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Original Article

The effects of modified constraint-induced movement therapy and mirror therapy on upper extremity function and its influence on activities of daily living

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Abstract. [Purpose] Modified constraint-induced movement therapy and mirror therapy are recognized as stroke rehabilitation methods. The aim of the present study was to determine whether these therapies influence upper extremity function and whether upper extremity function influences the ability to perform activities of daily living in further. [Subjects and Methods] Twenty-eight stroke patients participated in the study. Interventions were administered five times per week for 3 weeks. Activities of daily living or self-exercise were performed after modified constraint-induced movement therapy or mirror therapy, respectively. Analyses were performed on the results of the Manual Function Test and the Korean version of the Modified Barthel Index to determine the factors influencing activities of daily living. [Results] Both groups showed improvement in upper extremity function, but only the modified constraint-induced movement therapy group showed a correlation between upper extremity function and performance in the hygiene, eating, and dressing. The improved hand manipulation function found in the modified constraint-induced movement therapy had statistically significant influences on eating and dressing. [Conclusion] Our results suggest that a patient's attempts to move the affected side result in improved performance in activities of daily living as well as physical function.

Key words: Activities of daily living, Mirror therapy, Modified constraint-induced movement therapy

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INTRODUCTION

Neuroscience and brain science have developed dramatically over the last century, and methods of rehabilitation have been influenced by changes in scientific paradigm[1, 2)]. Various new types of rehabilitation therapies have been introduced in the fields of neuroplasticity and brain mechanisms[3, 4)]. One of the popular rehabilitation interventions for upper body function following stroke is mirror therapy, which is based on the concept of Ramachandran's synesthesia phenomenon in phantom limbs[4)]. In mirror therapy, a hemi-paretic patient is asked to move the unaffected limb while watching the moving limb being reflected in the mirror. In this therapy, though the paralyzed limb does not move behind the mirror, the congruent visual feedback through the mirror affects brain lesions and motor-related areas on the affected side. Mirror therapy has been applied to many stroke populations and been found to facilitate motor recovery in randomized clinical trials[5)]. Many studies have also reported biomechanical recovery and functional improvement in activities of daily living (ADLs) following mirror therapy[6, 7)].

Constraint-induced movement therapy (CIMT), another type of traditional rehabilitation therapy, was first developed by

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Taub et al. in 1993[8, 9]. This technique prompts the use of the affected arm by limiting the use of the unaffected side with a sling or splint. Although there are time and resource limitations associated with CIMT, it has been adopted as the best clinical practice[10, 11]. Recently, various types of modified version of CIMT (mCIMT) have been introduced to minimize the limitations of traditional CIMT. mCIMT still has ethical issue in controversy that it constrains one side of arms, however it is no doubt that the patients are willing to do corporate with their paralyzed arms and hands, especially when it is combined with task oriented exercise. The intention to move the paralyzed extremities and rehearsal of planning to execute movement were activated during therapy session. Many studies have reported that mCIMT improves upper extremity (UE) function and ADL performance[12–14]. In this study, we applied mCIMT to stroke patients. A resting hand splint was applied during the session in order to minimally constrain the use of the unaffected arm. The procedure was based on Smania's protocol[11, 12].

The main difference between mirror therapy and mCIMT is the part of the extremity engaged in the rehabilitation exercise. In mirror therapy, the unaffected arm is moved and the patient receives only visual feedback from the mirror. However, in mCIMT, the unaffected arm is restrained and the affected arm is voluntarily engaged even though the arm itself is not effectively moved. At most, the intention to move the paralyzed arm is activated. There is no doubt that the two types of rehabilitation facilitate motor function recovery[5, 13]. In the acute phase following stroke, these therapies have been shown to speed up recovery in the appropriate motor areas. According to a large study, it has been demonstrated that both mirror therapy and mCIMT are reliable therapeutic methods based on scientific evidence[15]. Both mCIMT and mirror therapy patients have been shown to experience improvements in UE function and the performance of ADL respectively[6, 14, 15].

To further the level of understanding in the field of stroke rehabilitation, we investigated whether changes in UE function directly impact improvement in ADL performance by comparing mCIMT and mirror therapy groups in this study.

SUBJECTS AND METHODS

The subjects were recruited from the university hospital located in Seoul. The subjects were the inpatients in acute phase of stroke. The purpose of this study was explained to all participants and consent form was received from all patients and their caregivers before participating in this study. The criteria of participants were below.

1) Diagnosed as stroke by the doctor of rehabilitation specialist
2) Onset within 3 months
3) Able to follow 3 steps of command
4) Able to grip the objects with paralyzed arm
5) Unable to oppose thumb and other fingers with paralyzed arm
6) Wrist extension >20°, MCP (Metacarpophalangeal) joints >10° (Taub et al., 1993)

All participants were pseudo-randomly allocated in mirror therapy group and mCIMT group. They went through Mini-Mental Sate Examination (MMSE). Two groups had no statistically significant difference ($t=0.99$, $p=0.12$) on cognitive function which possibly influences on understanding and cooperation of therapy and further impacts on the results of therapy[16]. Mean of MMSE was 25.9 for mirror therapy group and was 24.0 for mCIMT group.

Mirror therapy group received mirror therapy (20 min) and mCIMT group received mCIMT (20 min) respectively. ADL training for 20 min and self-exercise with therapeutic equipment for 20 min were followed after both mirror therapy and mCIMT. Mirror therapy and mCIMT including ADL training and self-exercise for both groups were provided 5 times a week, 60 min a session, and for 3 weeks.

In the mirror therapy group, the mirror (57.5 × 57.5 cm) was placed in the midline of patient and the paretic arm was hidden behind the mirror. The patient was instructed to watch the unaffected arm movement reflecting on the mirror, so the patient can receive visual feedback from them. The patient moves unaffected arm by therapist's cueing. The mirror therapy program was consisted of shoulder, elbow, forearm, wrist, finger movement and hand exercise with therapeutic putty and hand size ball. The contents of program was constructed by literature[5]. In the mCIMT group, movements on shoulder, elbow, forearm, fingers joint on the affected side guided by the therapist were performed. Repetitive training were focused on muscle strengthening, gross motor exercise, and fine motor exercise. Activities with thera-band, grip power, therapeutic putty were applied for muscle strengthening. Moving the arch-ring, throwing and catching the ball, and cup shifting were provided in gross motor exercise and peg-boards and block construction were used for fine motor exercise. The speed, difficulty, frequency, weight of task were adjusted according to individually pronounced deficits and functions[11]. The resting hand splint was used to constrain unaffected arm during 60 min intervention session[12].

ADL training for both group was conducted in domain of feeding, hygiene, dressing, toilet use, transfer according to the client-centered need from the initial interview and training program was individually optimized to the level of patient's function. Self- exercise was designed as gross motor and fine motor exercise with equipment such as sanding, arm skateboard, pegboard, blocks, gym ball etc. It was conventional and routine for OT program.

The improvement of UE function before and after intervention of both groups was assessed by Manual Function Test (MFT) translated by Kim (1994). MFT is consisted of arm movement, grasp and pinch, and manipulation three sub-categories. The test-retest reliability and inter-rater reliability are 0.95[17]. The independency level of ADL was evaluated by Korean version of Modified Barthel Index (K-MBI). MBI 5th ed. was translated in Korean by Jung (2007). K-MBI was conducted by direct observation or interview in 10 domain of ADLs such as hygiene, feeding, bathing, dressing, toilet use, bladder

Table 1. Correlation between changes on the MFT and changes in the sub-domains of the K-MBI

MFT (d')	Hygiene	Bathing	Feeding	Toilet	Stairs	Dressing	Bowels	Bladder	Ambulation	Transfer
mCIMT	0.60*	−0.29	0.76**	0.28	−0.25	0.56*	−0.27	−0.27	0.32	0.47
Mirror	−0.22	−0.11	−0.18	0.31	−0.12	−0.33	0.00	−0.08	0.60*	0.24

*p<0.05, **p<0.01 / d'=score after intervention − score before intervention.

Table 2. Influencing factors on changes in eating by multiple regression analysis (mCIMT group)

MFT (d')	Changes in the independence level of eating (K-MBI)								
	B	SD	Beta	t	p	VIF	DW	R^2	F
Changes in UE function	0.27	0.99	0.05	0.27	0.79	1.02			
Changes in grip power	1.82	1.34	0.26	1.36	0.21	1.02	1.69	0.65	6.07* (0.01)
Changes in manipulation	1.71	0.42	0.78	4.11	0.00**	1.01			

*p<0.05, **p<0.01 ad R^2=0.54.

Table 3. Influencing factors on changes in hygiene by multiple regression analysis (mCIMT group)

MFT	Changes in the independence level of hygiene (K-MBI)								
	B	SD	Beta	t	p	VIF	DW	R^2	F
Changes in UE function	−0.16	0.52	−0.07	−0.31	0.76	1.02			
Changes in grip power	0.48	0.70	0.16	0.69	0.50	1.02	2.11	0.47	2.90 (0.09)
Changes in manipulation	0.63	0.22	0.68	2.90	0.02*	1.01			

*p<0.05, **p<0.01 ad R^2=0.31.

Table 4. Influencing factors on changes in dressing by multiple regression analysis (mCIMT group)

MFT	Changes in the independence level of dressing (K-MBI)								
	B	SD	Beta	t	p	VIF	DW	R^2	F
Changes in UE function	−1.01	0.67	−0.29	−1.52	0.16	1.02			
Changes in grip power	1.55	0.90	0.33	1.72	0.12	1.02	1.91	0.63	5.76* (0.02)
Changes in manipulation	1.01	0.28	0.69	3.60	0.01**	1.01			

*p<0.05, **p<0.01 ad R^2=0.52.

and bowel control, transfer, ambulation, stairs. The inter-rater reliability by occupational therapist is 0.97–1.00 and internal consistency is 0.84[18]. There are no statistical differences in upper extremity function and the independence level of ADLs between mCIMT and mirror therapy groups.

Data were analyzed using SPSS 22.0 for Windows (IBM, Armonk, NY, USA). Pearson's correlations were performed to determine the relationship between UE function and ADL performance. Multiple regression analysis was performed to determine the factors that led to improvements in certain ADL domains.

RESULTS

Among the 28 participants, 18 were male and 10 were female. The average age of the participants was 61.3 ± 11.2 years. Two participants had hemorrhagic strokes and 26 had infarction strokes. Right hemiplegia was present in 13 participants and left hemiplegia was present in 15. Participants were pseudo-randomly assigned to the two groups. There were no demographic differences between the groups. There were no statistically significant differences in the results of the baseline MFT and K-MBI between the two groups.

There were positive correlations between improvement on the MFT and improvement in the hygiene (0.60, p<0.05), feeding (0.76, p<0.01), and dressing (0.56, p<0.05) components of the K-MBI in the mCIMT group. There was a positive correlation between improvement on the MFT and improvement in the ambulation (0.60, p<0.05) component of the K-MBI in the mirror therapy group (Table 1).

Multiple regression analysis was conducted in order to scrutinize the factors that positively influenced the improvement of performance skills on hygiene, feeding, and dressing in the mCIMT group. The regression model for changes in eating was statistically significant (F=6.07, p<0.05). The power of the regression model was 65.0%. The changes in manipulation significantly influenced eating improvement (B=1.71, t=4.11, p<0.01). The manipulation score on the MFT increased by 1, and the eating score on the K-MBI increased by 0.78 (78.0%; Table 2). The regression model for changes in hygiene was not statistically significant (F=2.90, p=0.09; Table 3). The regression model for changes in dressing was statistically significant

(F=5.76, p<0.05). The power of the regression model was 63.0%. The changes in manipulation significantly influenced dressing improvement (B=1.01, t=3.60, p<0.01). The manipulation score on the MFT increased by 1, and the dressing score on the K-MBI increased by 0.69 (69.0%; Table 4).

DISCUSSION

Both the mCIMT and mirror therapy groups showed UE function improvement. Only the mCIMT group showed increased UE function that was significantly correlated to ADL performance in hygiene, feeding, and dressing areas that require mainly hand and arm movements. Although ambulation was influenced by UE function in the mirror therapy group, but plausible correlation is not explained. Patients in the mirror therapy group showed improved UE function, but this improvement did not consequently have an influence on ADL performance.

The main difference between the mCIMT group and the mirror therapy group was that patients in the mCIMT group tried to move their affected arm, while those in the mirror therapy group did not. Even though there was no voluntarily movement, the intention and attempt were at least involved in the exercise. On the contrary, patients in the mirror therapy group were instructed to hold their affected arm behind the mirror and to move the unaffected arm, thereby receiving visual feedback from the mirror. The intention to move the extremity on the affected side is a notable difference between the two groups. Even though the paralyzed limb does not effectively engaged in the task, patients were willing to move the paralyzed upper extremities, and that was motivated in the ADL performance also. The attempt to execute movement leads to reorganization of motor areas in the brain, resulting in motor skill improvement and higher performance on ADLs[2, 19]. The execution of motor processes, from merely attempting to move the affected arm to actually moving the affected arm, is helpful in the performance of daily tasks. These findings imply that it is the performance of whole motor actions, rather than increased mechanical muscle function, that is of clinical importance. Another reason that the mirror therapy group did not show improvement in ADL performance may be that the interventional period was not sufficiently long. Mirror therapy was provided five times per week for 3 weeks, which may not be sufficient to result in neural plasticity[1, 2].

In a further regression analysis, changes in manipulation significantly influenced eating improvement (B=1.71, t=4.11, p<0.01) and dressing (B=1.01, t=3.60, p<0.01). The regression model for changes in hygiene was not statistically significant (F=2.90, p=0.09). Eating and dressing require hand and UE functions; therefore, improvement in manipulation directly impacts eating and dressing. Despite being significantly correlated, the improvement in arm and hand movements did not impact hygiene. Compared to eating and dressing, hygiene requires more complex actions and use of objects such as toothbrushes, razors, combs, and make-up tools. Therefore, it might require more cognitive resources and manipulation than eating and dressing.

mCIMT and mirror therapy were found to have significant rehabilitative effects on motor function and ADLs, respectively. It is important to consider the impact of motor function improvement on ADL performance in respect to the patient's ability to live independently. CIMT has gone through significant challenges in both the clinic and research in order to be accepted, including controversial opinions regarding the forced use of the affected arm and the strict constraint of the unaffected arm. However, our results suggest that attempting to voluntarily move the affected arm causes an increase in motivation and ultimately lead to functional improvement in ADL performance. Future studies should include a chronic stroke population.

REFERENCES

1) Dimyan MA, Cohen LG: Neuroplasticity in the context of motor rehabilitation after stroke. Nat Rev Neurol, 2011, 7: 76–85. [Medline] [CrossRef]
2) Kleim JA, Jones TA: Principles of experience-dependent neural plasticity: implications for rehabilitation after brain damage. J Speech Lang Hear Res, 2008, 51: S225–S239. [Medline] [CrossRef]
3) Bae SH, Jeong WS, Kim KY: Effects of mirror therapy on subacute stroke patients' brain waves and upper extremity functions. J Phys Ther Sci, 2012, 24: 1119–1122. [CrossRef]
4) Ramachandran VS, Rogers-Ramachandran D: Synaesthesia in phantom limbs induced with mirrors. Proc Biol Sci, 1996, 263: 377–386. [Medline] [CrossRef]
5) Yavuzer G, Selles R, Sezer N, et al.: Mirror therapy improves hand function in subacute stroke: a randomized controlled trial. Arch Phys Med Rehabil, 2008, 89: 393–398. [Medline] [CrossRef]
6) Kim K, Lee S, Kim D, et al.: Effects of mirror therapy combined with motor tasks on upper extremity function and activities daily living of stroke patients. J Phys Ther Sci, 2016, 28: 483–487. [Medline] [CrossRef]
7) Park JY, Chang M, Kim KM, et al.: The effect of mirror therapy on upper-extremity function and activities of daily living in stroke patients. J Phys Ther Sci, 2015, 27: 1681–1683. [Medline] [CrossRef]
8) Taub E: Movement in nonhuman primates deprived of somatosensory feedback. Exerc Sport Sci Rev, 1976, 4: 335–374. [Medline] [CrossRef]
9) Taub E, Miller NE, Novack TA, et al.: Technique to improve chronic motor deficit after stroke. Arch Phys Med Rehabil, 1993, 74: 347–354. [Medline]
10) Reiss AP, Wolf SL, Hammel EA, et al.: Constraint-induced movement therapy (CIMT): current perspectives and future directions. Stroke Res Treat, 2012, 2012: 159391. [Medline]
11) Smania N, Gandolfi M, Paolucci S, et al.: Reduced-intensity modified constraint-induced movement therapy versus conventional therapy for upper extremity rehabilitation after stroke: a multicenter trial. Neurorehabil Neural Repair, 2012, 26: 1035–1045. [Medline] [CrossRef]
12) Kim DY, Park CI, Chang WH, et al.: Effect of constraint-induced movement therapy in chronic hemiplegic patients. J Korean Acad Rehabil Med, 2003, 27:

813–818.
13) Jung MY, Jun HS, Park HS, et al.: The effect of constraint-induced movement therapy on persons with stroke evaluated by using 3D motion analysis. J Korean Soc Occup Ther, 2007, 15: 67–80.
14) Park J, Lee N, Cho Y, et al.: Modified constraint-induced movement therapy for clients with chronic stroke: interrupted time series (ITS) design. J Phys Ther Sci, 2015, 27: 963–966. [Medline] [CrossRef]
15) Yoon JA, Koo BI, Shin MJ, et al.: Effect of constraint-induced movement therapy and mirror therapy for patients with subacute stroke. Ann Rehabil Med, 2014, 38: 458–466. [Medline] [CrossRef]
16) Brunner IC, Skouen JS, Strand LI: Recovery of upper extremity motor function post stroke with regard to eligibility for constraint-induced movement therapy. Top Stroke Rehabil, 2011, 18: 248–257. [Medline] [CrossRef]
17) Miyamoto S, Kondo T, Suzukamo Y, et al.: Reliability and validity of the Manual Function Test in patients with stroke. Am J Phys Med Rehabil, 2009, 88: 247–255. [Medline] [CrossRef]
18) Jung HY, Park BK, Shin HS, et al.: Development of the Korean version of Modified Barthel Index (K-MBI): multi-center study for subjects with stroke. J Korean Acad Rehabil Med, 2007, 31: 283–297.
19) Michielsen ME, Selles RW, van der Geest JN, et al.: Motor recovery and cortical reorganization after mirror therapy in chronic stroke patients: a phase II randomized controlled trial. Neurorehabil Neural Repair, 2011, 25: 223–233. [Medline] [CrossRef]