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Action observation training enhances upper extremity function in subacute stroke survivor with moderate impairment: a double-blind, randomized controlled pilot trial

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| Abstract |

PURPOSE: This study's aim was to investigate the effects of an action observational training in subacute stroke patients with moderate impairment.

METHODS: 22 participants (men=13, women=9) with hemiparesis were randomly assigned to action observation training group or task-oriented training group. Patients in both group underwent a patient-specific multidisciplinary rehabilitation program. Participants in the action observation group (mean age, 62.78±9.85) were asked to watch the video scene, in the knowledge that they would then attempt to perform the same movement task after watching. The control group (mean age, 61.49±8.64) practiced the same tasks, without watching the video. To evaluate upper limb function, the upper extremity part of the Fugl-Meyer Assessment upper extremity and the Box and Block Test were used. The modified Barthel index was used to assess ADLs, and the modified Ashworth scale were used to assess spasticity in the upper extremity.

RESULTS: The action observational training group exhibited greater changes in the Fugl-Meyer assessment upper extremity ($P<0.05$; 95% CI, 0.929 – 6.403), the Box and Block test ($P<0.05$; 95% CI, 0.086 – 5.913), and the modified Barthel index ($P<0.01$; 95% CI, 2.483 – 12.627) between groups. And the modified Ashworth scale ($P>0.05$; 95% CI, -0.402 to 0.624) did not show significantly different between groups.

CONCLUSION: These findings suggest that action observational training may be more helpful to improve upper-extremity function than physical training only in subacute patients with moderate impairment after stroke.

Key Words: Action observation, Moderate impairment, Stroke, Subacute, Upper-extremity function

I. Introduction

Motor impairment of the upper extremity is common in stroke patients, and result in limitations to activities of daily living (ADLs) (Langhorne et al, 2009). The basis of current stroke rehabilitation is that repeated physical practice improves motor functions, and that these improvements are a result of altered activation in the brain

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sensorimotor network (Peurala et al, 2012). Recent therapeutic concepts have been based on enhancing neuroplasticity in brain representations of upper extremity functions after stroke (Coupar et al, 2012 Kleim & Jones, 2008 Lee & Chun, 2014). These studies have suggested that task-oriented training is an effective intervention to improve upper extremity function.

It has been suggested that action observation training, which involves the patient observing movements performed by another person, might be an additional rehabilitation strategy that could be beneficial for motor rehabilitation after stroke (Bang et al, 2013). During action observation, similar brain regions are activated in the premotor area and the parietal lobe (Grezes & Decety, 2001). This neurological mechanism based on the discovery of mirror neuron systems (Celnik et al, 2006). In a previous review it was suggested that the prefrontal, premotor, and supplemental motor areas, cingulate gyrus, parietal cortex, and cerebellum, are also active during the observation of movement (de Vries & Mulder, 2007). In a study of action observational training, observation of walking activity had a more significant effect on balance, walking speed, and endurance compared with the observation of a nature video unrelated to gait training for the same amount time (Bang et al, 2013). These results suggest that, in comparison to simple task-specific training, additional action observation training may be a beneficial strategy for motor function recovery after stroke (Buccino et al, 2006).

Action observation training using video, in combination with task-oriented training to improve upper extremity movements, could represent a viable intervention option. However, most of the studies that have been conducted to date have only evaluated the effects of action observation training on upper extremity function in the early or chronic stage (Bang et al, 2013). Little is known about the effects of this approach in the subacute stage. Therefore, the present study was intended to determine whether additional action observation training influences upper extremity motor

function and ADLs during task-oriented training in subacute stroke patients with moderate motor impairment.

II. Methods

1. Participants

The participants had been admitted to a rehabilitation clinic of university in the Republic of Korea. The inclusion criteria were: (1) aged between 18 and 70 years with a first-time ischemic or hemorrhagic stroke; (2) stroke experienced more than 1 month and below 6 months before the study; (3) sufficient cognition to participate in the study: a Mini-Mental State Examination (MMSE) scores of 24 or higher (Folstein et al, 1975); (4) no excessive spasticity, defined as a grade of 3 or higher on the modified Ashworth scale (Bohannon & Smith, 1987).

The exclusion criteria were: (1) patient with any comorbidity or disability other than stroke that preclude upper-extremity training; (2) any uncontrolled health condition for which exercise is contraindicated.

After the initial screening, 22 patients were eligible to be included in the study. Participation in the study was voluntary and patients fully understood the purpose of the study. All participants were informed about the tests and the use of the results and were asked to sign a written informed consent statement.

2. Experimental design

We conducted a double-blinded, pilot randomized controlled study. A computer-generated random number was used to allocate participants arbitrarily to the action observation training group or the control group. Participants were randomized into 2 groups (directly after test) by a physical therapist who was not involved in the study. The action observation training group underwent task-oriented training after watching a related video. The control group underwent task-oriented training without watching the

related video.

3. Interventions

The experiment began 1 day after randomization. For both groups, the intervention progressed during the regularly scheduled therapy session, and all other routine interdisciplinary stroke rehabilitation proceeded as usual. In both group, the training protocol involved 20 sessions (40 min/day, 5 times/week, for 4 weeks). For the duration of the study, all participants also received a conventional rehabilitation program that involved occupational (1 hour/day), physical (2 hours/day), and speech therapies (as required); the duration and intensity was, the same for both study group. Action observation and task-oriented training were performed by four physical therapists with a career of 5-8 years.

1) Action observation

Participants in the action observation group were asked to watch the video scene, in the knowledge that they would then attempt to perform the same movement task after watching. During action observation, participants were seated 60 cm away from a monitor and asked to assume a comfortable posture. The video was specially produced for the action observation training for a total of 9 minutes. The video was divided into 3 phases, according to play speed (normal speed, 50% of the normal speed, and normal speed). Each video involved the same task actions, performed by a healthy woman, and provided 3 views simultaneously (front, side, and top). After watching the video tasks, participants in the action observation group attempted the same movements using the paretic hand. The protocol involved the participants watching the video (9 minutes), a break to organize their thoughts (1 minute), and a period for practicing the task-oriented training (30 minutes). The total duration of the action observation training combined with the task-oriented training was 40 minutes. In addition, while participants were watching the

videos, the therapist provided verbal feedback for training consistency and synchronization to the observed movement, such as elbow flexion during reaching and grasping, thereby improving the efficiency of action observation.

2) Task-oriented training

Task-oriented training was performed in an ADL room. During task-oriented training, participants were seated at a table with a comfortable posture. Task-oriented training consisted of performing task based on ADLs, such as folding up a towel, removing a bottle cap, lifting a cup and drinking from it, and cleaning the table with a towel. The control group practiced the same tasks during a 30 minutes period, without watching the video.

4. Outcome measures

To evaluate upper limb function, the upper extremity part of the Fugl-Meyer Assessment (FMA-UE) and the Box and Block Test (BBT) were used. The modified Barthel index (MBI) was used to assess ADLs, and the modified Ashworth scale (MAS) were used to assess spasticity in the upper extremity. All evaluations were performed before and immediately after treatment by a single experienced occupational therapist with a career of 5 years, who was not aware of the treatment allocation.

The upper extremity section of FMA (FMA-UE) is a quantitative assessment tool that measures motor recovery in the shoulder, elbow, forearm, wrist and hand. The reliability and validity of the FMA-UE are considered good (Alonso-Alonso et al, 2007).

The Box and Block Test (BBT) was used to assess gross manual hand dexterity (Mathiowetz et al, 1985). The number of blocks transferred indicates the level of manual hand dexterity. The reliability and validity of the BBT was reported to be excellent (Desrosiers et al, 1994;Lin et al, 2010).

The modified Barthel index (MBI) comprises 10-item: dependent or independent for feeding, bathing, grooming

or dressing; toilet use; mobility on level surface (immobile, use of wheelchair, walk with help or independent); bowels and bladder continent or incontinent. Higher scores indicate the greater functional autonomy (Nazzal et al, 2001). The reliability and validity of the MBI was considered very high (Nazzal et al, 2001).

The modified Ashworth scale (MAS) was used clinically to grade spasticity. Higher scores correspond to greater spasticity or increased tone, whereas lower scores indicate normal muscle tone (Pandyan et al, 1999). The reliability and validity of the MAS was reported to be good (Pandyan et al, 1999)

5. Statistical Analysis

All collected data were analyzed using SPSS 18.0 version program. All 22 participants' demographic and clinical characteristics were analyzed to check for homogeneity between groups. Differences between categorical variables were analyzed using the chi-square test and independent t-test. Independent t-tests were used to compare differences between group means and means change scores. Paired t-tests were used to compare within group means. The size of the treatment effect was estimated by using the group's mean difference at 95% confidence interval. Data were presented as mean and standard deviation (SD). Statistical significance was set at $p < .05$.

III. Results

Eighty-seven participants with impaired upper-extremity motor function because of stroke were evaluated. Among these participants, 22 patients met inclusion criteria and were enrolled. The participants were randomly assigned into an action observational training group ($n=11$) or control group ($n=11$). All participants completed the entire study. Therefore, a total of 22 participants completed this study. No major adverse effects associated with action observation and task-oriented training were reported by any of the

participants who completed all 20 consecutive sessions.

Demographic characteristics, including participant age, sex, and stroke-related characteristics did not differ significantly between groups (Table 1). And there were no significant differences between the action observational group and control group in the upper- extremity section of Fugl-Meyer Assessment (FMA-UE), Box and Block Test (BBT), modified Barthel index (MBI), and modified Ashworth scale (MAS) in pretest (Table 2).

The mean change of FMA-UE in the action observation training was 12.33 (SD 2.59) scores and control group was 8.67 (SD 2.87) scores, which was significantly different between groups ($P < 0.05$; 95% CI, 0.929 – 6.403). The mean change of BBT in the action observation training was 10.67 (SD 3.78) numbers and control group was 7.66

Table 1. Demographic data of the participants.

	AOT group (n =11)	TOT group (n = 11)	P-value
Sex(n)			
Men	7	6	0.67
Women	4	5	
Side of stroke(n)			
Right	5	5	1.00
Left	6	6	
Type of stroke(n)			
Infarction	9	7	0.34
Hemorrhage	2	4	
Time after stroke (week)	12.89 (2.93)	11.33 (2.96)	0.28
Age (years), mean (SD)	60.77 (7.03)	59.11 (7.05)	0.62
MMSE (scores), mean (SD)	26.44 (1.42)	25.78 (1.30)	0.32
MAS (grades), mean (SD)	0.89 (0.78)	1.00 (0.71)	0.76

NOTE. Baseline demographic data for participants include in the two different groups and significance level at $P < 0.05$ for difference between the groups.

Abbreviations: MMSE, mini-mental state examination; MAS, modified Ashworth scale.

Table 2. Descriptive measurements.

Variables	AOT group (n=11)		TOT group (n=11)		Between groups P-values (95% CI) – 2 tailed
	Pretest	Posttest	Pretest	Posttest	
FMA-UE (scores)	40.00 (2.59) ^a	52.78 (3.35) ^{*†}	39.89 (3.66)	48.44 (2.88) [*]	0.009 (1.215~7.451)
BBT (no.)	14.22 (1.79)	24.67 (2.55) ^{*†}	14.33 (1.23)	22.00 (2.18) [*]	0.030 (0.297~5.037)
MBI (scores)	50.78 (3.16)	78.56 (3.47) ^{*†}	50.22 (3.89)	70.56 (2.51) [*]	0.001 (4. 977~11.023)
MAS (grades)	0.89 (0.78)	1.34 (0.50) [*]	1.00 (0.71)	1.22 (0.15)	0.624 (-0.359 to 0.582)

^aMeans (SD); ^{*}Significant difference within groups; [†]Significant difference between groups.

Pre-test was performed before the intervention, and post-test was performed after 4 weeks.

In the pre-test between groups, there was no significant difference ($P>.05$).

The significance level were set at $P<0.05$ for differences between the groups.

Abbreviations: AOT, action observational training; TOT, task-oriented training; FMA-UE, Fugl-Meyer assessment upper extremity; MBI, modified Barthel index; MAS, modified Ashworth scale.

(SD 1.63) numbers, which was significantly different between groups ($P<0.05$; 95% CI, 0.086 – 5.913). The mean change of MBI in the action observation training was 27.55 (SD 5.36) scores and control group was 20.00 (SD 4.76) scores, which was significantly different between groups ($P<0.01$; 95% CI, 2.483 – 12.627). The mean change of MAS in the action observation training was 0.44 (SD 0.53) grades and control group was 0.33 (SD 0.50) grades, which was not significantly different between groups ($P>0.05$; 95% CI, -0.402 to 0.624).

IV. Discussion

The results of this study suggested that action observation training, in addition to task-oriented training, could improve motor performance and the performance of ADLs in the affected arm, in patients in the subacute phase of stroke with moderate motor impairment. Hence, a stroke rehabilitation program that includes action observation training as an adjunct may be beneficial.

In the present study, we used tasks that were similar to ADLs. The study protocol may have elicited a positive effect, in terms of improving motor function in subacute stroke patients with moderate motor impairment, because

the task were related to daily activities performed by the patients. We prepared video clips in which the speed was varied across 3 phases for each task. This protocol allowed participants with stroke to correctly observe the movements performed (Bang et al, 2013). After watching the video, participants were asked to recall the observed movements during a 1 minute break period, after which they were required to practice the same movements.

Sugg et al. (2015) reported a greater improvement in recovery of upper extremity function following action observation training plus physical training, in comparison with that achieved after sham relaxation plus physical training. Participants in this study had a moderate motor impairment of upper extremity functioning, according to FMA-UE scores (Fugl-Meyer et al, 1975). Participants in this study had a similar motor impairment level. On the basis of these results, it was suggested that implementation of action observation combined with physical practice, may be associated with additional improvements in terms of upper extremity motor function in stroke patients with moderate motor impairment.

Another study on action observation training combined with physical practice was performed by Franceschini et al. (2012), who studied the effectiveness of action observation as an add-on treatment in the early post-stroke

period. The result of this study revealed that action observation training can facilitate beneficial training effects, compared with the control group. Their study enrolled patients with early stage stroke, a recovery stage similar to that of this study's participants. On the basis of these results, it has been suggested that action observation training combined with physical practice may be a useful method by which to recover limitations in motor function, and improve activity levels in patients in the subacute post-stroke stage.

A feature of the present study is that the improvement observed in the action observation group reached a value higher than the minimal clinically importance difference (MCID) for FMA-UE scores. The mean change of FMA-UE in the action observation group was more than 10 points. The change in FMA-UE score ($\geq 6-8$ points) indicates that the addition of action observation training is associated with clinically meaningful improvements, and may be helpful in improving upper extremity functions in stroke patients (Page et al, 2012). However, the control group showed ambiguous score changes (5–10 points). Hsieh et al, (2014) reported that participants with a baseline BBT score of 10–20 were more likely to achieve FMA-UE improvements, compared with those with a BBT score of <10 . Thus, participants of this study might have had a greater chance of improvement after intervention than individuals with a lower BBT scores.

Both the action observation group and the control group showed improvements in the motor performance of the upper limb. However, the change from baseline in terms of motor recovery (FMA-UE), gross hand dexterity (BBT), and capacity to perform ADLs (MBI) was higher in the action observation group, compared with the control group. Brunner et al, (2014) reported that this improvement in motor performance may be related to activation in the inferior temporal gyrus and the thalamus, and movement-related areas, such as premotor, supplementary, and motor cortex during action observation. Gonzalez-Rosa et al,

(2015) reported action observation was associated with greater beta synchronization over bilateral parietal regions, compared with motor imagery and control groups. Furthermore, this beta synchrony demonstrated the strongest association with kinematic errors, which were also significantly lower in the action observation group, compared with the control group. Indeed, activation of the cerebellum and premotor area correlated with improvement in upper extremity function (Harmsen et al, 2014). In previous studies (Brunner et al, 2014; Franceschini et al, 2012; Gatti et al, 2013) in which action observation training was combined with task-oriented training, greater improvements in motor performance occurred in the action observation group than in the control group, consistent with findings in the present study.

This study has some limitations. First, a small number of patients and only patients in the hospital were recruited, so these data may not represent stroke patients as a whole. Second, absence of long-term effect did not allow for determination of the durability of effects. Thus, the results should be considered with caution.

V. Conclusion

The present study showed that action observation training contributes to motor re-learning. The results provide evidence that may clarify the beneficial effects of action observation training on motor recovery of the upper extremity in subacute stroke patients with moderate motor impairment. This combined approach to training is easy and inexpensive to apply in clinical rehabilitation.

References

- Alonso-Alonso M, Fregni FPascual-Leone A. Brain stimulation in poststroke rehabilitation. *Cerebrovasc Dis.* 2007;

- 24:157-66.
- Bang DH, Shin WS, Kim SY et al. The effects of action observational training on walking ability in chronic stroke patients: a double-blind randomized controlled trial. *Clin Rehabil.* 2013;27(12):1118-25.
- Bohannon RWSmith MB. Interrater reliability of a modified Ashworth scale of muscle spasticity. *Phys Ther.* 1987;67(2):206-7.
- Brunner IC, Skouen JS, Erslund L et al. Plasticity and response to action observation: a longitudinal fMRI study of potential mirror neurons in patients with subacute stroke. *Neurorehabil Neural Repair.* 2014;28(9): 874-84.
- Buccino G, Solodkin A Small SL. Functions of the mirror neuron system: implications for neurorehabilitation. *Cogn Behav Neurol.* 2006;19(1):55-63.
- Celnik P, Stefan K, Hummel F et al. Encoding a motor memory in the older adult by action observation. *Neuroimage.* 2006;29(2):677-84.
- Coupar F, Pollock A, Rowe P et al. Predictors of upper limb recovery after stroke: a systematic review and meta-analysis. *Clin Rehabil.* 2012;26(4):291-313.
- De Vries S, Mulder T. Motor imagery and stroke rehabilitation: a critical discussion. *J Rehabil Med.* 2007;39(1):5-13.
- Desrosiers J, Bravo G, Hebert R et al. Validation of the Box and Block Test as a measure of dexterity of elderly people: reliability, validity, and norms studies. *Arch Phys Med Rehabil.* 1994;75(7):751-5.
- Folstein MF, Folstein SEMcHugh PR. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res.* 1975;12(3):189-98.
- Franceschini M, Ceravolo MG, Agosti M et al. Clinical relevance of action observation in upper-limb stroke rehabilitation: a possible role in recovery of functional dexterity. A randomized clinical trial. *Neurorehabil Neural Repair.* 2012;26(5):456-62.
- Fugl-Meyer AR, Jaasko L, Leyman I et al. The post-stroke hemiplegic patient. 1. a method for evaluation of physical performance. *Scand J Rehabil Med.* 1975; 7(1):13-31.
- Gatti R, Tettamanti A, Gough PM et al. Action observation versus motor imagery in learning a complex motor task: a short review of literature and a kinematics study. *Neurosci Lett.* 2013;540:37-42.
- Gonzalez-Rosa JJ, Natali F, Tettamanti A et al. Action observation and motor imagery in performance of complex movements: evidence from EEG and kinematics analysis. *Behav Brain Res.* 2015;281: 290-300.
- Grezes J, Decety J. Functional anatomy of execution, mental simulation, observation, and verb generation of actions: a meta-analysis. *Hum Brain Mapp.* 2001; 12(1):1-19.
- Harmsen WJ, Bussmann JB, Selles RW et al. A Mirror Therapy-Based Action Observation Protocol to Improve Motor Learning After Stroke. *Neurorehabil Neural Repair.* 2014;
- Hsieh YW, Lin KC, Wu CY et al. Predicting clinically significant changes in motor and functional outcomes after robot-assisted stroke rehabilitation. *Arch Phys Med Rehabil.* 2014;95(2):316-21.
- Kleim JAJones TA. Principles of experience-dependent neural plasticity: implications for rehabilitation after brain damage. *J Speech Lang Hear Res.* 2008;51(1): S225-39.
- Langhorne P, Coupar F Pollock A. Motor recovery after stroke: a systematic review. *Lancet Neurol.* 2009;8(8):741-54.
- Lee SJ, Chun MH. Combination transcranial direct current stimulation and virtual reality therapy for upper extremity training in patients with subacute stroke. *Arch Phys Med Rehabil.* 2014;95(3):431-8.
- Lin KC, Chuang LL, Wu CY et al. Responsiveness and validity of three dexterous function measures in stroke rehabilitation. *J Rehabil Res Dev.* 2010;47(6):563-71.
- Mathiowetz V, Volland G, Kashman N et al. Adult norms

- for the Box and Block Test of manual dexterity. *Am J Occup Ther.* 1985;39(6):386-91.
- Nazzal M, Sa'adah MA, Al-Ansari D et al. Stroke rehabilitation: application and analysis of the modified Barthel index in an Arab community. *Disabil Rehabil.* 2001;23(1):36-42.
- Page SJ, Fulk GDBoyne P. Clinically important differences for the upper-extremity Fugl-Meyer Scale in people with minimal to moderate impairment due to chronic stroke. *Phys Ther.* 2012;92(6):791-8.
- Pandyan AD, Johnson GR, Price CI et al. A review of the properties and limitations of the Ashworth and modified Ashworth Scales as measures of spasticity. *Clin Rehabil.* 1999;13(5):373-83.
- Peurala SH, Kantanen MP, Sjogren T et al. Effectiveness of constraint-induced movement therapy on activity and participation after stroke: a systematic review and meta-analysis of randomized controlled trials. *Clin Rehabil.* 2012;26(3):209-23.
- Sugg K, Muller S, Winstein C et al. Does Action Observation Training With Immediate Physical Practice Improve Hemiparetic Upper-Limb Function in Chronic Stroke? *Neurorehabil Neural Repair.* 2015;