excitability. This also agreed with few earlier studies (Debaere et al., 2004), (Cramer, 2008) and (Schaechter and Perdue, 2008).

The present study is contradicting with (Gerloff and Andres, 2002) who reported no significant effect of bilateral arm training on improving the neuroplasticity in stroke patients. This contradiction might be due to working on subacute stroke not chronic stroke patients and the impairment degree was different between two studies. The present study is also contradicting with (Lotze et al., 2006) who concluded that the bilateral arm training did not produce any effect on the interhemisheric interaction or enhance the neural plasticity. That contradiction may due to using asymmetric bimanual movements, not symmetric bilateral arm movement as in the current study. That contradiction may also due to not using task oriented training.

CONCLUSION

Task oriented training in form of (bilateral weighted arm training and bilateral arm training) is a recommended method to increase sensory area plasticity and excitability in chronic stroke patients especially whose after two years of stroke.

ABBREVIATIONS

d-EEG: digital Electroencephalography
UL: Upper limb
CT: Computed tomography
MRI: Magnetic resonance image
CVA: Cerebro-Vascular Accident
FMAS: Fugle –Myer assessment scale
ADL: Activity of Daily Living

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