Journal of Clinical Case Reports

Kingau and Kung'u, J Clin Case Rep 2016, 6:8
DOI: 10.4172/2165-7920.1000848

Case Report Open Access

The Role of Caregiver in Modified Constraint Induced Movement Therapy in Uasin-Gishu County, Kenya

Naomi Kingau* and Mwaniki Kung'u

Department of Orthopedics and Rehabilitation, Moi University, School of Medicine, Kenya

***Corresponding author:** Kingau N, Department of Orthopedics and Rehabilitation, Moi University, School of Medicine, Kenya, Tel: +254721422899, E-mail: nkwanjiru@yahoo.com

Rec Date: Jun 19, 2016, **Acc Date:** Aug 10, 2016, **Pub Date:** Aug 15, 2016

Abstract

Constraint induced movement therapy (CIMT) is an effective rehabilitative intervention for motor recovery of the affected upper extremity in post stroke patients. However, this concept is not directly applicable in a resource scarce setting. Using the principle of CIMT in the patients' home utilizing a trained caregiver can modify this. The aim of this study was therefore to determine the role of the caregiver in modified Constraint Induced Movement Therapy in a patient with sub-acute stroke Methodology: The study was conducted at the patient's home in Uasin-Gishu County, Kenya. A 52-year-old woman, with a medical history of hypertension, and presented with left-sided hemiplegia. The unaffected hand was constrained in a mitten during working hours, except for bathing and toileting. For 6 weeks, patient spent 4.30 hours performing supervised tasks with paretic arm. Wolf Motor Function Test and the Motor Activity Log were used for data collection. Result: All except two tasks of the timed component of the WMFT had scores above the Minimal Detectable Change; however, the patient could not complete 2 tasks. The Factional Ability Scale and MAL indicated improvement. Conclusion: Support from caregiver increased therapy time, and was a significant factors in improved upper-limb functions.

Keywords: Hemiplegia; Stroke; Constraint induced movement therapy; Physiotherapy; Caregiver

Introduction

Stroke is the third leading cause of death and disability worldwide [1-3] and the leading cause of death and disability in many Western nations [4-6]. It is estimated that 16 million people are affected by disability secondary to stroke whilst 6 million deaths are recorded globally [3].

The impacts of strokes are severely taxing. Post stroke impairments, activity limitations and decreased participation, can cause inability to return to work [7]. The most common impairments are motor-related (impaired muscle tone, impaired coordination, poor balance, impaired sensation, poor bladder control, impaired cognition), affecting mobility and agility [8]. A study by Hoyle [9] asserts that other body functions impaired after stroke includes consciousness, orientation, mental functions of language and memory functions. Additionally, Ostwald [10] suggested that stroke related structural impairments lead to psychological and physiological malformations. These instigate complex social and economic effects on individual, households and communities due to indirect productivity losses [11,12].

Conventionally, stroke rehabilitation has concentrated on traditional exercises. Nonetheless, in recent years, stroke rehabilitation has advanced with complexity in neuroscience, and rehabilitation. This has shown the potential for the neural system to augment recovery after stroke related brain damage [13]. Contemporary theories suggest that post stroke recovery is a process whereby patient regain, via practice, an ability to meet and overcome task demands [14]. This process has led to the development of new rehabilitation research interventions to restore post-stroke upper extremity motor function [6,15,16].

Arm weakness post stroke occurs in 70% to 80% of patients, and persists in 40% [17]. Utmost recovery of paretic arm occurs in the initial 3 months post stroke [18,19]. After onset of stroke, the brain immediately begins reorganization [20-22] and in the chronic phase there is little probability of spontaneous neuronal plastic changes [23].

The recovery process for upper extremity functions is often slower than the lower extremity [7,24]. This has led to the development of constraint induced movement therapy [6]. Constraint induced movement therapy (CIMT) is a form of rehabilitation that improves upper extremity functions in stroke and other patients with central nervous system damage by increasing the use of the affected upper extremity. CIMT combines restraint of the unaffected limb and intense use of the affected limb with the goal of promoting purposeful movements. CIMT stimulates cortical-re-organization. The purpose for this treatment is to overcome the "learned non-use" of the affected arm [25]. Wolf 6 examined forced use in 25 individuals with hemiplegia due to CVA and traumatic brain injury. The researcher studied the effectiveness of restraining the unaffected upper extremity during working hours in the subjects' home over a 2 week period. The result exhibited improvement in movement of the upper extremity in 19 of 21 functional task measures, and improvements endured at 1 year follow up. The continued improvement through the follow-up period provides evidence that forced use of the affected extremity appears to reverse the learned "non-use" phenomenon.

CIMT can be expedited by involvement of a caregiver. A study by Galvin [26] found that majority of individuals with stroke (87%) and their family members (91%) were willing to participate in unsupervised exercises in both hospital and community settings. Likewise, systematic reviews have shown that greater intensities of physical therapy, and occupational therapy during stroke rehabilitation result in improved functional outcomes [26-28]. Waldt and Mothabeng [29], in a similar study reported greater improvements in mobility for patients with stroke who had family members participating in treatment. Additionally, Van Peppen [30] and Barreca [31] reported statistically significant results for increased time spent in treatment on ADL and upper-limb function scores.

Physical therapists have reported that support for family involvement could help maintain treatment gains, and be an avenue for family management of stroke-related disability [26]. A study by Harris [32] reported that a 4 week, inpatient, upper-limb exercise program (Graded Repetitive Arm Supplementary Program [GRASP]) significantly improved Upper-limb functions in individuals with sub-acute stroke. An important aspect of this program was encouragement of family members or friends as they become involved in the exercise program. The role of family members in stroke rehabilitation has gained attention as a method for clinicians to increase treatment time as a potential factor in improved functional outcomes.

CIMT is an effective treatment that has been studied extensively in highly resourced settings where patients are able to spend hours in health facilities with therapists and in settings where insurance often covers the cost of the intensive rehabilitation. In Kenya, where the effects of stroke are just as devastating, the typical patient has limited access to such therapies. Patients often cannot afford to pay out of pocket for the daily outpatient sessions; likewise patients often have to travel long distances to access the available services. Given these barriers, as well as others, there is great need for researches into effective treatment that takes into account the challenges faced by patients in resource scarce settings. This study therefore sorts to follow the philosophies of CIMT, but focused significant treatment at the patients' home utilizing a trained caregiver.

Case Report

The patient was a 52-year-old woman from Uasin-Gishu County. The lady had a past medical history of hypertension. She developed a sudden onset of left-sided weakness approximately 6 weeks before the time of data collection. An initial head computed tomography scan showed a right ischemic lacunar infarct in the posterior internal capsule. When admitted to the Hospital, gross motor tests revealed 5/5 in the right extremities, 2/5 in the left upper extremity, and 3+/5 in the left lower extremity. The patient had forearm pronation and wrist flexion, 15 degrees of active metacarpal phalangeal, and intercarpal phalangeal joint extension, and 25 degrees of active wrist extension

These measurements were taken during a standard inpatient clinical evaluation. She received 19 days of inpatient rehabilitation, including both physical therapy and occupational therapy. In discharge, she was independent with bed mobility, but required supervision with transfers and ambulation within household distances. Straight cane was used for ambulation. She exhibited a predominant flexor synergy in her left UE through approximately 3/4 of the range against gravity at the shoulder and elbow, with trace movement at the wrist and finger flexors. Two months post-CVA, she was independent with all activities of daily living, but ambulated without an assistive device. She was living with a caregiver who could provide some assistance with meal preparation and cleaning. She displayed no effort to initiate any activity with her impaired limb, suggestive of "learned none use". She was selected for the CIMT intervention, and consequently for the case report, since she met the established inclusion criteria as suggested by Taub and Wolf. The patient was likewise motivated and willing to adhere to intervention protocol.

Data Collection Procedure

The wolf motor function test (WMFT), and motor activity log (MAL) were used for data collection. WMFT and the MAL collected data before the treatment (baseline Data) and at the end of intervention (at 6 weeks).

Intervention

The caregiver was initially taken through one-hour orientation sessions for four days by a physiotherapist. The caregiver learnt the principles of CIMT, safety procedures and how to sequence components of the functional tasks selected by the patient. The caregiver supervised the patient during the entire day monitoring wearing of the mitt and providing verbal encouragement.

Initially the patient was asked what activities she had participated in prior to the stroke and whether she had a preference of tasks she would like to practice. These activities included but not limited to grooming, writing, dressing, playing games, gardening, and sewing. The caregiver subdivided the task in to hierarchy to minimize failure or frustration.

The patient wore a mitt on the uninvolved hand during working hours except when travelling, sleeping, and dressing or during toileting for a period of six weeks. The patient participated in task practice using the affected hand at home supervised by a caregiver for at least 4.30 hours a day. The patient also visited outpatient physiotherapy department once a week for supervised task practice in an outpatient setting for 4 hours a day. The physiotherapist observed therapy session, as the patient worked with the caregiver to ensure correctness. The therapist had no input to the patient. The researcher likewise visited the patient at home once a week to ensure that the tasks were correctly performed in the home setting. Every day use of the hand on activities of daily living was the primary focus.

Based on the protocol established by Taub, a typical day started with the patient practicing a task related to her activities of daily living for one hour, followed by a break, then playing a game for the next one hour followed by another break, then household cleaning for one hour. Lunch lasted an hour (including food preparation) and was followed by three, 30 minutes sessions separated by rest breaks. During these sessions the patient practiced sewing, gardening, and simple household cleaning. The patient was also monitored during meals, she was asked to keep an activity log that described all tasks performed with the paretic limb while away from the rehabilitation facility. No standardized form of activity log was found in literature, therefore a self-developed form was provided to the patient by the researcher. Each morning the caregiver reviewed the activity log with the patient, discussing use of the affected arm during the previous day. The patient's family member was recruited to supervise daily tasks.

Objective Finding

All except two tasks of the timed component of the WMFT had scores above the Minimal Detectable Change (0.7 seconds). Forearm to table (side) (1.24), Extend elbow (side) (4.62), Extend elbow (weight) (1.58), Hand to table (front) (2), Hand to box (front) (0.92), Lift can (17,82), Stack checkers (9.92), Flip cards (10.61), Turn key in lock (15.64). However, three tasks had scores below the Minimal Detectable Change. Forearm to table (side) (0.4), Lift pencil (0.29), and Reach and retrieve (0.4). Likewise, the patient could not complete the 2 most difficult tasks of folding a towel and lifting a basket.

All measurements expressed in seconds. A maximum score of 120 seconds was given when patient was unable to complete the task. One trial was given for each task task (Tables 1-4).

The factional ability scale (FAS) component of the WMFT, change score also indicated improvement, (MDC of the FAS component the WMFT is 0.1 points). Table 3 shows the results of FAS component of the WMFT whose change score also indicated improvement

The MAL evaluation indicated improvement in the use of the affected limb in daily functional activities. Table 3 shows the pre-treatment and post-treatment scores (of all 30 functional items) on the amount of use component of the MAL and Table 4 shows the scores of the how well component of MAL. Prior to treatment, the patient stated that she used her affected limb only occasionally for 20 of the 30 activities. After treatment, she was using her limb at least half as much as before the stroke in all except 10 of the activities. Those activities that were most difficult included writing and buttoning a shirt.

Time	Activity	Time	Activity
0800 hrs to 0830 hrs	Caregiver and patient reviews activities of the previous day discussing performance of these activities	1230 hrs to 1330 hrs	Lunch Break
0830 hrs to 0930 hrs	Patient practices activities of daily living of his choice e.g. grooming	1330 hrs to 1400 hrs	Simple household cleaning
0930 hrs to 1000 hrs	Break	1400 hrs to 1430 hrs	Break
1000 hrs to 1100 hrs	Patient plays a game of choice	1430 hrs to 1500 hrs	Gardening
1100 hrs to 1130 hrs	Break	1500 hrs to 1530 hrs	Break
1130 hrs to 1230 hrs	Sewing	1530 hrs to 1600 hrs	Sewing

Table 1: The breakdown of hours on a typical day.

Task	Pre-treatment	Post-treatment	Change score
Forearm to table (side)	1.75	0.51	1.24
Forearm to table (side)	1.16	0.76	0.4
Extend elbow (side)	5.04	0.42	4.62
Extend elbow (weight)	2.1	0.52	1.58
Hand to table (front)	2.53	0.53	2
Hand to box (front)	1.68	0.76	0.92
Reach and retrieve	1.14	0.74	0.4
Lift can	20.17	2.35	17.82
Lift pencil	5.09	4.8	0.29
Lift paper clip	Unable	10.53	N/A
Stack checkers	17.44	7.52	9.92
Flip cards	23.09	12.48	10.61
Turn-key in lock	20.77	5.13	15.64
Fold towel	Unable	Unable	N/A
Lift basket	Unable	Unable	N/A
Weight to box (llb)	Not tested	N/A	N/A
Grip strength (kg)	Not tested	N/A	N/A

Table 2: Pre and post intervention scores of the timed component of the WMFT.

Task	Pre-treatment	Post-treatment	Change score
Forearm to table (side)	3	4	1
Forearm to box (side)	3	4	1
Extend elbow (side)	2	4	2
Extend elbow (weight)	2	3	1
Hand to table (front)	3	4	1
Hand to box (front)	3	4	1
Reach and retrieve	3	4	1
Lift can	1	2	1
Lift pencil	2	3	1

Lift paper clip	1	2	1
Stack checkers	1	1	0
Flip cards	1	2	1
Turn-key in lock	1	2	1
Fold towel	1	1	0
Lift basket	1	1	0
Weight to box (llb)	Not tested	N/A	N/A

Table 3: Pre-treatment and post-treatment scores of the FAS component of the WMFT.

Activity	Pre-treatment score	Post-treatment score	Change score
Turn on a light switch	1	3	2
Open drawer	1	3	2
Remove an item of clothing from drawer	1	4	3
Pick up phone	1	3	2
Wipe off a kitchen counter or another surface	1	3	2
Get out of a car	1	4	3
Open refrigerator	1	3	2
Open door by turning a door knob handle	1	2	1
Use T V remote control	1	2	1
Wash your hands	1	3	2
Turn water on/off	1	2	1
Dry your hands	1	3	2
Put on your socks	1	2	1
Take off your socks	1	3	2
Put on your shoes	1	2	1
Take off your shoes	1	3	2

Table 4: Pre-treatment and post-treatment scores of the MAL (Amount of use score).

Discussion

Following a 6 weeks period of CIMT using task oriented practice; there was improvement on the patient's motor abilities. Increased exercises time, and caregiver involvement in rehabilitation showed a positive association, with enhanced upper-limb functions. These are factors that are amenable to change and can be utilized by resource scarce setting to improve therapy outcome.

The results of the current study showed that intensity of therapy is a predictor of functional outcome consistent with [7]. Kwakel [2] and Vanpeppen [30], in systematic review, showed that an increase in therapy time has a positive effect on activities of daily living and mobility. The authors suggested that an additional 16 hours of therapy is required for improvements in lower-limb and activities of daily living outcomes. Additional time that utilizes one-on-one treatment principles is not always feasible in either an inpatient or outpatient settings in Kenya. The result of the current study suggest that adding supplementary upper-limb activities by using alternate means such as homework or family members may be required to facilitate increased exercise time upper-limb severity was not a significant predictor of improved upper-limb ability when exercise intensity and support were integrated. This is contrary to studies done by Hashimoto [33] Smania [34], and Suzuki [35], who asserts stroke severity as a major predictor of the recovery. The reason for this difference could be that the previous studies used the baseline motor impairment score to predict the post intervention score, whereas in the current study the researcher used the change score (the difference between baseline score and post intervention score). The findings indicates that the more time spent doing the prescribed activities in the treatment protocol, the more the patient can and does use her paretic upper limb in daily activities.

In the current study, caregiver support with the CIMT protocol produced a significant main effect for upper-limb functions. These findings are supported by Nudo [13] who demonstrated that augmented therapy time (an additional 15 hours of upper-limb therapy over 4 weeks) has a significant effect on upper-limb functions and use. Correlation analyses have revealed a significant relationship between support and exercise intensity, indicating that those individuals without support were more likely to spend an increased amount of time completing the upper-limb exercises [26]. Furthermore, group comparison between those with support and those without support demonstrated that even in the low-intensity group, support was a significant element of improved scores of upper limb functions [36]. These findings may suggest that involvement of caregiver in upper-limb treatment will produce improved outcomes beyond those seen with increased time in treatment alone. These findings support those of studies that have linked positive family and social support to improved post stroke recovery [37], and encourage the involvement of caregiver in rehabilitation. Other studies that support these findings have revealed the critical importance of social and family support to quality of life in individuals with stroke [38]. A plausible explanation may be that family support may contribute to upper limb recovery by increasing confidence and motivation, and decreasing stress and depression [34]. Involving caregivers in rehabilitation may help patients increase participation in rehabilitation thus increasing the potential for improvement [19]. The impact of support not only on paretic upper-limb performance (WMFT) but also on use of the upper limb outside of therapy time (MAL amount of use scale) is a vital new finding. The ultimate goal of rehabilitation is for patients to not only use their paretic upper limb during therapy but also transfer these skills to everyday living. Any element that can affect this goal is highly relevant to physical therapists, as well as other members of the clinical team. Evidence suggests that individuals who are encouraged to use the affected upper limb are often able to do so [30,31]. Consequently, CIMT may not be changing actual movement potential, but may be changing behavior so that individuals are willing to use their limb more, thus achieving their real movement capabilities [39].

Another possible explanation for improved use may lie in the theory of neural re-organization, perhaps due to axonal sprouting as a precursor to improved motor performance [29]. This explanation remains improbable because of the short duration of treatment and rapid improvement of the subject. Alternatively, one cannot dismiss the importance of enhanced synaptic efficacy [40], as mechanisms that can be engaged with repetitive activity to promote improved task-specific limb usage. Thus, perhaps the constraint portion of the intervention addresses the behavioral issues of learned nonuse, and the supervised task practice portion incorporates the theories of long-term potentiation or enhanced synaptic efficacy. In combination, these interventions may be effective in improving motor capabilities after neurological insult.

References

1. American Heart Association. Retrieved 2015 22-04 from Information about stroke: http:/www.stroke association.org/strokeorg/about stroke/about stroke UCM/308529/sub Home page.jsp. 2011a.
2. Jowi J, Mativo P (2008) Pathological sub-types, risk factors and outcome of stroke at the Nairobi Hospital, Kenya. East Afr Med J 85: 572-581.
3. WHO. World Health Organisation. (2005) Retrieved 2011 19-03 from Disability and rehabilitation in Primary Health Care. A guide for district health and rehabilitation managers.
4. Begg S, Vos T, Baker B, Stevenson C, Stanley L, et al. (2007) The burden of disease in injuries in Australia: Australian institute of health and wellness. Canberra, Australia.
5. Munter P, Gurrett T, Klag M, Coresh J (2002) Trend in stroke prevalence in US population. Stroke 33:1209-1213.
6. Wolfe CD (2000) The impact of stroke. Br Med Bull 56: 275-286.
7. Kwakkel G, Pepper R, Wagenaar R, Dauphinee S, Richard C, et al. (2004) Effects of Augmented Exercise Therapy Time After Stroke. Stroke 35: 2529-2539.
8. McKevitt C, Fudge N, Redfern J, Sheldenkar A, Chrichton S, et al. (2011) Self-Reported Long-Term Needs After Stroke. Stroke 42: 1398-1403.
9. Hoyle M, Gustafsson L, Meredith P, Ownsworth T (2012) Participation after stroke. Cambridge J 13: 4-15.
10. Ostwald S, Godwin M, Ye S, Gron S (2013) Serious adverse events experienced by survivors of stroke in the forst year following discharge from inpatient rehabilitation. Rehabil Nurs 38: 254-263.
11. Sherlock P (2010) Stroke in developing countries:epidemiology, impact and policy implications. Development Policy Review 28: 693-709.
12. Ogungbo B, Mendelow A, Walker R (2004) The epidemiology, diagnosis and treatment of subarachnoid haemorrhage in Nigeria: What do we know and what do we need to know?. Br J Neurosurg 18: 362-366.
13. Nudo R (2003) Functional and structural plasticity in motor cortex: implication of stroke recovery. Phys Med Rehabil Clin N Am 14: 57-76.
14. Krakauer J (2006) Motor learning: Its relevance to stroke recovery and neurorehabilitation. Curr Opin Neurol 19: 84-90.
15. Lo AC, Guarino P, Richards L, Haselkorn J, Wittenberg G, et al. (2010) Robot assisted for long term upper limb impairement after stroke. N Eng J Med 362: 1772-1783.
16. Woodbury M, Howland DR, McGuirk TE, Davis SB, Senesac CR, et al. (2009) Effect of stroke restrained combined with intensive task practice on post stroke upper extemity reach and function: A pilot study. Neurorehabilitation Neural Repair 23: 78-91.
17. Parker M, Wade T, Hewer L (1986) Loss of arm function after stroke: Measure frequency and recovery. Int Rehabil Med 8: 69-73.
18. Coupar F, Pallock A, Rowe P, Weir C, Longhorne P (2011) Predictor of upper limb recovery after stroke : a systematic review and meta-analysis. Clinical Rehabilitation 26: 291-313.
19. Nakayama H, Jorgensen H, Raaschou H, Olsen T (1994) Compensation in recovery of upper extremity function after stroke: The Copenhagen Stroke Study. Arch Phys Med Rehabil 75: 852-857.
20. Ward S, Brown I, Thompson A, Frackowiak R (2003) Neural correlates of motor recovery after stroke: a longitudinal fMRI study. Brain 126: 2476-2496.
21. Rossini P, Calautti C, Pauri F, Baron J (2003) Post-stroke plastic reorganisation in the adult brain. Lancet Neurology 2: 493-502.
22. Trompetto C, Assini A, Buccolieri A (2000) Motor recovery following stroke. A transcranial magnetic stimulation study. Clin Neurophysiol 111: 1860-1867.
23. Verheyden G, Nieuwboer A, De Wit L, Thijs V, Dobbelaere J, et al. (2008) Time course of trunk, arm, leg, and functional recovery after ischemic stroke. Neurorehabil Neural Repair 22: 173-179.
24. Wagenaar R (1990) Functional Recovery After Stroke. Netheland: Free University Press.
25. Taub E, Crago J, Uswatte G (1998) Constraint-induced movement therapy: A new approach to treatment in physical rehabilitation. Rehabilitation Psychology 43: 152-170.
26. Galvin R, Murphy B, Cusack T, Stokes E (2008) The impact of increased duration of exercise therapy on functional recovery following stroke - what is the evidence? Stroke Rehabil 15: 365-377.
27. Jocelyn E, Harris J, William C, Andrew S (2010) The Role of Caregiver Involvement in Upper-Limb Treatment in Individuals With Subacute Stroke. Phys Ther 90: 1302-1310.
28. Duncan P, Zorowitz R, Bates B, Choi J, Glasberg J, et al. (2005) Management of Adult Stroke Rehabilitation Care: a clinical practice guideline. Stroke 36: 100-143.

29. Waldt J, Mothabeng J (2009) Family Involvement in the Rehabilitation of a Stroke Patient (A Case Report). Nigerian Journal of Medical Rehabilitation 14: 31-35.

30. Van Peppen R, Kwakkel G, Wood-Dauphinee S, Hendrik H, Van der Wees P, et al. (2004) Functional outcome, early intervention. Stroke 30: 14785.

31. Barreca S, Wilkins S (2008) Experiences of nurses working in a stroke rehabilitation unit. J Adv Nurs 63: 36-44.

32. Harris J, Miller W, Dawson A (2009) A self-administered Graded Repetitive Arm Supplementary Program (GRASP) improves arm function during inpatient stroke rehabilitation: a multi-site randomized controlled trial. Stroke 40: 2123-2128.

33. Hashimoto K, Higuchi K, Nakayama Y, Abo M (2007) Ability for Basic Movement as an Early Predictor of Functioning Related to Activities of Daily Living in Stroke Patients. Neurorehabil Neural Repair 21: 353-357.

34. Smania N, Paolucci S, Tinazzi M, Borghero A, Manganotti P, et al. (2007) Active finger extension: a simple movement predicting recovery of arm function in patients with acute stroke. Stroke 38: 1088-1090.

35. Suzuki M, Omori M, Hatakeyama M, Yamada S, Matsushita K, et al. (2006) Predicting Recovery of Upper-Body Dressing Ability After Stroke. Arch Phys Med Rehabil 87: 1496-1502.

36. Barker N, Brauera S (2005) Upper limb recovery after stroke: The stroke survivors' perspective. Disabil Rehabil 27: 1213-1223.

37. Tsouna-Hadjis E, Vemmos K, Zakopoulos N, Stamatelopoulos S (2000) First-stroke recovery process: the role of family social support. Arch Phys Med Rehabil 81: 881-887.

38. Rabadi M, Galgano M, Lynch D, Akerman M, Lesser M, et al. (2008) A pilot study of activity-based therapy in the arm motor recovery post stroke: a randomized controlled trial. Clin Rehabil 22: 1071-1082.

39. Blanton S, Wolf S (1999) An application of upper-extremity constraint-induced movement therapy in a patient with subacute stroke. Phys Ther 79: 847-853.

40. Chollet F, DiPiero V, Wise R, Brooks D, Dolan R, et al. (1991) The functional anatomy of motor recovery after stroke in humans: a study with positron emission tomography. Ann Neurol 29: 63-71.