Original Article

The effects of modified constraint-induced therapy combined with mental practice on patients with chronic stroke

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Abstract. [Purpose] The purpose of this study was to investigate the effects of the modified constraint-induced therapy (mCIT) combined with mental practice (MP) on patients with chronic stroke. [Subjects] The subjects were 26 patients with chronic stroke. [Methods] Patients were randomly assigned to the mCIMT + MP group or the MP group. All subjects were administered mCIT consisting of (1) therapy emphasizing affected arm use in functional activities 5 days/week for 6 weeks and (2) 4 hours of restraint of the less affected arm 5 days/week. The mCIT + MP subjects received 30-minute MP sessions provided directly after therapy sessions. To compare the two groups, the Action Research Arm Test (ARAT), Fugl-Meyer Assessment of Motor Recovery after stroke (FM), and Korean version of Modified Barthel Index (K-MBI) were performed. [Results] Both groups showed significant improvement in ARAT, FM, and K-MBI after the interventions. Also, there were significant difference in ARAT, FM, and K-MBI between the two groups. [Conclusion] mCIT remains a promising intervention. However, its efficacy appears to be enhanced by use of MP after mCIT clinical sessions.
Key words: Mental practice, Motor imagery, Stroke

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INTRODUCTION

During mental practice (MP), physical activities are mentally rehearsed, usually in the absence of voluntary physical movement[1)]. The same muscular[2–4)] and neural structures[5, 6)] subserve both physical and mental practice, enabling MP to offer similar benefits to rehabilitation in patients with stroke. For example, MP can be used as a method of acquiring additional practice attempts in rehabilitation settings[7–9)], especially when physical activity is not possible due to severe impairment[10)]. In stroke rehabilitation settings, the addition of MP to repetitive, task-oriented training regimens significantly increases affected arm use[11)] and function in subacute[12, 13)] and chronic patients[11)], and this was also reported in a recent, randomized controlled trial[14)].

Modified constraint-induced movement therapy (mCIMT) is an outpatient-based, task-oriented training protocol that increases affected arm use and function at all stage after a stroke[15–18)]. During mCIMT, affected arm use is emphasized in 2 ways, each administered during a 6-week period: (1) Patients participate in half-hour task-oriented training sessions occurring 3 days/week that emphasize affected arm use. Shaping is also applied during the therapy sessions, in which subjects are verbally encouraged to perform progressively more difficult components of the activity. (2) Patients practice activities of daily living (ADLs) with the affected arm for 5 hours/day every weekday.

Given the success of MP when combined with other task-oriented training regimens, this study examined whether the addition of MP, provided directly after clinical mCIT sessions, increases the mCIT treatment effect. We hypothesized that subjects receiving mCIT and MP would exhibit lager reductions in affected arm functional limitation and impairment than in those receiving mCIT only.

SUBJECTS AND METHODS

Volunteers were recruited in a local rehabilitation hospital. A researcher screened volunteers using the following study criteria derived from previous mCIT research: (1) history of no more than one stroke; (2) ability to actively extend at least 10° at the metacarpophalangeal joints of each digit and actively extend 20° at the wrist; (3) stroke experienced > 6 months before study participation; (4) a score ≥ 24 on the Korean version of Mini Mental Status Examination, and (5) affected arm nonuse, defined as a score < 2.5 for the amount of use scale of the Motor Activity Log. The researcher also applied the following exclusion criteria: (1) excessive spasticity at the affected arm joint and (2) excessive pain anywhere in the affected limb.

The researcher examined the following 3 outcome measures: the Action Research Arm Test (ARAT)[19)], the 66-point

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Table 1. Audiotape sequence and when tape was used

Tape No.	Functional task described	When administered
1	Reaching for and grasping an object	Weeks 1, 2
2	Proper use of pencil or pen	Weeks 3, 4
3	Turning a page in a book	Weeks 5, 6

Table 2. Subjects characteristics

		mCIT + MP (n=13)	mCIT (n=13)
Gender	Male	7	9
	Female	6	4
Age (years)		60.9 (6.8)	63.1 (6.7)
Arm affected	Right	7	5
	Left	6	8
Onset period (months)		15.9 (5.8)	14.4 (4.3)

Mean (SD). SD: standard deviation

upper extremity section of the Fugl-Meyer Assessment of Motor Recovery after stroke (FM)[21], and the Korean version of the Modified Barthel Index (K-MBI). The ARAT is a 19-item, 57-point test divided into 4 categories (grasp, grip, pinch, and gross movement), with each item graded on a 4-point ordinal scale (anchored by 0=can perform no part of the test; 3=performs test normally). It has high intrarater (r^2=0.99) and retest (r^2=0.98) reliability and validity[19, 20]. The FM assesses impairment using a 3-point ordinal scale (anchored by 0=cannot perform; 2=can perform fully). It offers impressive test-retest reliability (total=0.98 to 0.99; subtest=0.87 to 1.00)[22], interrater reliability, and construct validity. The K-MBI is a 10-item, 100-point test, with each item graded ordinal scale with a given number of points assigned to each level. The range of the score of the K-MBI is 0 to 100, with a higher score implying more independence in ADLs. The K-MBI has high validity (r^2=0.94) and reliability (r^2=0.97). The main study goal was to compare difference in motor outcomes associated with participation in the 2 interventions.

One week after screening and signing consent forms approved by the local Institutional Review Board, all subjects were administered the outcome measures. All of the instruments were administered by a research assistant with 5 years of experience in using the measures. After this testing session, the subjects were then randomly assigned to one of 2 groups using a random number table: (1) mCIT (n=13); or mCIT with MP administered directly after the mCIT clinical sessions (mCIT + MP; n=13).

Each subject began a regimen of 30-min sessions of individualized therapy administered 5 times/week for 6 weeks by the same therapist. Approximately 25 minutes of the therapy concentrated on use of more affected limb in the ADLs listed in Table 1. Approximately 5 minutes of therapy was spent on the range of motion of the more affected limb as needed. Shaping techniques were used with the ADLs to encourage motor learning and increase the difficulty of the tasks in proportion to the subject's abilities.

During the same 6 weeks, the subject's unaffected hands and wrists were restrained every weekday for 4 hours identified as a time of frequent arm use. The hands and wrists were restrained using holding mitts with Velcro straps around the wrist (Sammons Preston). Logs were kept to document device use time as well as activities performed during restraint hours.

In addition to mCIT participation, subjects randomly assigned to the mCIT + MP group also engaged in MP sessions. These 30-minute sessions were held directly after the clinical mCIT sessions in a quiet treatment room. MP subjects received the appropriate MP intervention corresponding to the week of therapy in which they were currently engaged (Table 1). All MP interventions were administered with audiotapes that were consistent in terms of content and duration with the MP tapes described by Page and colleagues[13]. The content of the tapes covered ADLs that subjects were also practicing during mCIT clinical sessions and consisted of (1) approximately 5 minutes of guided relaxation exercises; (2) 15 to 20 minutes of guided motor imagery, in which the subject was instructed to imagine himself/herself performing each component of each ADL; and (3) 5 minutes of refocusing into the room. For example, when mentally practicing reaching for a cup, the subject was taken through the visual image of reaching for the object from the first-person perspective, as well as the sensations associated with reaching for it (e.g. the feeling of extending the elbow and fingers and the feeling of the object in their hand). The scripts for the tapes were read by and occupational therapist with over 6 years of clinical experience. Subjects were instructed to not mentally practice in environments other than those that were part of this study. All subjects were assessed immediately after the 6-week interventions. The ARAT, FM, and K-MBI were administered by the same examiner who had performed the pre-test assessments and was blinded to group assignment. The researcher emphasizes that both groups received the same amount of time with the occupational therapists, i.e., during the mCIT only because the MP intervention was self-administered with an audiotape.

RESULTS

Applying the inclusion criteria, 38 subjects were screened for this study, with 12 excluded for the following reasons: (1) insufficient motor function (n=8); and (2) cognitive impairment (n=4). Consequently, 26 subjects were included, and their demographic characteristics are illustrated in Table 2.

Due to the small number of subjects, the distributional assumption that underlies the t test could not be satisfied. Thus, the Wilcoxon signed-rank test and Mann-Whitney U test were applied and revealed no significant differences between the groups in mean age and mean time since stroke. The pre-intervention ARAT, FM, and K-MBI scores also did not significantly differ between the groups.

After the interventions, the subjects in both groups exhibited significant increases in the scores of the ARAT, FM, and K-MBI. Qualitatively, all subjects reported using their more affected limbs for the ADLs listed in Table 1 as well

Table 3. Patients' ARAT, FM, and K-MBI scores before and after the interventions

	ARAT			FM			K-MBI		
	Pre	Post	Change	Pre	Post	Change	Pre	Post	Change
mCIT+MP (n=13)	26.8 (1.2)	41.8 (1.6)	15.0 (0.9)	33.6 (3.1)	41.6 (3.4)	8.0 (1.0)	71.4 (5.9)	83.1 (5.3)	11.7 (2.1)
mCIT (n=13)	27.3 (1.1)	39.5 (2.0)	12.2 (1.4)	35.4 (2.4)	39.6 (2.4)	4.2 (0.6)	75.2 (5.9)	81.5 (4.4)	6.3 (1.3)

Mean (SD). "Change" refer to mean change in score

as new ADLs such as grooming and dressing. Comparison of the scores between the pre- and post-intervention assessments revealed that the mCIT + MP group exhibited a mean increase of +15.00 points on the ARAT, +8.00 points on the FM, and +11.69 points on the K-MBI. Subjects in the mCIT only group displayed a mean increase of +12.23 points on the ARAT, +4.23 points on the FM, and +6.31 points on the K-MBI. Using the Wilcoxon signed-rank test, the mCIT + MP group revealed a significant improvement at the post-intervention assessments with regard to the ARAT ($p<0.05$), FM ($p<0.05$), and K-MBI ($p<0.05$). The control group also showed significantly improvement in the ARAT ($p<0.05$), FM ($p<0.05$), and K-MBI ($p<0.05$). There were statistically significant differences in the changes in the ARAT ($p<0.05$), FM ($p<0.05$), and K-MBI ($p<0.05$) between the groups.

DISCUSSION

Modified constraint-induced therapy is an approach encouraging affected arm use through participation in clinical practice sessions. Given the efficacy of MP when combined with other promising approaches, the current study examined the efficacy of MP when combined with mCIT.

Consistent with previous mCIT studies[15, 16], all subjects exhibited sizable changes in the outcome measures. These motor changes were clinically significant, conveying ability to perform skills. As noted earlier, MP elicits neural and muscular activations that are similar to those exhibited during physical performance of a task. Thus, the author hypothesized that participation in a mCIT and MP would provide more practice attempts for the affected cortical areas than mCIT only. This increased practice would be behaviorally manifested in mCIT + MP subjects exhibiting lager functional limitation reductions (reflected by increased ARAT scores), decreased impairment of the more affected arm (reflected by increased FM scores), and larger increases in activities of daily living skill (reflected by increased K-MBI scores) than in subjects receiving mCIT only. Consistent with the author's hypothesis, the mCIT + MP subjects exhibited significantly larger changes in the scores of the ARAT, FM, and K-MBI than mCIT only subjects (Table 3). These study results appear consistent with those of other studies in which MP was combined with other approaches for the affected arm[11–17, 23, 24].

mCIT and MP have independently been shown to produce neural changes[25, 26]. The author hypothesizes that the combination of mCIT and MP participation provided substantially more practice opportunities and more opportunities for neural plasticity to occur than participation in mCIT only. The preponderance of other studies showing effects of MP would seem to argue for the validity of the data reported here. Nonetheless, the small size and lack of assessment of fidelity of the MP intervention (other than the subjects telling the researcher that they adhered to the intervention) are possible study limitations.

In future studies, this study should be replicated with a larger group of subjects. Also future researchers should consider examining such changes using neuroimaging.

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