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

JIN HYUCK PARK, OT, MPH1)

1) Department of Occupational Therapy, College of Health Science, Yonsei University: 1 Yonseidae-gil, Wonju, Gangwon-do 220-710, Republic of Korea

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 mCIT + 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

INTRODUCTION

During mental practice (MP), physical activities are mentally rehearsed, usually in the absence of voluntary physical movement1). The same muscular2–4) and neural structures5, 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 settings7–9), especially when physical activity is not possible due to severe impairment10). In stroke rehabilitation settings, the addition of MP to repetitive, task-oriented training regimens significantly increases affected arm use11) and function in subacute12, 13) and chronic patients11), and this was also reported in a recent, randomized controlled trial14).

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 stroke15–18). 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 after a stroke15–18). 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 larger 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...
The FM assesses impairment using a 3-point ordinal scale (anchored by $0 = \text{cannot perform}$; $2 = \text{can perform fully}$). It offers impressive test-retest reliability (total=0.98 to 0.99; subtest=0.87 to 1.00)\textsuperscript{19, 20}, 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\textsuperscript{13}).

### 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 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. 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.

### 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             | Female      |
|                  | 7                | 6           |
|                  | 9                | 4           |
| Age (years)      | 60.9 (6.8)       | 63.1 (6.7)  |
| Arm affected     | Right            | Left        |
|                  | 7                | 6           |
|                  | 5                | 8           |
| Onset period (months) | 15.9 (5.8) | 14.4 (4.3) |

Mean (SD). SD: standard deviation
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 improved results 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, 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 a larger group of subjects. Also future researchers should consider examining such changes using neuroimaging.

| 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 | 41.8 | 15.0    | 33.6 | 41.6 | 8.0     | 71.4 | 83.1 | 11.7   |
|                                  | (1.2) | (1.6) | (0.9)  | (3.1) | (3.4) | (1.0)   | (5.9) | (5.3) | (2.1)  |
| mCIT (n=13)                      | 27.3 | 39.5 | 12.2    | 35.4 | 39.6 | 4.2     | 75.2 | 81.5 | 6.3    |
|                                  | (1.1) | (2.0) | (1.4)  | (2.4) | (2.4) | (0.6)   | (5.9) | (4.4) | (1.3)  |

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

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.

### REFERENCES

1. Choi JH, Choi YW, Nam KS, et al.: Effect of mental training on the balance control ability of healthy subjects. J Phys Ther Sci, 2010, 22: 51–55. [CrossRef]
2. Bakker FC, Boschker M, Chung J: Changes in muscular activity while imaging weight lifting using stimulus or response propositions. J Sport Exerc Psychol, 1996, 18: 313–324.
3. Hale BD: The effects of internal and external imagery on muscular and ocular concomitants. J Sport Exerc Psychol, 1984, 4: 379–387.
4. Livesay JR, Samaras MR: Covert neuromuscular activity of the dominant forearm during visualization of a motor task. Percept Mot Skills, 1998, 86: 371–374. [Medline] [CrossRef]
5. Lafleur MF, Jackson PL, Malouin F, et al.: Motor learning produces parallel dynamic functional changes during the execution and imagination of sequential foot movements. NeuroImage, 2002, 16: 142–157. [Medline] [CrossRef]
6. Lacourse MF, Turner JA, Randolph-Orr E, et al.: Cerebral and cerebellar sensorimotor plasticity following motor imagery-based mental practice of a sequential movement. J Rehabil Res Dev, 2004, 41: 505–524. [Medline] [CrossRef]
7. Fairweather MM, Sidaway B: Ideokinetic imagery as a postural development technique. Res Q Exerc Sport, 1993, 64: 385–392. [Medline] [CrossRef]
8. Williams IG, Odleyl J, Callaghan M: Motor imagery boosts proprioceptive neuromuscular facilitation in attainment and retention of range of motion at the hip joint. J Sports Sci Med, 2004, 3: 160–166. [Medline]
9. Sidaway B, Trzaska AR: Can mental practice increase ankle dorsiflexor torque? Phys Ther, 2005, 85: 1053–1060. [Medline]
10. Fassler CL, Poff CL, Shepard KF: Effects of mental practice on balance in elderly women. Phys Ther, 1985, 65: 1332–1338. [Medline]
11. Page SJ, Levine P, Leonard AC: Effects of mental practice on affected limb use and function in chronic stroke. Arch Phys Med Rehabil, 2005, 86: 399–402. [Medline] [CrossRef]
12. Page SJ, Levine P, Sisto S, et al.: Imagery combined with physical practice for upper limb motor deficit in sub-acute stroke: a case report. Phys Ther, 2001, 81: 1445–1462. [Medline] [CrossRef]
13. Page SJ, Levine P, Sisto S, et al.: A randomized efficacy and feasibility study of imagery in acute stroke. Clin Rehabil, 2001, 15: 233–240. [Medline] [CrossRef]
14. Page SJ, Levine P, Leonard A: Mental practice in chronic stroke: results of a randomized, placebo-controlled trial. Stroke, 2007, 38: 1293–1297. [Medline] [CrossRef]
15. Page SJ, Sisto S, Johnston MV, et al.: Modified constraint-induced therapy in subacute stroke: a case report. Arch Phys Med Rehabil, 2002, 83: 286–290. [Medline] [CrossRef]
16. Page SJ, Sisto SA, Levine P: Modified constraint-induced therapy in chronic stroke. Am J Phys Med Rehabil, 2002, 81: 870–875. [Medline] [CrossRef]
17) Page SJ, Levine P, Leonard AC: Modified constraint-induced therapy in acute stroke: a randomized controlled pilot study. Neurorehabil Neural Repair, 2005, 19: 27–32. [Medline] [CrossRef]
18) Yu S, Kang H, Jung J: Effects of modified constraint-induced movement therapy on hand dexterity, grip strength and activities of daily living of children with cerebral palsy: a randomized control trial. J Phys Ther Sci, 2012, 24: 1029–1031. [CrossRef]
19) Lyle RC: A performance test for assessment of upper limb function in physical rehabilitation treatment and research. Int J Rehabil Res, 1981, 4: 483–492. [Medline] [CrossRef]
20) Van der Lee JH, De Groot V, Beckerman H, et al.: The intra- and inter-rater reliability of the action research arm test: a practical test of upper extremity function in patients with stroke. Arch Phys Med Rehabil, 2001, 82: 14–19. [Medline] [CrossRef]
21) Fugl-Meyer AR, Jääskö L, Leymann I, et al.: The post-stroke hemiplegic patient. 1. a method for evaluation of physical performance. Scand J Rehabil Med, 1975, 7: 13–31. [Medline]
22) Duncan PW, Propst M, Nelson SG: Reliability of the Fugl-Meyer assessment of sensorimotor recovery following cerebrovascular accident. Phys Ther, 1983, 63: 1606–1610. [Medline]
23) Crosbie JH, McDonough SM, Gilmore DH, et al.: The adjunctive role of mental practice in the rehabilitation of the upper limb after hemiplegic stroke: a pilot study. Clin Rehabil, 2004, 18: 60–68. [Medline] [CrossRef]
24) Kwon YH, Yeo SS, Kwon JW, et al.: Neuromuscular adaptation induced by motor imagery training in the serial reaction time task. J Phys Ther Sci, 2010, 22: 413–418. [CrossRef]
25) Szaflarski JP, Page SJ, Kissela BM, et al.: Cortical reorganization following modified constraint-induced movement therapy: a study of 4 patients with chronic stroke. Arch Phys Med Rehabil, 2006, 87: 1052–1058. [Medline] [CrossRef]
26) Szaflarski JP, Page SJ: Mental practice: a non-invasive strategy that increases affected arm function and cortical representation. Poster presented at the International Stroke Conference; New Orleans, LA; February 2008.