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To compare the effects of bimanual functional practice training versus unimanual functional practice training on functional performance of upper extremity in chronic stroke

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Abstract
Objective- To compare the effects of bimanual functional practice training versus unimanual functional practice training on functional performance of upper extremity in chronic stroke.
Design: - Pre-test and Post test design.
Setting: - Inpatient and rehabilitation hospital.
Participants: - Patients were randomized to receive bimanual functional practice (n=15) or unimanual functional practice training (n-=15) at 3-4 months post-stroke onset.
Intervention- Supervised bimanual or unimanual practice training for 25 minutes on 5 days week over 2 weeks using a standardized program.
Main Outcome Measures: - Upper extremity outcomes were assessed by Graded Wolf-Motor Function test (GWMFT) and Fugl-Meyer scale (F.M.S).
Results: - No significant differences were found between the group on any measure (GWMFT-MPT. p=0.75 & GWMFT-FAS. P=0.31 & FMS-p=0.43). But within the group there were significant changes in mean performance time (Bimanual group-p=0.002 &Unimanual group-p=0.029) and there were significant difference found in functional ability scale (GWMFT-FAS Bimanual group p=0.00 &Unimanual group p=0.00) Similarly, there were significant changes in fugl-Meyer score (Bimanual group p=0.00 & Unimanual group-p=0.00).
Conclusion- This study suggest that 20 minutes a day of bilateral training of funcationally related tasks is no more effective than unilateral training for upper limb functional recover in chronic stroke patients, regardless of the initial severity of the impairment, Furthermore, for recovery of functional motor performance, unimanual training appears less beneficial than bimanual practices. Several other studies have found benefits of bimanual training: therefore, this approach can be accepted as and upper limb intervention in stroke on the basis of finding this study. The study does not suggest the training characteristics, such as the nature of the tasks and strength of inter limb coupling required for effects may influenced outcomes: therefore future work should examine the optimal timing, dose and training tasks that might optimize the already known facilitatory effects of inter limb coupling.

Keywords: Parental attitude, MPT, Bimanual, Unimaual, GWMFT, FAS

Introduction
Stroke is an acute onset of neurological dysfunction due to and abnormality in cerebral circulation with resultant signs and symptoms that corresponds to involvement of focal areas of the brain [1]. This can be due to ischemia (lack of blood supply) caused by thrombosis or embolism or due to a hemorrhage. As a result, the affected area of the brain is unable to function, leading to inability to move one or more limb on one side of the body, inability to understand or formulate speech or inability to see one side of the visual field. In the past, stroke was referred to as cerebrovascular accident or CVA, but the term "stroke" is now preferred. The term cerebrovascular accident (C.V.A) is used interchangeably with stroke to the cerebrovascular conditions that accompany either ischemic or hemorrhagic lesions. A stroke is a medical emergency and can cause permanent neourological damage, complications and death. It is the leading cause of adult disability.
Systemic hypoperfusion (general decrease in blood supply, e.g. in shock) and venous thrombosis Stroke without and obvious explanation is termed "cryptogenic" (of unknown origin); this constitutes 30-40% of all ischemic strokes. intraparenchymal hemorrhage or intraventricular hemorrhage (blood in the ventricular system).

Intracranial hemorrhage is the accumulation of blood anywhere within the skull vault. A distinction is made between intra-axial hemorrhage (blood inside the skull but outside the brain). Intra-axial hemorrhage is due to The main types of extra-axial hemorrhage are epidural hematoma (bleeding between the dura mater and the skull), subdural hematoma (in the subdural space) and subarachnoid hemorrhage (between the arachnoid mater and pia mater). Most of the hemorrhagic stroke syndromes have specific Intracerebal hemorrhage (ICH) is bleeding directly into the brain tissue, forming a gradually enlarging hematoma (pooling of blood). Stroke is a major global health problem. It is the third most common cause of death in world and risk factors for stroke onset are high blood pressure, smoking, diabetes, heart failure, carotid artery stenosis and hyperlipidemia (SBU 1992; Gresham *et al*. 1995).

The incidence of stroke increases exponentially from 30 years of age. And etiology varies by age. Advanced age is one of the most significant stroke risk factors. 95 % of strokes occur in people age 45 and older, and two-thirds of strokes occur in those over the age of 65. A person's risk of dying if he or she does have a stroke [3]. Improve movement control of impaired limb promoting neural plasticity. Bimanual practice is getting both hands to work co-operatively to hold and manipulate and object using each hand to perform different actions.Thus the objective of the study is to compare the efficacy of bimanual functional practive with unimanual functional practice on functional performance upper extremity in chronic stroke.

Methodology

A total of 30 subject (26 males and 6 females), at O.P.D. Of Fortis Hosptial, Sector-62, NOIDA, U.P, were be included in the study and will be divided by sample of convenience into two groups with 15 subjects each. Group (1) will be given bimanual practice intervention for 5 days a week for 2 weeks. Each treatment session will be of 1 hour.

Group (2) will be given unimanual practice intervention for 5 days a week for 2 weeks. Each treatment session will be of 1 hour.On the first visit a complete neurological assessment was done subjects found suitable for participants in the study as per the inclusion and exclusion criteria were requested to sign the consent form. A detailed subjective examination was taken regarding type, side, duration, occurrence of stroke, handedness and motor function.

All the selected subject were informed in detail about the type and nature of the study and asked to sign the informed consent.After taking down the demographic data the asurement of functional performance were assessed by fugl. Mayer assessment scale and graded wolf motor function test. Group "1" Participants of group 1 were trained for bimanual activity participants were encouraged to do the bimanual practices for 25 minutes with 10 minutes rest periods The total time period of the bimanual practice was one hour, which was divided into two training sessions (25*2=50min) and one rest period of 10 minutes. Participants were trained for following bimanual task practices (15). Each participants were taught about individually and sitting at the chair comfortably in font of the cable.

1. To ask the patient to hold the one cup with one hand (non- affected) which was initially filled with water and asked to hold the another cup with other hand (affected) and both hands held up the table. Instruct the patient to pour the water first from non-affected hand to affected hand and than affected hand to non-affected. This task was performed for 5 minutes daily in two sessions.
2. To ask the patients to hold the receiver with one hand (non-affected) and the numbers with another hand(affected) again this task performed alternately hold the receiver with affected hand and dial the number with affected hand.
3. Intially fold the towel lengthwise and asked the patient to roll the towel with both hands up to the towel end.
4. Asked the patients to hold the jar with non-affected and practiced to open the jar or move the cup of the jar to clockwise and anticlockwise. This task was practiced for 5 minutes in two sessions.

A. Asked the patient to hold the lock with non- affected hand and open the lock or move the key in the lock.

Clockwise and anticlockwise for 5 minutes daily in two sessions. Group "2": Participants of the intervention group '2' were taught about the unimanual practice. Participants were encouraged to do the unimanual practice for 5 days in a week for 2 weeks. Total treatment time was 1 hour only. Two treatment sessions were given for 25 minutes and after each treatment session 10minutes rest was given. Following unimanual activities will be practiced by all Group-Participants:-

- Spoon out dry ingredients (Rajma)
- Grasp the glass and attempts to supinate the forearm
- Tries to touch the glass to the table.
- Hold the glass to drink the water.
- Brush the teeth.
- Wipe the table.

Firstly, to trained the patient hold the spoon, and practiced the patient spoon out the dry ingredients like Rajma. This task was practiced for 5 minutes in two session. Initially, a patient was trained to hold glass by cylindrical grasp and after that patient was practiced to supinate the forearm tries to touch the glass to table Again, firstly patient was trained to grasp the glass and was instructed to drink the water or tries to take the glass near the mouth. This task was trained for 5 minutes in two sessions.

Patient was instructed to bring their own tooth brush and was trained to brush the teeth. This task was practiced for 5 minutes in two sessions. Patients was trained to hold the towel and practiced to wipe the table with full flexion and extension of the arm and the elbow.

Results

The results in table 5.4 show that MPT of Wold-motor Function Scale after 2 weeks of bilateral training program was significantly less. Similarly FAS score improved significantly after a 2 week training program.

Table 1: MPT of Wold-motor Function Scale after 2 weeks of bilateral training program

Variable $	Pre-test Day0 Mean+ S.D N=15	Post-test Week 2 Mean +- S.D N=15	Paired T test	
			T Value	P Value
GWMFT	1.75+0.46	2.05+0.57	-7.35	0.00
FAS	17.13+4.6	15.80+5.5	3.69	0.00
GWMFT	0	3	-	2
MPT	36.93+4.0	42.87+5.2	11.6	0.00
FMS	7	5	0	

Table 2 shows that the MPT of GWMFT reduced significantly after unilateral training, but the improvement was not as significant as FAS score. The table also shows that unilateral arm training also provided a significant improve in FMS score (table 2)

Table 2: Within group analysis: Group 2

Variable$	Pre-test Day0 Mean+ S.D N=15	Post-test Week 2 Mean +- S.D N=15	Paired T test	
			T Value	P Value
GWMFT	1.57+0.52	1.82+0.62	-7.73	0.00
FAS	17.93+6.4	16.5+5.5	2.43	0.02
GWMFT	6	3	-	9
MPT	35.87+4.8	44.53+6.2	12.7	0.00
FMS	4	0	3	

Discussion

The Study compared the effects of bilateral and unilateral upper limb-task training on upper limb motor functions during post stroke rehabilitation. The result of this study showed that there was a significant improvement in functional performance of upper extremity on G.W.M.F.T and Fugl-Meyer scale in chronic stroke patients after 2 week of bimanual and unimanual functional practice. The result of the study showed that there was no significant difference in bimanual and unimanual practice group on GWMFT (Pre MPT: p=0.70 & Post MPT: p=0.75 and Pre FAS: p=0.32 & Post FAS: p=0.312) and Fugl-Meyer score. (Pre: p=0.519 and Post: p=0.43) Participants of bimanual practice group showed a decrease in performance time (p=0.002) and increase on functional ability score (p=0.00) and showed highly significant improvement on motor functional performance of Fugl-Meyer scale (p=0.00). The mean time to perform 15 tasks in GWMFT was (17.13+4.60) which decreased after 2 weeks of bimanual practice training (15.80+5.53) and the functional ability score (1.75+0.46) improved after training (2.05+0.57). The result showed that 2 weeks of bimanual training improved motor functional performance on Fugl-Meyer scale (42.87+5.25).

Similarly participants of unimanual practice group showed a decrease in performance time (p=0.029) and increase on functional ability score (p=0.00) and showed highly significant improvement on motor functional performance of Fugl-Meyer scale (p=0.00). The mean time to perform 15 tasks in GWMFT was (17.93+46) which decreased after 2 weeks of unimanual practice training (16.5+6.88) and the functional ability score (1.57+0.452) improved after training (1.82+0.62). The result showed that 2 weeks of bimanual training improved motor functional performance on fugl-Meyer scale (44.53+6.20). The result of the study suggested that, training involving the practice of actions bilaterally and simultaneously may be effective in promoting recovery of upper limb motor function in chronic stroke patients. Of particular importance was signigicant increase in participants of the bilateral training group in functional ability from the training of a specific movement to general upper limb function. Moreover individuals receiving bilateral training showed improvements in the time to complete the graded wolf motor function test (GWMFT) movement with the impaired limb movement in individuals engaging in unilateral training [15]. In the study, participants were trained in complex multijoint functionally relevant tasks, whereas other bilateral training studies have involved protocols using simple repetitive movements with electric stimulation [45] or auditory cueing [35, 36]. Such augmentation of bilateral movement may provide more effective upperlimb coupling and consequent facilitation of the paretic arm than was possible with the free movements practiced in the study, suggesting that the effects of bilateral training may be influenced by task constrains. Furthermore visualizing and processing information from the non-paretic limb, while simultaneously attempting to perform new, Progressively changing, relatively complex precise motor goals with both arm may have provided a dual-task challenges greater than in other studies. Evidence suggests that stroke participants find tasks requiring divided attention difficult, and aimed movements of the hemiplegic arm require greater attention resources then aimed movement in healthy subjects. Participants receiving bilateral training in the study reported ease of performing the task bilaterally. The effectiveness of bilateral movement training in promoting stroke recovery is also likely to depend on the extent of damage sustained to direct corticospinal pathways [58]. While bilateral movements may also help recruit secondary motor areas in both hemispheres, recovery promoted by these areas will be less than that obtained through direct corticospinal projections [58, 59]. This can be explained by the changes in the functional ability of impaired limb as evidenced by GWMFT scores and in motor performance by Fugl-Meyer score in the patient group used in the study. Recent research has shown that lesion location greatly influences the pattern of motor cortex excitability observed [60]. Intervention timing may have influenced outcomes. The study showed significant effects of bilateral training n chronic stroke participants, whereas some studies showed no effects of bilateral training in patients acute stroke [34]. Stroke appears to alter normal transcallosal inhibition resulting in increased intact hemisphere excitability during hemiparetic arm movement that may be inhibitory in nature, thus suppressing output from the damaged hemisphere [23]. Depending on the lesion site and size, these over activation appear transient, and more normal contralateral activation pattern resume over time [49]. Identical motor command generated in each hemisphere during bilateral movement may modulate transcallosal inhibition, balancing stroke related interhemspheric over activity and facilitating output from the damage hemisphere as well as from normally inhibited ipsilateral pathway of the undamaged hemisphere to augment movement of the paretic arm [50]. The extensive disruption of normal transcollassal inhibition soon after stroke may, however render bilateral training more in chronic stages when interhemspheric interactions have resumed a more normal balance; therefore the effects of bilateral Training may be time dependent. Inter limb coordination studies in healthy adults have identified the coupling of homologous muscles as the preferred control mode of the motor system. The present results indicate that this tendency can be exploited to promote functional recovery of a paretic limb in the chronic stroke patients. Further more, there is a strong neurophysiological evidence to suggest that when the impaired and non-impaired arms are moved symmetrically, crosses facilitatory drive from the intact hemisphere will be produced increase excitability in homologous motor pathways in the impaired limb[50, 51]. Additionally, cortical damaged from stroke produces hyperexcitability of the contralesional M1 [52] leading to abnormally high levels of transcollasal inhibition (TCI) on the legend hemisphere, thereby further impairing motor performance of the paretic hand [53]. There is recent evidence of improved affected hand performance in chronic stroke patients from reducing the abnormal inhibitory drive to the ipsilesional hemisphere [54, 55]. Furthermore balanced interhemspheric interactions appear necessary for normal voluntary movements [56] and the restitution of the voluntary movements and the restitution of the normal balance between the two hemispheres has been linked to better recovery following stroke [57]. It has been bypothesized that practicing by lateral symmetrical movements may facilitate motor output from the ipsilesional hemisphere by normalizing (TCI) influences. Interestingly, in the subset of patients assessed with wolf motor function test and Fugl-Meyer scale in the study the bilateral trained patients exhibiting the latgest increase may promote increased involvement of pathways not investigated in the present study such as spared corticopropriospinal pathways [50]. The improvement in the unimanual practice group might be due to greatly improved motor performance. This can be explained by muscle output area size in the affected hemisphere might have enlarged and also there might be recruitment of the adjacent brain areas [23]. The improvement can also be seen through the unimanual training which was task oriented and specific to the affected extremity. Both the training groups showed a significant improvement after training, which might be explained by the stage of stroke. The chronic nature of stroke might have allowed the plastic nature of brain to adjust to the various levels of tasks to be performed, both unimanualy and bimanually. Initially, just after stroke, bimanual movement echanced activation in the primary motor cortes M1 of the affected hemisphere did not differ between unimanual paretic hand and bimanual movement [14]. Also, the tasks performed both during unimanual paretic hand both during unimanual and bimanual practice training were almost similar in nature. Therefore, non-significant between group difference can be explained. The frequency and duration of the program may not have been optimal. One may ask whether 20 25 minutes session devoted to the bimanual and unimanual task are sufficient to trigger brain reorganization and to observe a change. This scheduled was based on practical reason and although it is similar to that used in previous study [34, 61], it has never been experimentally proven to be the optimal dose. More important is the fact that the participants in both groups received high level of stimulation in the training program, leading to the possibility of a saturation effect in arm recovery. In fact, participants in both groups were stimulated every day to use their arms in their daily activities. Therefore, the technique used to promote batter recovery could not have had any impact on the final result. In other words, regardless of the technique used, perhaps the important thing in the spontaneous recovery and training period is to provide patients with frequent and continuous opportunities to use their arms in their activities further more for recovery of functional motor performance, unilateral training appears less beneficial than bilateral practices. Several other studies have found benefits of bilateral training: therefore, this approach can be accepted as an upper limb intervention in stroke on the basis of finding this study. The study does not suggest the training characteristics, such as the nature of the tasks and strength of inter limb coupling required for effects, may influenced outcomes: therefor future work should examined the optimal timing, dose and training task that might optimize the already known facilitatory effects of interlimb coupling.

Conclusion

The study suggest that 20 minutes a day of bilateral training of functionally related tasks is no more effective than unilateral training for upper limb functional recovery in chronic stroke patients, regardless of the initial severity of the impairment. Further more, for recovery of functional motor performance, unimanual training appears less beneficial than bimanual practices. Several other studies have found benefits of bimanual training: therefore, this approach can be accepted as an upper limb intervention in stroke on the basis of finding this study. The study does not suggest the training characteristics, such as the nature of the tasks and strength of inter limb coupling required for effects, may influenced outcomes: therefor future work should examine the optimal timing, dose and training tasks that might optimized the already known facilitatory effect of interlimb coupling. Thus, null-hypothesis proved.

References

1. Gresham GE, Duncan PW, Stason WB. Post-stroke rehabilitation; Clinical practice guideline. [AHCPR.], 1995, 16.
2. Broeks JG, Lankhorsi GJ, Rumping K, Prevo AJH. The long- term outcome of arm function after stroke: results of a follow up study. [Disability and Rehabilitation. 1999; (21):357-364.
3. Ostendorf C, Wolf SL. Effect of forced used of the upper extremity of a hemiplegic patient on changes in function. Physical Therapy. 1981; (61):1022-1028.
4. Morris DM, Taub E. Constraing- induced therapy approach to restoring function after neurological injury. Top stroke Rehabil. 2001; (8):16-30.

5. Senesac D, Davis SB, Richard LG. Generalization in repetive bilateral training in stroke.
6. Nagako Murase, Julie Duque *et al*. Influence of Interhemispheric Interactions on motor function in chronic stroke. Ann Neurol. 2004; 55:400-409.
7. Patricia Pohl S, Carl Luchies W, Pamela Duncan W *et al*. Upper Extremity Control in Adults Post with Mild Residual Impairment. Neurorehabitation and neural repair. 2000; 14(1):33-41.
8. DT Wade, Wood VA, Hewer RL *et al*. Recovery After stroke-the first 3 months. Journal of Neurology, neurosurgery and psychiatry. 1985; 48:7-13.
9. Leeanne Carey M, David Abbott F, Gary Egan F *et al*. Motor Impairment and Recovery in the Upper Limb After Stroke. Stroke. 2005; 36:625-629.
10. Hirofumi Nakayama *et al*. Henrik Stig Jorgenses *et al*. Recovery of Upper Extremity Funciton in Stroke patients: The Copenhagen Stroke Study. Arch Phys Med Rehabil Val. 1994; 75:394-398.
11. Judith SchaechterD. Motor Rehabilitation and Brain Plasticity after hemiparesis. Progress in Neurobiology. 2004; 73(1):61-72.
12. Gert K wakkel, Robery Wagenaar C, Tim Koelman W. Effects of Intensity of Rehabilitation after Stroke. Stroke. 1997; 28:1550-1556.
13. Koichi Hiraoka. Rehabilitation effort to Improve Upper Extremity Function in Post Stroke Patients: A Meta-Analysis. Journal of Physical Therapy science. 2001; 13(1):5-9.
14. Staines WR, Mcilory WE. Bilateral Movements Enhances ipsilesional cortical activity in acute stroke: A pilot functional MRI study. Neurology. 2001; 56:401-404.
15. Mudie MH, Matyas TA. Can simultaneous bilateral movement involue the undamaged hemisphere in reconstruction of neural networks damaged by stroke? Disabil Rehabil. 2000; 20(22):1-2.
16. Cunningham CL, Phillips Stoykov ME, Walter CB. Bilateral facilitation of motor contral in chronic hemiplegia. Acta Psychologica.
17. Michael Garry I, Ian Franks M. Spatially precise bilateral arm movements are controlled by the contralateral hemisphere. Exp Brain Res. 2002; 142:292-296.
18. Lang Catherine E, Wagner. Upper Extremily use in people with hemiparesis in the first few weeks after stroke. Journal of Neurologic Physical Therapy. 2007; 31:56-63.
19. Nestor Bayona A, Jamie Bitensky. The role of task specific training in rehabilitation therapies. Topics in Stroke Rehabilitation. 2005; 12(3):58-65.
20. Fiseher, Heide C, Stubble field. Hand rehabilitation following stroke: a pilot study of assisted figure extension training in a virtual environment. Topic in stroke rehabil, 2007.
21. Laufer Y, Gatternio L, Sinai B. The time related changes in motor performance of upper extremity inpsilateral to the side of the lesion n stroke survivors. Neurorehabilitation and neural repair. 2001; 15(3):167-172.
22. Michaelsen, Stella Maris. Specific training with trunk restraint on arm recovery in stroke: RCT. Stroke. 2006; 37(1):186-192.
23. Liepert. Treatment induced cortical reorganization after stroke in humans. Stroke. 2000; 31:1210-1216.
24. Timothy Carroil J, Michael Lee. Unilateral practice of a ballistic movement bilateral increases in performance and corticospinal excitability. J Appl. Physiology. 2008; 104:1656-1664.
25. Carole Ostendorf G, Seven Wolf L. Effect of forced use of upper extremity of a hemiplegic patient on changes in funcation. Physical Therapy. 1981; 61(7):1022-1028.
26. Johana Van der Lee H, Robert Wagenaar C. Froced use fo the upper extremity in chronic stroke patients. Stroke. 1999; 30:2369-2375.
27. Edward Taub, Neal Miller E, Thomas. Technique to improve chronic motor deficit after stroke, Arch Phys Med Rehabil. 1993; 74:347-354.
28. Wolfgang Miltner HR, Monika Sommer. Effects of constant induced movement therapy on patients with chronic motor deficit after stroke. 1999; 30586-592.
29. Steven Wolf L, Carolee Winstein J, Philips Miller, Edward Taub. Effect of constant induced movement therapy on upper extremity function in 3 to 9 months after stroke. JAMA. 2006; 296:2095-2104.
30. Sandy Mc Combe Waller, Jill Whit all. Fine Motor Control in adults with and without chronic hemiparesis: Baseline comparison to nondisabled and effects of bilateral arm training. Adults, Arch Phy Med Rehabil. 2004; 85:1076-1082.
31. Dorian Rose K, Carolee Winstein J. Bimanual training after stroke: Are Two hands better than one? Topics in Stroke Rehabil. 2004; 85:1087-1082.
32. Dorian Rose K, Carolee Winstein J. Bimanual training after stroke: Are Two hands better than one? Topics in Stroke Rehabil. 2004; I1(4):22-30.
33. Jeffery Summers J, Florian Kagerer A, Michael Garry I, James Cauraugh H *et al*. Bilateral and unilateral movements training on upper limb functions in chronic stroke patients; A TMS Study. Journal of Nourological Sciences. 2007; 252:76-82.
34. Jacqui Morris H, Frederike Van Wijck, Sara Joice *et al*. A comparison of bilateral and unilateral upper limb task training in early post stroke rehabilitation: A RCT. Arch Phys Med Rehabil. 2008; 89:1237-1245.
35. Jill Whitall, Sandy Mc Combe Waller, Richard MackoF.Repetitive bilateral arm training with rhythmic auditory cueing improves motor function in chronic hemiparetic stroke. Stroke. 2000; 31:2390-2395.
36. Andreas Luft R, Sandy Mc Combe Waller, Jill Whiltall. Repetitive bilateral arm training and motor cortex activation in chronic stroke. JAMA.2004; 292(15):1853-1861.
37. Steven Wolf L, Pamela Catlin A, Michael Ellis. Assessing wolf motor function test as outcome measure for research in patients after stroke. Stroke. 2001; 32:1635-1639.
38. Pamela Ducan W, Larry Goldstein B, David Matchar. Measurement of motor recovery after storke: Outcome assessment by Fugl Meyer Scale. Stroke. 1992; 23:1084-1089.
39. Evelyn Lee Teng, Helena Chang Chui. The modified mini-mental state (3MS) examination. JClin. Psychiatry. 1987; 48:314-318.
40. Janet Car, Roberta Shepherd. Bimanual Practice Neurological Rehabilitation Optimizing Motor Performance, 1998, 142-145.

41. Dickstein T, Hocherman S, Pillar T, Shaham R. Three exercise therapy approaches, Physical Therapy. 1986; 66:1233-38.
42. Kelso JA, Southard DL. Goodman D. On the nature of human inter limb coordination. Science. 1979; 203:1029-31.
43. Canningham CL, Stoykov ME, Walter CB. Bilateral facilitation of motor control in chronic hemiplegia. Actapsychol (Amst). 2002; 110:321-37.
44. Lewis GN, Byblow WD. Neurophysiological and behavioral adaptation to a bilateral training intervention in individuals following stroke. Clin Rehaabil. 2004; 1848-59.
45. Dorian Rose K, Carolee Winstein J. Bimanual training after stroke: Are two hands batter than one? Topics in stroke rehbil. 2004; 11(4):20-30.
46. Hesse S, Suhulte-Tigges G. Konard M, Baradeleben A, Werner C. Robot-assisted arm trainer for the passive and active practice of bilateral forearm and wrist movements in hemiparetic subjects. Arch Phys Med Rehabil. 2003; 84:915-920.
47. Janet Car, Roberta Shepherd. Bimanual Practice neurological Rehabilitaion Optimizing Motor Performance, 1998, 142-145.