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Bilateral Arm Training Improve Reaching Kinematics in Hemiparetic Patients

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Abstract : Background and Purpose:Motor recovery after stroke is depending on the balance between neural network activity of both affected and non affected motor cortices. Bilateral arm training induce the rebalanced of inter hemispheric activation and inhibition. The aim of the study was to determine the improvement in reaching kinematics after bilateral arm training in hemiparetic patients. **Patients and Methods:** Twenty male patients with ischemic stroke included in this study and their age ranged between 40-55 years. Patients were divided randomly into two equal groups. The first group received bilateral arm training plus a selected physical therapy program. The second group received the selected physical therapy program only. Assessing kinematics of reaching movement of the affected upper limb was done before and after treatment using three-dimensional analysis. **Results:** Within the first group (before and after treatment) the results revealed that a statistically significant decrease in compensatory trunk displacement and decrease time of reach to grasp after treatment (P=<0.0002and P= 0.0001 respectively). Within the second group (before and after treatment) the results revealed that a statistically significant increase in compensatory trunk displacement(P=0.004) while there was no significance difference in time of reach to grasp after treatment (P=0.40). Between both groups, there was significant difference of trunk displacement and time of reach to grasp post treatment(P=0.0001 and p=0.0004 respectively) favouring first group. **Conclusion:** Bilateral arm training improves movement control and kinematics of reaching movement in affected upper limb in hemiparesis.

Key words: Stroke, neural network, bilateral arm training, time of reach, Trunk displacement and reaching kinematics.

Introduction

Plastic properties of central nervous system (CNS) allowing its adaptation through development and potentially activated in case of brain lesion. Motor function impairment characterises one of the major causes of disability after stroke, Pawel et al.[1]

Impairment of the upper limb function has negative impact on quality of life and disturbs activities of daily living (ADL). The recovery process occurs through different neural mechanisms mediating spontaneous cortical reorganization, but intensive training is essential to enhance motor recovery too, Urtonet al.[2]

Recovery of the upper extremity after stroke is typically poor, only, about 20% to 80% of patients demonstrating incomplete recovery depending on the initial stroke severity. Upper-limb impairment in stroke is characterized by paralysis, absence of manual dexterity, and movement abnormalities that may affect mainly on the performance of activities of daily living (ADLs) McCrea et al., [3]. Patients used frequently sound limb and decreased utilization of the affected one, both of them contribute to learned non-use Huang et al., [4].

Reaching ability is essential for nearly all activities of daily living (ADL) such as toileting, grooming, eating, transfers, and dressing. Reaching ability can be defined as the voluntary positioning of the hand at or near a desired location so that it may interact with the environment. It needs coordination of various joints and includes both the musculoskeletal and neural systems Morris et al.,[5].

Motor control of the trunk may be bilaterally controlled and so trunk is less affected than the upper limb in cases of unilateral hemispheric lesion. Therefore, patients tend to make more trunk displacement as an adaptation of the nervous system to overcome disabilities from reduce range of shoulder flexion and elbow extension in the hemi paretic limb Shumway and Woollacot,[6].

During reaching activities, trunk is involved in the reaching process and acts as a posture stabilizer. Stroke patients may depends on alternative strategies of the trunk to overwhelmed impairments when performing functional tasks and limit the subsequent motor movement of the paretic arm. Kinematic analysis of reaching forward should involve trunk movement to distinguish between compensation with the trunk and the reappearance of abnormal patterns Wu et al., [7].

The aim of the study was to investigate the effect of bilateral arm training(BAT) on reaching kinematics in hemiparetic patients.

Patients and Methods:-

Patients:-

Twenty male ischemic stroke stroke patients in the domain of carotid system based on careful clinical assessment by a neurologist and radiological investigations including computed axial tomography or magnetic resonance imaging of the brain. Patients Participates in this study have the following inclusion criteria: 1) male ischemic stroke 2) aged from 40 to55 years old 3) duration of illness from three months to one year 4) motor deficit involving one arm with the ability to perform at least 20°wrist extension and 10° finger extension,5)No serious cognitive deficits (score ≥ 24 on the Mini-Mental State examination), 6) muscle tone of affected upper limb ranged from 1 to 1+ according to Modified As worth Scale (MAS) Bohannon and Smith 1987. 7) Moderate arm motor impairment(between 30 and 49 scores) on the Fugl-Meyer (FM) arm section scale according to Michaelsen et al. [8]and 8)Patients had the ability to understand and follow simple instructions and two step commands. Exclusion criteria include patients who had recurrent stroke, moderate and sever spasticity, apraxia, unilateral spatial neglect, visual or auditory defects, other neurological ororthopedic disorders affecting the reaching to grasping ability such as ataxia, joints stiffness or subluxation, diabetic poly neuropathy, deep sensory loss and peripheral nerve injuries.

Patients were selected from the outpatient clinic of the Faculty of Physical Therapy, Cairo University. Patients were divided into two equal groups. The first group (Group I) received bilateral arm training plus a selected physical therapy program and the second group (Group II) received the selected physical therapy program only. A written consent forms must be signed by Every Patient approved by the Ethics Committee of the Faculty of Physical Therapy, Cairo University.

Instrumentation:-

For clinical evaluation:

The Modified Ashworth Scale is considered the primary clinical measure of muscle tone in patients with neurological conditions in clinical practice and research field. It is a rating scale to measure abnormality in tone or the resistance to passive movements. The Modified Ashworth Scale is a 6-point scale Bohannon and Smith[9]. Scores range from 0 to 4, where lower scores represent normal muscle tone and higher scores represent spasticity or increased resistance to passive movement.

The arm section of the FM scale was used for assessment of impairment of the upper limb and Modified As worth Scale for assessment of muscle tone for all patients was evaluated as inclusion criteria. FM scale is a stroke-specific, performance-based impairment index which includes 4 motor sub items. Each item was rated on a 3-point scale (0=cannot perform; 1=partially performs; 2=performs fully) for a 66-point maximum. Michaelsen et al.[8].

For kinematic Analysis: Two-Dimensional (2D) Motion Analysis System: It required a digital video camera and a digitizing software program Kirtley[10]. It was used to measure trunk displacement and time of reach to grasp.

Procedure:-

A) Evaluation Session:

- Assessment of arm motor impairment using the FM arm section scale and muscle tone assessment by using modified Ashworth scale. These tests were done pretreatment only for inclusion criteria.

For kinematic analysis: assessment start with the patient seated on chair without trunk restrain. Hip and knee joints flexed to 90° and feet supported on the floor. The affected arm was close to the body, elbow flexed 90°, forearm pronated and rested on patient's lab. The patient was asked to reach and grasp a target by the affected arm at his preferred speed using whole-hand grasping. The target was seated at a distance corresponds to 80% the patient's arm length Kirtley[10]. Four markers were placed on the following bony prominence; Ipsilateral acromion, lateral epicondyle, Centre of dorsal aspect of the wrist, and middle of iliac crest according to Mohammed et al.,[11].This test was done pretreatment and post treatment.

B) Training Session :-

The first group received training for 2-hour per day, 5 days per week, for 3 weeks. The participants concentrated on simultaneous movement of the ULs in functional tasks in symmetric or alternating patterns that emphasized both ULs moving synchronously, such as Grasping and folding a towel , unscrewing a bottle, where the non-affected hand stabilizes the bottle and the affected hand manipulates the cover, Lifting 2 cups, Reaching forward or upward to move blocks ,Alternative movements included exercises such as Alternative reaching forward or upward ,The patients were especially reminded of the importance of not letting the less-affected arm compensate too much for the weaker arm and the focus was to allow the participation from the affected arm in addition to the selected physical therapy program.

The second group received the selected physical therapy program only. This include Postural control and balance activities, Upper extremity control as the patient held the arm with the extended elbow then eccentric and finally concentric, Proprioceptive Neuromuscular Facilitation (PNF), Weight bearing and weight shift exercises as modified plantigrade, Lower limb control and Gait training. It was given for patients in two groups.

Data Analysis: Sagittal movement of acromion marker from the edge of the chair in millimetres was calculated to determine Trunk displacement and Time of reach to grasp was calculated from movement end time corresponded to the moment of hand contact with the target.

Statistical Analysis:-

Descriptive statistics were done in the form of mean and standard deviation for age, duration of illness, arm impairment by FM scale, trunk displacement and time of reach to grasp. Paired t-test was used to assess changes within groups and un-paired t-test used to assess the changes between the two groups. Analysis was done using SPSS version 18. P value was ≤ 0.05 is consider significant.

Results:-

Demographic and clinical characteristics of the patients in both groups:-

The mean value of age in GI and GII were 51.33± 2.41and 51.07± 2.89 years old respectively. The mean values of stroke duration in GI and GII were 8.73±1.83 and 8.27±.282months respectively. The mean value of FM score in GI and GII were 40.40±4.27and 41.20±7.20respectively. Comparison of the mean values of the age, stroke duration and FM score between the two groups revealed no statistically significant differences as p value <0.05 (Table 1).

Table (1): Demographic and clinical characteristics of the patients in both groups (GIand GII):

Demographic and clinical characteristics	GI		GII		Comparison	
	Mean	SD	Mean	SD	t-value	P-value
Age (year)	51.33	2.41	51.07	2.89	0.228	0.3414
Duration of illness (months)	8.73±1.83	8.73±1.83	8.27±.282	8.27±.282	0.184	0.2158
FM score	40.40	4.27	41.20	7.20	0.368	0.3071

SD: standard deviation. P: probability. S: significance. NS: Non-significant. FM: Fugl-Meyer.

Comparison of trunk displacement and time of reach to grasp within groups:

Group (I):-

There was a statistically significant decrease in trunk displacement score post treatment in GI (P=0.0001). The mean value of trunk displacement was 109.9±7.83mm pretreatment and 85.47±8.57 mm post treatment. Also, there was a statistically significant decrease in time of reach to grasp score post treatment in GI (P=0.0002). The mean value of time of reach to grasp was 2.27±0.35 sec pre-treatment and1.91±0.34 sec post treatment **(Table 2).**

Group (II):-

There was a statistically significant increase in trunk displacement score post treatment in GII (P=0.0004). The mean value of trunk displacement was 113.9±7.73 mm pre-treatment and 126.61±3.72mm post treatment. Also,' there was a statistically no significant difference in time of reach to grasp score post treatment in GII (P=0.40). The mean value of time of reach to grasp was2.21±0.32 sec pre-treatment and 2.26±0.25sec post treatment **(Table 2).**

Table (2): Comparison between pre and post treatment mean values of trunk displacement and Time of reach to grasp in both groups:

Variables		Pre-treatment Mean ± SD	Post-treatment Mean ± SD	Mean difference	t-value	P- value
Trunk displacement (mm)	**GI**	109.9±7.83	85.47±8.57	24.47	10.96	0.0001*
	GII	113.9±7.73	126.61±3.72	+12.67	4.62	0.0004*
Time of reach to grasp (sec)	**GI**	2.27±0.35	1.91±0.34	-0.37	5.84	0.0002*
	GII	2.21±0.32	2.26±0.25	+0.05	0.88	0.40

SD: Standard deviation. P: Probability. *: Significant at $P \leq 0.05$.

ii) Comparison between both groups regarding trunk displacement and Time of reach to grasp pre and post treatment:-

There were no significant difference in the mean values of trunk displacement and time of reach to grasp between GI and GII pretreatment(P=0.4967and P=0.623 respectively). There were a statistically significant difference in the mean values of trunk displacement and time of reach to grasp between GI and GII post treatment (P=0.0001 and P=0.0004 respectively) favoring G1(**Table 3**).

Table (3): Comparison of the mean values of trunk displacement and time of reach to grasp between both groups pre and post treatment:

Un paired t-test	Trunk displacement (mm)				Time of reach to grasp (sec)			
	Pre-treatment		Post-treatment		Pre-treatment		Post-treatment	
	GI	GII	GI	GII	GI	GII	GI	GII
Mean	109.5	113.9	85.47	126.61	2.27	2.21	1.91	2.26
SD	8.73	7.73	8.57	3.72	0.35	0.32	0.34	0.25
Mean difference	3.6		41.67		0.06		.35	
t-value	0.7417		11.453		0.874		4.366	
P-value	0.5127		0.0001*		0.623		0.0004*	

SD: Standard deviation. P: Probability. *: Significant at $P \leq 0.05$.

Discussion

From the results of this study, according to therapeutic intervention, the recovery of reaching movement post stroke differed. motor compensation used for reaching movements in the affected upper limb in stroke patients are mainly to enable the patients to adequately reach the target placed within the length of the arm accompanied with limited shoulder flexion and elbow extension ROM. Repetitive training of reaching may reinforce the affected limb to control of movement and decrease compensatory strategies.

the results of the current study revealed that there was a significant decrease in trunk displacement in GI, while there was a significant increase of trunk displacement in GII and this came with agreement with(lin., et al [12]) who reported that the possible explanation for the improvement of the BAT group was to the concept of inter hemispheric disinhibition triggered by bilateral movements. When the intact arm was resting during the unilateral task, the undamaged hemisphere was not activated to generate the template of firing organization to guide the affected arm during skilled actions

In a line with the present studyWu et al.,[13], concluded that the improvement after BAT may be due to diminish transcallosal inhibition from the unaffected hemisphere and increase motor output from the affected hemisphere through crossed facilitatory drive from the sound hemisphere will produce increased excitability in homologous motor pathways in the impaired limb.

The significant decrease in trunk displacement after BAT came in agreement with Levin et al., [14] and Wu et al., [13]who compared the effect of BAT and modified constraint induced movement therapy (mCIMT) on arm reaching in stroke and reported that the displacement of the trunk movement throughout reaching usually occurred earlier and was greater in patients with hemiparesis than in healthy individuals. After training the BAT group demonstrated less trunk displacement at the beginning of reaching than the mCIMT group while the mCIMT group demonstrated less trunk involvement at the middle part of reaching, and the descriptive data indicated that both mCIMT and BAT diminished compensatory trunk movement, as characterised by increased values of the slope at the middle part of reaching after intervention.

The explanation for this might be partly related to neurologic reorganization in the motor cortex. When both arms execute bilateral symmetric movements simultaneously in the BAT, the "template" generated by the undamaged hemisphere may provide normal motor plans (i.e., reaching with appropriate trunk recruitment) to assist in restoring the movement pattern of the hemiplegic side. Repetitive practice facilitates the reorganization of motor cortex and movement control. Consequently, bilateral might lead to less compensatory trunk movements at the beginning of reaching than mCIMT.Wuet al., [7]which came in agreement with the present study

The more decrease in trunk displacement in BAT in this study might be due to trunk compensation occurring in association within sufficient trunk and proximal muscle strength. Compared with control group, BAT was suggested to produce greater muscle strength in the proximal part of the arm. This may decrease the need of trunk involvement to assist in performing reaching tasks and lead to the superiority of BAT in reducing compensatory strategies Yang et al.,[15].

The results of this study contradicted with the results of Schneiberg et al., [16]who reported that there was an increase in compensatory movements with stroke patients and in children with mild cerebral palsy after three weeks of constraint induced movement therapy(CIMT). This may be due to different methodology and small sample size.

The increased trunk displacement score in GII may be to enable the patients to adequately reach the target placed within the length of the arm, accompanied with limited shoulder flexion and elbow extension ROM. This was considered a type of mal adaptive plasticity. By which the patient used excessive trunk recruitment as an adaptation of the nervous system during early recovery from stroke to achieve a short-term reduction of the disability Roby et al., [17].However, this compensatory strategy may be maladaptive and detrimental in the long term since, by providing an alternative method for the hand to reach an object, the system is less motivated to utilize a solution needing recovery of lost movement components (such as elbow extension and shoulder flexion) Cirstea and Levin,[18].

Wu et al [19] reported that early focus on compensation may limit long-term recovery. Even in the acute stroke period, patients may learn not to use or explore more normal movements with the affected limb because of habitual dependence on compensatory strategies and thus miss out on a time window of plasticity within which true recovery could be maximized.

The significance increase in trunk displacement in the control group may be an adaptation of the nervous system during early recovery from stroke to overcome disabilities due to diminish range of shoulder flexion and elbow extension. Another explanation for this excessive trunk displacement may be a compensatory mechanism from the action of spared cortical and su-bcortical region as reported by Shumway and Woollacott, [6]

The improvement in time of reach to grasp in BAT group came in agreement with the results obtained from a randomized experimental study done by Whitall et al., [20]who reported that improved spatial and temporal recovery of arm function after bilateral training three times a week for six weeks as well as the maintenance of arm function at follow-up after four months. Also, the significant increase in time of reach to grasp in group II may be due to a long time that the patient takes to control movement.

Conclusion:

The present study showed that bilateral arm training improves spatial and temporal parameter of reaching kinematics in stroke patients through decreasing trunk displacement and decreasing reaching time respectively.

References

1. Pawel Kiper, Alfonc Baba, MichelaAgostini and Andrea Turolla , Kiperet al. Proprioceptive Based Training for stroke recovery. Proposal of new treatment modality for rehabilitation of upper limb in neurological diseases Archives of Physiotherapy 5:6 ,2015.
2. Urton ML, Kohia M, Davis J, Neill MR. Systematic literature review of treatment interventions for upper extremity hemiparesis following stroke.OccupTher Int;14:11—27, 2007.
3. McCrea, P.H, Eng, J.J. and Hodgson, A.J. Saturated muscle activation contributes to compensatory reaching strategies after stroke. J Neurophysiol. 94(5):2999-3008,2005.

4. Huang WC, Chen YJ, Chien CL, Kashima H, Lin KC. Constraint-induced movement therapy as a paradigm of translational research in neurorehabilitation: Reviews and prospects. Am J Transl Res;3(1):48-60, 2010.
5. Morris JH, van Wijck F, Joice S, Ogston SA, Cole I, MacWalter RS: A comparison of bilateral and unilateral upper-limb task training in early post stroke rehabilitation: a randomized controlled trial. Arch Phys Med Rehabil, 89:1237–1245, 2008.
6. Shumway-Cook A, Woollacott MH: Normal reach, grasp, and manipulation. In Motor Control: Translating Research into Clinical Practice. Edited by Shumway-Cook A, Woollacott MH. Baltimore, MD: Lippincott Williams & Wilkins; 477–501, 2012.
7. Wu Ching-yi, Chieh-ling Yang, Ming-de Chen, et al.: Unilateral versus bilateral robot-assisted rehabilitation on arm-trunk control and functions post stroke: a randomized controlled trial. Journal of NeuroEngineering and Rehabilitation, 10:35, 2013.
8. Michaelsen SM, Dannenbaum R and Levin MF. Task-specific training with trunk restraint on arm recovery in stroke: randomized control trial. Stroke. 37(1):186-192, 2006.
9. Bohannon, R.W. and Smith, M.B.: Interrater reliability of a Modified Asworth Scale of muscle spasticity. PhysTher. 67: 206-207,1987.
10. KirtleyC.: Clinical gait analysis: Theory and practice. Philadelphia: Elseveir, 2006.
11. Mohammed BA, Abou shady N A, El wishy, A A and Zaki, M.A.: Kinematic and electromyographic analysis of reaching pattern in stroke patients. M.ScThesis. Faculty of Physical Therapy, Cairo University. Eygpt, Pp: 61-62, 2006.
12. Lin KC, Chang YF, Wu CY, Chen YA: Effects of constraint-induced therapy versus bilateral arm training on motor performance, daily functions, and quality of life in stroke survivors. Neurorehabil Neural Repair,23:441–448, 2010.
13. Wu CY, Chuang LL, Lin KC, Chen HC, Tsay PK: Randomized trial of distributed constraint-induced therapy versus bilateral arm training for the rehabilitation of upper-limb motor control and function after stroke. Neurorehabil Neural Repair, 25:130–139, 2011.
14. Levin MF, Michaelson SM, Cirstea CM and Roby-Bramii A. Use of the trunk for reaching targets placed within and beyond the reach in adult hemiparesis. Exp.Brain Res. 143:171-180, 2002.
15. Yang C-L, Lin K-C, Chen H-C, Wu C-Y, Chen C-L: Pilot comparative study of unilateral and bilateral robot-assisted training on upper-extremity performance in patients with stroke. Am J OccupTher, 66:198–206; 2012.
16. Schneiberg, S., Lamarre, C., Bibeau, A., Gendron, S., Bilodeau, N. and Levin, M.F. Kinematic patterns during reach and grasp movement in children with mild cerebral palsy before and after constraint-induced therapy. American Academy of Cerebral Palsy and Developmental Medicine. Los Angeles, Calif, 2004.
17. Roby-Brami, A, Fuchs, S, Mokhtari, M,.and Bussel,B. Reaching and grasping strategies in hemiparetic patients. Motor Control. 1:72–91, 1997.
18. Cirstea MC, Levin MF. Compensatory strategies for reaching in stroke. Brain. 123 (5):940-953, 2000.
19. Wu CY, Chen YA, Chen HC, Lin KC, Yeh IL. Pilot trial of distributed constraint-induced therapy with trunk restraint to improve poststroke reach to grasp and trunk kinematics. Neurorehabil Neural Repair; 26:247-255, 2012.
20. Whitall J, Waller SM, Sorkin JD, Forrester LW, Macko RF, Hanley DF, et al. Bilateral and unilateral arm training improve motor function through differing neuroplastic mechanisms: a single blinded randomized controlled trial. Neurorehabil Neural Repair; 25: 118–129; 2011.

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