Effectiveness of Modified Constraint-Induced Movement Therapy on Upper Limb Function in Stroke Subjects

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Abstract-

Background and purpose: Of all stroke survivors, more than 50% are left with motor disabilities. Impairment of upper limb movement is a common motor disability. Constraint-Induced Movement Therapy (CIMT) is an intervention which has been used for the treatment of upper extremity motor disabilities in stroke patients. Although CIMT is an effective intervention, a recent survey revealed that this procedure is viewed with apprehension by many clinicians because of concerns about practicality and resource issues. We developed a modified CIMT that reserves the massed training of the affected arm without any physical restriction of the intact one and then used it on our stroke patients. This study was designed to evaluate the effectiveness of this Modified-Constraint-Induced Movement Therapy (m-CIMT).

Methods: Thirty stroke patients were randomly assigned to either an m-CIMT (n=13) or a control group (n=17). Subjects in the m-CIMT group received a 2-week course of m-CIMT. Outcomes were evaluated using the Wolf Motor Function Test (WMFT).

Results: After only 2 weeks of training, significant differences ($p<0.05$) in favor of m-CIMT were found in the following 6 elements of the WMFT: Extend elbow with weight, Lift pencil, Stack checkers, Flip cards, Turn key in lock, and Lift basket.

Conclusion: The present study shows that our m-CIMT is useful in improving the function of the affected upper extremity in stroke patients.

Key Words: Modified constraint induced movement therapy, Stroke, Upper extremity function

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INTRODUCTION

Stroke is the leading cause of motor disability in the world. A recent study indicated that the number of stroke patients may be much higher than previously thought[(1)]. In addition, over 50% of these individuals are

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left with motor disabilities[2]. Impairment of upper limb function is among the most common of motor disabilities and it has a great impact on functional and social independence of the patients and thus these disabilities represent a major public health problem[3]. Compounding the problem, the recovery of upper extremity function is often slower than that of the lower extremity[4,5]. In order to enhance the process of recovery, there has been many rehabilitation methods developed[6].

Constraint-Induced Movement Therapy (CIMT) is an intervention that has been used mainly for the treatment of the upper extremities for stroke patients[6-9]. Most of the work with CIMT has involved constraining the use of the unaffected upper extremity while forcing the affected upper extremity to practice a variety of motor tasks[10,11]. This intervention has been shown to achieve substantial long-term improvements for stroke patients in a follow-up period of up to two years[12]. But, in the minds of clinical therapists, the applicability and the efficacy of CIMT remains ambiguous[3,13].

The principles of CIMT are based on previous research on monkeys in which somatic sensation of a single upper extremity was surgically abolished by dorsal rhizotomy[7,14]. Deprived of sensory feedback, the monkeys never used this forelimb, unless they were forced to do so[15]. Experimental evidence showed that the loss of motor function secondary to deafferentation was the result of learned nonuse[7,14]. The learned nonuse of an affected arm is also noted in stroke patients[10,16]. However, this decreased use of an affected arm can be facilitated by either restraint of the intact limb or mass training of the affected one[17-20].

Although CIMT has been proved to be an effective intervention, a recent survey revealed that this procedure is viewed with reservations by many clinicians because of concerns about practicality and safety issues[21]. A modified CIMT (m-CIMT) that reserves the massed training of the affected arm without any physical restriction of the intact one was developed and used on our stroke patients. This study was designed to evaluate the effectiveness of this modified form of CIMT.

METHODS

Subjects

Thirty subjects were recruited from the Department of Neurology of Taipei Municipal WanFang Hospital in Taiwan. They all met the following inclusion criteria: (1) A history of a single stroke resulting in a hemiparesis; (2) A minimum of 20 degrees of active wrist extension and 10 degrees of active finger extension; (3) Age 18 to 80 years; and, (4) No severe aphasia or cognitive impairments. The subjects were excluded if they had (1) Other diseases that would confound this study, such as Parkinson's disease, shoulder subluxation or (2) Recurrent stroke during the training period. All patients gave their written informed consent.

Design

In an observer-blinded randomized clinical trial, all subjects were assigned randomly into 2 groups- m-CIMT and control. Subjects in the m-CIMT group received a 2-week (6 hrs/day) treatment based on the modified CIMT[6]. Subjects in the control group received their regular program, such as physical therapy (gait training, facilitation, balance training...etc.) or occupational therapy. Basic information was recorded before treatment. The Wolf Motor Function Test (WMFT)[22], a 15-item timed instrument, was used as the outcome measure. All 15 items were tested twice in both pretreatment and posttreatment evaluations. In each evaluation, the better one was chosen for comparison.

Modified CIMT

Modified CIMT reserving the mass training of the affected arm, a procedure termed "shaping", was carried out for 2 weeks (6 hrs/days) without any physical restriction of the intact one. The shaping procedure involved (1) Providing explicit verbal feedback for small improvements in task performance, (2) Selecting tasks that were tailored to address the motor deficits of the individual patient, and (3) Helping the subjects to carry out parts of a movement that they, at first, can not perform[11,22-24]. A battery of approximately 50 tasks was used for shaping, from which a subset of 15 to 20 tasks were selected for individual subjects[10]. The household objects (e.g., jars, eating utensils, spring-loaded clothespins) and standard devices used in physical and occupational therapy were used as the task objects in this study[10].

WMFT

The WMFT was developed by Wolf et.al. to examine and measure the effectiveness of CIMT for survivors of stroke and traumatic brain injury[8,21]. It is sensitive to the level of motor functioning characteristics in patients with mild to moderate stroke. The WMFT is an instrument with high interrater reliability, internal consistency, and test-retest reliability[21]. The original form of the test consisted of 21 simple tasks sequenced according to joints involved and level of difficulty[8]. As recommended by Wolf, the current version reserves 17 tasks, two of which are simple measures of strength[21]. We used the other 15 items which measured the performance time. We asked the subjects to complete these tasks as fast as they could. If a subject was unable to complete an item within 2 minutes, the attempt was stopped and a performance time of over 120 seconds assigned.

Statistical analysis

Data analysis was performed using SPSS for Windows, version 10.0. The time for completing the WMFT was analyzed by one-way ANOVAs. Comparisons of the differences within each group before and after the two weeks in items of the WMFT were performed by using the Paired *t* test.

RESULTS

A total of 30 patients (aged from 47 to 80 years) with upper limb paresis after stroke were included in this study. Thirteen patients were assigned to m-CIMT group (67.85±11.2 years old, 5 right and 8 left hemiparesis, 8 men and 5 women, time from onset of stroke: 8.38±8.00 months). The other 17 became the control group (69.53±9.23 years old, 10 right and 7 left hemiparesis, 6 men and 11 women, time from onset: 6.18±7.89 months).

Table shows the means and SDs of all outcome measures in the WMFT before and after the 2-week training period. Comparing the m-CIMT group with the control

Table. *Means and SDs of all outcome measures in WMFT* before and after the 2-week training period among m-CIMT** and control groups*

	Control (n=17)		m-CIMT (n=13)	
	Pre-test	Post-test	Pre-test	Post-test
1. Forearm to table (side)	1.30 ±0.40	1.17 ±0.38	1.37 ±0.36	1.00±0.30
2. Forearm to box (side)	1.52 ±0.79	1.43 ±0.74	1.39 ±0.35	1.16±0.41
3. Extend elbow (side)	2.15 ±0.91	2.01 ±0.88	2.97 ±2.30	1.99±0.79[b]
4. Extend elbow (weight)	2.95 ±1.40	2.68 ±1.33	3.93 ±.3.89	2.04±0.72[a, b]
5. Hand to table (front)	1.45 ±0.78	1.22 ±0.63	1.62 ±0.57	1.17±0.38
6. Hand to box (front)	1.69 ±0.87	1.47 ±0.81	1.74 ±0.67	1.18±0.45
7. Reach and retrieve	3.24 ±1.65	3.06 ±1.54	3.43 ±1.46	2.57±0.93
8. Lift can	2.91 ±2.69	2.70 ±2.45 (n=11)	2.72 ±1.19	1.80±0.46 (n=6)
9. Lift pencil	2.58 ±2.06	2.47 ±2.12 (n=11)	3.16 ±1.76	1.98±0.83[a, b] (n=7)
10. Lift paper clip	2.86 ±2.09	2.59 ±2.00 (n=11)	2.48 ±0.56	1.89±0.70 (n=6)
11. Stack checkers	6.48 ±3.11	5.34 ±2.61 (n=11)	8.15 ±5.70	4.06±1.72[a, b] (n=6)
12. Flip cards	4.15 ±2.21	3.89 ±2.26 (n=11)	10.41 ±14.58	3.18±1.13[a, b] (n=6)
13. Turn key in lock	3.75 ±3.59	3.21 ±3.29 (n=11)	3.64 ±2.11	2.09±0.84[a, b] (n=6)
14. Fold towel	4.12 ±3.85	3.84 ±3.57 (n=11)	3.31 ±1.10	2.54±0.75 (n=6)
15. Lift basket	3.35 ±2.34	3.11 ±2.25 (n=11)	4.19 ±2.42	2.02±0.40[a, b] (n=7)

a: p<0.05 between group comparison; b: p<0.05 within group comparisonl; *WMFT: Wolf Motor Function Test; **m-CIMT: modified Constraint Induced Movement Therapy group, significant differences ($p < 0.05$) in m-CIMT group were demonstrated in the following 6 items: Extend elbow with weight, Lift pencil, Stack checkers, Flip cards, Turn key in lock, and Lift basket after the 2-weeks of training. No significant difference was observed in the other items of the WMFT. In this study, not all subjects were able to complete all 15 items. If they failed to complete the task within 120 seconds in the first evaluation, the task would not be recorded and compared. All subjects completed the first seven items. 18 subjects (control: 11; m-CIMT: 7) completed the following two items-lift pencil and lift basket. Only 17 subjects (control: 11; m-CIMT: 6) completed other items. The results are listed in Table 1 with the significant items highlighted in bold and colored font.

DISCUSSION

The results indicate that our Modified Constraint Induced Movement Therapy is useful in improving the motor control of the affected upper extremity in stroke patients. Many studies have already reported that CIMT is an effective treatment with restriction of the intact upper limb during training[6-9]. The restrictive device and supervised training schedules may make stroke patients hesitant to participate in such a program[23,26]. Although most activities of daily living can be performed with one hand, others need to be performed by two hands[25]. In a similar study, Sterr and Freivogel tried to resolve this problem. They used a 3-week protocol, during which, patients received shaping training of the affected arm for only 90 minutes each day and had no constraint[3]. Their results showed an increased use of the affected limb in everyday situations (measured by Motor Activity Log)[3]. Our findings are similar to their observations. Although both studies show some clinical benefits achieved without physical restriction of the intact limb, it is not to say that the element of constraint is irrelevant to the clinical outcome of CIMT. The results also show that more difficult tasks seemed to have better potential for significant improvement. These more difficult tasks (such as stack checkers, turn key in lock, or lift basket) need more hand control and strength. This phenomenon might indicate that the shaping program has more effect on the complex and functional tasks. Similar research also showed that their m-CIMT participation elicited functional changes[26]. After 'shaping' treatment, stroke patients might get more motor gains and better independent activities of daily life. Because more difficult tasks need more joints combined and more effective motor control, it may take more time to complete. In other words, an easy task needs less time so that the efficacy of shaping treatment may not be significant. More studies are needed to substantiate this point of view.

The choice of outcome measures is a difficult one[25]. The measurement of time needed to complete the WMFT may not totally represent the effect of m-CIMT because the quality of the movement is not measured. Subjects might use a compensatory strategy, such as synergy pattern, to complete the request. However, the goal of the training is to restore the ability of motor function and not only to complete the tasks. This represents the difficulty in selecting an appropriate outcome measure. This study shows that m-CIMT can significantly improve some items in the WMFT. Although the number of patients is small and the outcome measures are not complex enough, the results of this study indicates that m-CIMT treatment is easily accepted and has a better result than traditional rehabilitation programs.

REFERENCES

1. Broderick J, Brott T, Kothari R, et al. The Greater Cincinnati/Northern Kentucky Stroke Study: preliminary first-ever and total incidence rates of stroke among blacks. Stroke 1998;29:415-21.
2. Stineman MG, Maislin G, Fiedler RC, et al. A prediction model for functional recovery in stroke. Stroke 1997;28: 550-6.
3. Sterr A, Freivogel S. Motor-improvement following intensive training in low-functioning chronic hemiparesis. Neurology 2003;61:842-4.
4. Wagenaar RC. Functional Recovery After Stroke [PhD thesis]. Amsterdam, Netherlands: VU University Press, 1990.
5. Kwakkel G, Wagenaar RC, Kollen BJ, et al. Predicting disability in stroke: a critical review of the literature. Age

Ageing 1996;25:479-89.

6. Taub E, Miller NE, Novack TA, et al. Technique to improve chronic motor deficit after stroke. Arch Phys Med Rehabil 1993;74:347-54.
7. Taub E. Somatosensory deafferentation research with monkeys: implications for rehabilitation medicine. In: Ince LP, ed. Behavioral Psychology in Rehabilitation Medicine: Clinical Applications. New York, NY: Williams & Wilkins, 1980:371-401.
8. Wolf SL, Lecraw DE, Barton LA, et al. Forced use of hemiplegic upper extremities to reverse the effect of learned nonuse among chronic stroke and head-injured patients. Exp Neurol 1989;104:125-32.
9. Taub E, Pidikiti RD, DeLuca SC, et al. Effects of motor restriction of an unimpaired upper extremity and training on improving functional tasks and altering brain behaviors. In: Toole JF, Good DC, eds. Imaging in Neurologic Rehabilitation. New York, NY: Demos Vermande, 1996: 133-54.
10. Miltner WH, Bauder H, Sommer M, et al. Effects of constraint-induced movement therapy on patients with chronic motor deficits after stroke: a replication. Stroke 1999;30: 586-92.
11. Morgan WG. The shaping game: a technique. Behav Ther 1974;5:271-2.
12. Sterr A, Elbert T, Berthold I, et al. Longer versus shorter daily constraint-induced movement therapy of chronic hemiparesis: an exploratory study. Arch Phys Med Rehabil 2002;83:1374-7.
13. Page SJ, Levine P, Sisto S, et al. Stroke patients' and therapists' opinions of constraint-induced movement therapy. Clin Rehabil 2002;16:55-60.
14. Taub E. Movement in nonhuman primates deprived of somatosensory feedback. Exerc Sport Sci Rev 1976;4:335-74.
15. Taub E, Wolf SL. Constraint-induced movement techniques to facilitate upper extremity use in stroke patients. Topics in Stroke Rehabilitation. 1997;3:38-61.
16. Andrews K, Stewart J. Stroke recovery: he can but does he? Rheumatol Rehabil 1979;18:43-8.
17. Knapp HD, Taub E, Berman AJ. Effect of deafferentation on a conditioned avoidance response. Science 1958;128: 842-3.
18. Knapp HD, Taub E, Berman AJ. Movements in monkeys with deafferented forelimbs. Exp Neurol 1963;7:305-15.
19. Taub E. Motor behavior following deafferentation in the developing and motorically mature monkey. Neural Control of Locomotion. In: Herman R, Grillner S, Ralston HJ, Stein PSG, Stuart D. New York: Plenum, 1976:675-705.
20. Taub E, Ellman SJ, Berman AJ. Deafferentation in monkeys: effect on conditioned grasp response. Science 1966; 151:593-4.
21. Morris DM, Uswatte G, Crago JE, et al. The reliability of the wolf motor function test for assessing upper extremity function after stroke. Arch Phys Med Rehabil 2001;82:750-5.
22. Taub E, Uswatte G. A new approach to treatment and measurement in physical rehabilitation: constraint-induced (CI) movement therapy. Handbook of Rehabilitation Psychology. In: Frank RG, Elliot TR. Washington, DC: American Psychological Association, 2000:475-96.
23. Penyan MV. How To Use Shaping. Lawrence, KS: H & H Enterprises, 1980.
24. Taub E, Crago JE, Burgio LD, et al. An operant approach to rehabilitation medicine: overcoming learned nonuse by shaping. J Exp Anal Behav 1994;61:281-93.
25. van der Lee JH. Constraint-induced movement therapy: some thoughts about theories and evidence. J Rehabil Med 2003;41 Suppl:41-5.
26. Page SJ, Sisto S, Levine P, et al. Efficacy of modified constraint induced movement therapy in chronic stroke: a single-blinded randomized controlled trial. Arch Phys Med Rehabil 2004;85:14-8.