Effects of modified constraint induced therapy on upper limb function in subacute stroke patients

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ABSTRACT

Objectives: To examine the feasibility and efficacy of a modified constraint induced therapy protocol on stroke patients.

Methods: This study was carried out during the period from August 2001 to January 2002 at the Riyadh Medical Complex, Riyadh, Kingdom of Saudi Arabia. Six stroke patients with subacute cerebrovascular accident (<6 months) were included in the study. Three male and 3 female patients with a mean age of 54.3±6.9 years (range 45-67 years), and mean duration of hemiparesis of 4.7 months (range 2.3-5.8 months). They were divided randomly into 3 groups of 2 patients. The first 2 patients (constraint induced therapy group) participated in half an hour of physical and occupational therapy sessions 3 times per week for 10 weeks. During the same period, their unaffected arms and hands were restrained 5 days per week for 5 hours identified as times of frequent use. The second 2 patients (traditional therapy group) received regular therapy administered after 10 weeks. The last 2 patients (control group) received no therapy. The Fugl-Meyer Assessment of Motor Recovery After Stroke (Fugl), Action Research Arm Test (ARA), Wolf Motor Function Test (WMFT), and Motor Activity Log (MAL) were administered to the patients.

Results: Patients receiving modified constraint induced therapy exhibited substantial improvement on the Fugl, ARA, and WMFT, as well as increases in amount and quality of use of the limb using the MAL. While patients receiving traditional physical and occupational therapy, and no therapy patients exhibited few improvements.

Conclusion: Modified constraint induced therapy may be an efficacious method of improving function and use of the affected arms in stroke patients exhibiting learned nonuse.

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Stroke secondary to cerebrovascular accident (CVA) is one of the most prevalent diagnoses treated by therapists.[1,2] Furthermore, on an outpatient basis, upper limb therapy is often administered for half an hour per day, 2-3 times per week, with single therapists.[1] Skills learned during sessions may result in a determination of independence, yet the patient may still not be able to function independently, as the individual's quality of life may remain low.[3] It is unsurprising that controlled studies evaluating physical and occupational therapy regimens for CVA have not yielded positive findings.[4] The animal research conducted during the 1970s,[5-6] suggested that a limb thought to be unusable is capable of movement by conditioning its use. Specifically, researchers[7-11] have restrained the unaffected arms of chronic patients with CVA for 14 hours each day for 2 weeks while patients perform purposeful activities with the affected arm for 6 hours per day on 10 consecutive weekdays. The results of a randomized controlled study,[12] and a case study[13] suggested that this constraint-induced movement therapy (CIT) overcomes "learned non-use," and increases use and function of the affected upper limb after stroke.[6] The CIT approach proposed by Taub and colleagues appears to have efficacy, particularly in chronic stroke.[8-12] Motor learning researchers have also noted that a number of alternative practice schedules can elicit similar outcomes.[14] As most patients receive

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therapy on an outpatient basis 2 to 3 times per week for one to 2 months, Page and colleagues[15] recently tested a modified CIT protocol on 2 patients 5 months post-CVA exhibiting stable motor deficits and learned nonuse in their affected upper limbs. This therapy was combined with wearing of a sling on the unaffected upper limb 5 days per week for 5 hours initially identified as a time of frequent use. Besides being implemented within most managed care guidelines, Page and colleague[15] reported substantial decreases in impairment as well as increases in upper-limb use and function.

The purpose of this study was to utilize randomized, controlled methods in: (a) Examining the feasibility of performing Page and colleagues protocol; (b) Comparing the efficacy of Page and colleagues' 10 week CIT protocol with a 10 week regimen of traditional physical and occupational therapy (TR), and with no treatment (CON), in improving scores on the Wolf Motor Function Test (WMFT) and Motor Activity Log (MAL). It was hypothesized that participants in the modified CIT group would exhibit greater reductions in impairment, greater increases in arm use, and greater functional improvements in the affected upper-limb, than participants in the TR or CON conditions.

Methods.

Instruments. The Fugl-Meyer Assessment of Motor Recovery After Stroke (Fugl)[16] assesses several dimensions of impairment, and has been extensively used in studies measuring recovery in patients with CVA, including the only randomized, controlled trial of CIT.[12] The 66-point upper-limb motor component of the Fugl was used in this study. Its specific items were derived from the Brunnstrom stages of post-CVA motor recovery,[17] applied to each item. The Fugl has been used extensively as a measure of impairment in studies measuring functional recovery in patients with strokes,[12] and has been shown to have impressive test-retest reliability (total = 0.98 - 0.99; subtests = 0.87 - 1),[18] interrater reliability, and construct validity.[19] The Action Research Arm Test (ARA)[20] is a 19-item test divided into 4 categories (grasp, grip, pinch and gross movement). The test provides ordinal-level scores, has interrater (r = 0.99) and retest (r = 0.98) reliability,[20] can be completed in a short amount of time, and is highly correlated with many functional measures of stroke outcome.[21] The ARA has also been used in CIT research.[12] Using the protocols of Wolf and colleagues[7] and Taub and colleagues,[8] the WMFT was used to measure the ability of patients to perform 19 simple limb movements and tasks with the affected arm. It has been widely used in CIT studies.[8-13] The MAL consists of a semistructured interview measuring how patients use their affected limb for activities of daily living (ADLs) in the home. The patient and caregiver are asked to independently rate how much and how well the patient has used the affected arm for 30 ADLs during the past week. Patients and caregivers use a 6 point Amount of Use (AOU) scale to rate how much they are using their affected arm and a 6 point Quality of Movement (QOM) scale to rate how well they are using it.

Subjects. All participants signed informed consent forms after receiving a detailed explanation of the study. They were selected according to an established inclusion criterion from previous CIT studies.[8,11,16] The following inclusion criteria was met; (a) Stroke 4 weeks - 6 months ago (b) Age between 18 - 75 (c) Completely discharged from rehabilitation (d) Ability to actively extend the metacarpophalangeal (MCP) and interphalangeal (IP) joints 10° (e) Ability to actively extend the wrist 20° (f) Motivated and willing to follow intervention guidelines. While the exclusion criteria included (a) Significant cognitive impairment less than 70 on the Modified Mini Mental Status Examination,[22] (b) Hemorrhagic or bilateral lesions (c) Lesions in the primary sensory or motor cortical areas (d) Significant spasticity, as defined as a score of "2" or higher on the Modified Ashworth Spasticity Scale,[23] (e) Significant pain in the affected upper limb, as measured by a score of "4" or higher on a Visual Analog Scale, and (f) Involving in any other experimental rehabilitation or drug studies. Six patients, 3 males and 3 females (mean age 54.3 ± 6.9 years, age range 45 to 67 years; mean duration of hemiparesis 4.7 months, range 2.3 to 5.8 months) with subacute CVA (<6 months) were included in the study. Comparison between observations at time of screening, discharge records, and physiatrist observations determined that all patients' physical and cognitive conditions had not changed from discharge. The patients were all capable of moving their affected arms outside of synergy. However, informal interviews, clinical judgment during screening, and formal assessment using the MAL, revealed that no attempts were being made to use the affected arms. It was, thus, concluded that they were exhibiting learned nonuse.[6] General subject characteristics are illustrated in **Table 1**.

Design. All subjects were randomly assigned to one of 3 groups with an equal probability. A randomized pre-test and post-test control group design was applied. The Fugl and ARA were then administered to all subjects on 2 occasions during the pre-testing period, while the WMFT and MAL were administered during one pre-testing session. Following the recommendations of Page and colleagues,[15] the 4 patients randomly assigned to the CIT and traditional rehabilitation (TR) conditions each participated in one half hour of physical therapy (PT) and one half hour of occupational therapy (OT) on an outpatient basis 3 times per week for 10 weeks. Eighty percent of each PT and OT session (24 minutes) focused on neuromuscular facilitation (PNF) techniques with emphasis on ADL tasks whenever possible, and 20 percent (6 minutes) focused on compensatory

techniques using the unaffected side (example, reaching and performing functional tasks with the unaffected arm, assisting the weak arm during reaching tasks). "Shaping" is a commonly used operant conditioning method in which a behavioral (in this case movement) objective is approached in small steps of progressively increasing difficulty. The participant is rewarded with enthusiastic approval for improvement, but never blamed (punished) for failure. In CIT, a basic principle is to keep extending motor capacity a small increment beyond the performance level already achieved. In addition, to other tasks practiced during therapy sessions, each CIT patient identified 2 functional tasks listed on the WMFT that were valued by them, and these tasks were recorded on the subject data sheet. During therapy sessions, each previously identified skill was practiced for at least 5 minutes as part of the upper-limb program. During the same 10 week period, the lower arms and hands of the 2 patients randomly assigned to the CIT condition were restrained every weekday for the 5 hours initially identified as a time of frequent arm use. The arm was restrained using cotton Bobath sling. The sling had a single strap worn around the neck and under the arm supporting the elbow and the forearm. The hand was placed in a mesh, polystyrene-filled mitt with a Velcro strap around the wrist (Sammons-Preston). After initial screening, instrument administration and random assignment, patients randomly assigned to the control condition (CON) received no therapy during the same 10-week period. After 10 weeks, all patients were again administered the Fugl, ARA, WMFT, and MAL.

Results. In-clinic interviews every 2 weeks, as well as informal interview (home visits) by the researcher, revealed high satisfaction with the protocol. The sling wear log also showed that CIT patients were actively attempting to use their arms during the 5 hours per day when the sling was being worn. Scores on the Fugl and ARA remained consistent between pre-testing sessions for all patients. After intervention, though, patients in the CIT group exhibited substantial improvement on the Fugl (**Table 2**), while TR and CON patients exhibited few improvements. All subjects also displayed consistent scores on the ARA during pre-testing, but subjects in the CIT group exhibited appreciably improved functional scores after intervention (**Table 2**). Traditional therapy and CON patients' levels of arm function, as measured by the ARA remained relatively stable and decreased, in some cases, after intervention.

Subjects in the CIT group also displayed substantial improvements on the WMFT between pre-testing (PRE) and post-testing (POST) sessions; both in terms of rating of movement and time taken to complete the movement (**Table 3**). In contrast, subjects in the TR and CON groups displayed few, if any, improvements between pre-testing and post-testing sessions as measured by the WMFT. Using the MAL, patients exhibited substantial changes, both in amount of use of the affected arm, and quality of use of the affected arm between PRE and POST (**Table 4**). Specifically, before intervention, patients in all 3 groups reported using the affected arm for between one and 3 of the 30 tasks listed on the MAL with average quality of use (QOU) ratings of 2 for the CIT group, 2.8 for the TR group, and 2.7 for the CON group. In contrast, at POST, patients in the CIT group reported using the affected arm for an average of 14 activities with a QOU rating of 4.3. In contrast, AOU scores for TR changed by 3 for the TR group and 2.2 for the CON group, and QOU scores changed by 0.2 for the TR group and 0.5 for subjects in the CON group.

Discussion. The feasibility and the efficacy of a modified clinically practical CIT protocol compared with a traditional regimen of physical and occupational therapy, and with no therapy on improving outcomes in the affected arm of patients with subacute CVA was examined. All patients exhibited stable scores during 2 separate administrations of the Fugl and ARA, before intervention. However, after intervention, subjects receiving modified CIT exhibited substantial increases in arm function as measured by the ARA and reduction in arm impairment as measured by the Fugl. In addition, considerable changes were also observed among CIT subjects between pre-testing and post-testing sessions on the WMFT, both in terms of rating of arm use, and in terms of time taken to complete the task. In contrast, patients in the TR and CON groups exhibited no changes between pre-testing and post-testing sessions. Patients in the CIT group showed especially strong improvements on the "shaping" tasks on the WMFT. Although improvements were seen in some of the gross items featured on each instrument, the most remarkable improvements among patients in the CIT group were displayed on fine motor skills (for example wrist movements on the Fugl, gripping and grasping movements on the ARA, turning cards, stacking checkers, picking up a paperclip on the WMFT).

Patients in the CIT group also displayed considerably larger improvements in the use and function of their affected arms, as measured by the MAL, compared with the TR or CON groups. These MAL scores are the first to suggest that the learned nonuse phenomenon observed in all patients at PRE can be overcome through modified training and a sling wear schedule still emphasizing repeated use. A shortcoming of rehabilitative studies in general has been a paucity of data describing the transfer of the treatment effect to the life situation. In this study, informal interviews conducted after intervention with patients assigned to CIT revealed a positive transfer of skills learned in rehabilitation to ADLs. Taken

Table 1 - General characteristics of the participating subjects in the study.

Subject	Gender	Age	Onset (months)	Side affected	Group
1	Male	53	5.4	Left	CIT
2	Female	57	5.8	Right	CIT
3	Male	55	5.6	Right	TR
4	Female	49	2.3	Left	TR
5	Male	67	5.5	Left	CON
6	Female	45	3.8	Right	CON

CIT - constraint induced therapy, TR - traditional physical and occupational therapy, CON - no treatment

Table 4 - Changes in self-ratings of amount and quality of affected arm use between PRE and POST group.

Group	PRE		POST	
	Average amount of use	Average quality of use	Average amount of use	Average quality of use
CIT	2	2	14	4.3
TR	1	2.8	5	3
CON	3	2.7	3	2.2

Scores on the scales are based on a subjective rating scale, with 0 being the lowest rating and 5 being the highest, CIT - constraint induced therapy, TR - traditional physical and occupational therapy, CON - no treatment, PRE - pre-testing, POST - post-testing

Table 2 - Scores of CIT patients on the Fugl and ARA before and after intervention.

Scale	CIT						Traditional						Control					
	1			2			3			4			5			6		
	PR1	PR2	POS	PR1	PR2	POS	PR1	PR2	POS	PR1	PR2	POS	PR1	PR2	POS	PR1	PR2	POS
Fugl	46	47	54	34	35	45	54	53	48	60	59	63	54	55	53	61	62	62
ARA	48	47	58	25	26	46	41	43	36	56	55	62	38	39	41	60	60	62

PR1 - score obtained during 1st pre-testing period, PR2 - score obtained during 2nd pre-testing period, POS - score obtained during post-test period
CIT - constraint induced therapy, Fugl - Fugl-Meyer Assessment of Motor Recovery After Stroke, ARA -Action Research Arm Test

Table 3 - Ratings of task performance and time taken to complete each task on the WMFT at PRE versus POST.

Task	CIT								Traditional								Control							
	1				2				3				4				5				6			
	PRE		POST		PRE		POST		PRE		POST		PRE		POST		PRE		POST		PRE		POST	
	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T
Forearm to table	3	3	4	2	3	5	5	1	5	1	5	1	3	3	4	5	4	3	4	3	2	5	3	5
Forearm to box	3	3	4	10	3	8	4	5	5	1	5	1	3	3	3	5	4	3	4	3	5	5	1	5
Extended elbow	4	4	5	5	3	8	4	5	5	1	5	1	4	3	4	5	4	1	4	1	3	5	4	5
Extended elbow with weight	3	3	4	5	2	9	4	5	5	1	5	1	4	3	3	10	5	3	5	5	3	10	3	5
Hand to table	4	4	4	1	4	10	5	5	5	3	5	3	4	2	4	5	5	2	5	5	2	5	4	5
Hand to box	4	4	4	5	3	5	4	5	5	4	5	4	4	2	4	5	5	2	5	5	5	8	1	8
Weight to box	3	3	4	5	3	8	4	5	4	4	4	4	3	3	4	3	5	2	5	5	2	10	3	10
Reach and retrieve	3	4	5	2	3	10	4	10	5	1	5	1	3	3	3	3	4	5	4	5	6	10	3	5
Lift can	3	4	5	2	4	8	4	5	5	1	5	1	2	6	3	10	4	5	4	5	1	3	4	10
Lift pencil	3	3	4	1	4	3	4	5	5	1	5	1	0	20	1	5	4	5	4	5	4	5	3	5
Lift paperclip	2	2	4	1	4	6	4	5	5	1	5	1	0	20	1	10	2	10	3	5	3	10	5	5
Stack checkers	2	3	5	1	3	4	4	5	5	1	5	1	0	20	1	10	3	7	3	5	3	8	5	5
Flip cards	3	3	4	2	3	5	4	5	5	1	5	1	0	20	0	20	3	10	3	5	3	7	2	NA
Grip strength	3.7	3.7	4.3	NA	3.5	NA	4	NA	4.5	NA	4.5	NA	4.1	NA	4.2	NA	4.9	NA	4.9	NA	NA	NA	3.9	5
Turn key in lock	4	4	5	5	4	2	5	10	5	1	5	1	3	3	2	5	4	5	4	5	5	5	3	10
Lift basket	3	3	4	5	4	4	4	5	5	1	5	1	3	3	2	5	4	5	4	5	5	10	1	6.1
Average	3.1	3.3	4.3	3.4	3.3	6.3	4.3	5.1	4.9	1.5	4.9	1.5	2.4	7.3	2.7	6.9	4	4.6	4.1	4.5	3.4	6.9	3	5

R - observer rating of patient ability to complete each task, T- time taken, in seconds, by patient to complete the task.
Patients were given 120 seconds to complete each task with one trial provided for each task. Averages do not include grip strength amount, measured in kilograms. NA - denotes tasks on which time was not recorded. WMFT - Wolf Motor Function Test, PRE - pre-testing, POST - post-testing

together, these data further support the supposition that combining restraint of the unaffected limb with the therapy protocol described herein overcomes the learned nonuse phenomenon, resulting in increases in arm use and function and reductions in impairment of the affected upper limb after CVA. The present study findings indicate that this protocol is more efficacious than both traditional therapy alone and no therapy.

Research with patients with CVA is often confounded by natural recovery among subjects. However, several factors make natural recovery an unlikely explanation for the effect observed (a) All subjects had been discharged from all forms of therapy for a minimum of one month (mean 3.6, range 1-4 months; (b) Comparison between observations at initial screening with medical records, and discharge summaries, suggested that patients had not exhibited improvement since time of discharge from therapy; (c) The multiple baseline pre-testing design showed no appreciable changes among any of the subjects prior to intervention; (d) The rapid progress that patients receiving modified CIT exhibited in a relatively short amount of time, particularly in comparison with TR and CON patients, also makes it unlikely that improvements were attributable to spontaneous recovery. Although, there is some dispute in natural recovery time for upper limb after stroke, the study findings can, based on these observations, thus, rule out the possibility of natural recovery as an explanation for the observed effects.

Informal interviews also revealed that participating therapists found the protocol easy to administer, particularly as PNF and compensatory training were already part of their treatment regimens for patients with CVA. This finding was in contrast to the survey by Page and colleagues,[15] which indicated that therapists felt that CIT was difficult to administer, and not implementable within most clinical environments without special training, additional resources or both.

In conclusion, the traditional CIT protocol may be problematic for many patients with CVA, due to the intensity of the practice schedule and the duration of the restraint schedule. Problems with the restraint schedule, such as inability to use the affected arm and hand for balance activities and instrumental ADLs, may also cause problems. Therapists have also noted that the practice schedule and restraint schedule in CIT could make patient adherence and motivation, as well as ability to engage the patient over 6 hours, problematic. Also, most therapy centers and subacute facilities have patients with CVA who exhibit learned nonuse, and who are receiving traditional therapy regimens on an outpatient basis. Although the CIT protocol is based on massed, repeated practice, there is much motor learning evidence suggesting that various types of practice schedules can facilitate motor learning.[14,24,25] Findings in the current study indicate that a modified CIT protocol using a more distributed practice schedule, but still emphasizing repeated use, is effective in reducing upper-limb impairment and improving upper-limb use and function. It is possible that repeated affected limb ADL practice, which is a deviation from current clinical practice, may be the critical variable in overcoming learned nonuse, while the practice schedule (for example, massed or distributed) may be less crucial. Controlled studies of modified CIT with CVA patients exhibiting learned nonuse should be encouraged.

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