The Effect of Reaching and Hand Function Based on Individual Problem-Solving Approach in Hemiplegic Patients after Stroke: A Randomized Controlled Study

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Purpose The purpose of this study was to investigate the effect of upper limb function based on individual problem-solving approach in hemiplegic patients after stroke in terms of reaching speed and upper limb function of affected side as compared with conservative occupational therapy. ***Methods*** 25 stroke patients who were hospitalized at rehabilitation center in Gyeonggi-do. And they were divided into an individual problem-solving approach group and a conservative approach group. The average speed of reaching motion and upper limb function before and after the intervention were evaluated. ***Results*** The average reaching speed before and after the intervention was statistically significant in experimental group (p<.05), but not statistically significant in the control group (p>.05). Upper limb function before and after the intervention was in significant difference statistically (p<.05) in experimental group, but not statistically significant in control group (p>.05). There was no statistically significant difference in the average reaching speed and UL function between the two groups (p>.05). ***Conclusion*** This study demonstrated that the UL function based on IPSA improves more than a conservative occupational therapy.

Key words Stroke, Individual problem-solving approach, Upper limb function, Reaching speed, Hand function

Ⅰ. Introduction

After stroke, the upper limb (UL) functions are damaged by the following as neural weakness, sensory impairment, abnormal muscle tone, impaired posture control as well as shoulder pain, shoulder sub-luxation, limb contracture and deformity, learned non-use and biomechanical alignment problems.[1] This loss of UL function is one of the most common and challenging sequelae after stroke and can limit in activities of daily living (ADL).[2] Understanding the relationship between motor impairment and functional activities following central nervous system (CNS) lesions is essential for successful rehabilitation. UL perform complex movements, such as reaching, grasping and lifting of functional task. It is achieved by gross motion of many joints and complex coordination of fine

motion.[3] The movement of the shoulders, which is the basis of the reaching motion, consists of the integrated activities of the scapulothoracic, gleno-humeral, acromioclavicular, and sternoclavicular joint, it is a scapulohumeral rhythm, a natural combination and interaction of all these joints.[4] The motion of hemiplegic patients is more segmented than normal people, which makes normal joint function difficult and slows down the movement and is characterized by high variability and deviation from straight track.[5] There is a clear correlation between speed and quality of motion.[6] According to a study comparing paralyzed arm pointing with a finger to a paralyzed target on a flat table for stroke patients, the paralyzed arm's reaching motion was characterized by low motion amplitude, slower speed, and more. It showed that the motion trajectories were distributed and clearly distinguished spatially.[7] Therefore, the recovery of constant velocity and consistent trajectory in reaching mo-

tion of affected side in hemiplegic patients may be the result of a qualitatively improved performance, which may depend on the stability and mobility of the shoulder.[8] In addition, the posture control provides strong stability when performing reaching components, which is an essential factor.[9] And it is important to keep yourself in the correct direction of movement and position towards the target point when training for the purpose of restoring reaching function in stroke patients.[10] An individual problem-solving approach (IPSA) is that treats patients with sensory, perceptual, and behavioral disorders, as well as movement problems, according to their problems.[11] In addition, IPSA is important to reduce abnormal patterns through posture control and proper weight support between the trunk and limbs.[12] To reach to grasp objects and manipulate them properly, need to be able to get their hands exactly on the target. A selective movement that creates stability of the shoulders and elbows should be paired with an anticipatory postural adjustment mechanism to treat the movements efficiently.[13] Conservative occupational therapy (COT) commonly used in clinic include tools to increase the range of motion of joints, strength exercises, task-oriented approaches, and ADL training using compensatory methods.[14] However, such as COT is difficult to functionally use the affected UL due to overlooking the fundamental problems that impede the patient's performance and functional participation, or the use of unaffected UL as a compensatory method in performing the operation of the UL.[15] Because patients have different regulating mechanisms of UL function, it is necessary to study the interventional method to find the fundamental cause and solve the problem.[16] In a study applying IPSA to recovery of UL, we reported that the Bobath concept or neurodevelopment treatment (NDT) had a significant effect on UL function[17], and also another study compared the UL function with the COT by scapular setting intervention based on Bobath concept.[18]

If the arm movement is sustained in an inefficient pattern, it is difficult to recover the function. Therefore, it is necessary to accurately evaluate and treat the individual problem factors of the patient. The purpose of this study is to find out the effect of UL function based on IPSA for hemiplegic patients after stroke, compared with conservative occupational therapy approach basis that can contribute to the recovery of patients.

II. Materials and Methods

1. Subjects

The study conducted 25 subjects with hemiplegic patients who were hospitalized at rehabilitation center in Gyeonggi area. Criteria for selection are follows as patients with stroke hemiplegia diagnosed by neurologist and rehabilitation specialist, those who can understand and follow the instructions for the research with a score of 23 or higher in Montreal Cognitive Assessment in Korean version (MoCA-K) and they have no pain or musculoskeletal disorders in the more affected UL, those who can detect when affected hand sensory stimulation and those who can sit alone and walk, who understand the content of this study and agree to voluntarily participate in the study

2. Procedure

25 subjects selected by the screening test were divided into two groups through block randomization. The subjects were divided into individual problem-solving approach group (IPSAG) and conservative occupational therapy group (COTG) according to the approach method. Each group received 90 minutes of physiotherapy and 60 minutes of occupational therapy in regular treatment sessions. And as an experimental treatment, IPSAG received intervention based on IPSA, and COTG was performed task-based COT 30 minutes a day, 3 times a week for 4 weeks. It was conducted by occupational therapists who had completed the Bobath basic course for more than three years of therapeutic experience. Each group received a preliminary evaluation before the intervention and a post evaluation after the intervention.

3. Intervention method

The two groups separated so that they did not know

about the interventions they were receiving, therapists were recruited as those who completed the Bobath basic course for more than three years of experience in the treatment of stroke patients. Prior to the intervention, the IPSAG had time to discuss the patient's individual problem inference and intervention with respect to the clinical reasoning process of the intervention based on IPSA. Therapists in the COTG agreed that occupational therapy interventions were used to repeat tasks using tools.

3-1. Individual problem-solving approach (IPSA)

IPSA is to the assessment and treatment of individuals with disturbances of function, movement and postural control due to a lesion of CNS and can be applied to individuals of all ages and all degrees of physical and functional disability.[19]

3-2. Procedure and methods of IPSAG

The intervention process of IPSAG involves analyzing the posture and movement of the subject before treatment to identify individual problems that limit UL function and to set treatment goals accordingly. The treatment was conducted to improve stability of the trunk and weight support to adjust muscle tone and posture, that was conducted to improve the efficient movement and move the arm in various postures, too. The exercise program was divided into trunk, shoulder, hand exercise as Table 1.[13]

3-3. Procedure and methods of COTG

In order to improve UL function, the UL was placed on the table and various treatment tools were used. The level of difficulty was adjusted to provide COT such as increasing range of motion of UL, strengthening exercise, progressive resistance exercise and task-based training.

4. Measurements tools

4-1. 3-dimentional motion analysis system

Reaching motion was measured by CMS10 of zebris medical GmbH CMS 10 (Germany), an UL 3-dimensional motion analysis system. It consists of measuring sensor, holding device, body surface marker, pads, cables and computer device (Figure 1). Basically, repetitive movement, range of motion, maximum speed movement, and aiming movement can be measured. Manuals on the measurement posture, tool position and method are presented within the software. When the subject starts to move, the measuring sensor detects the ultrasonic signal of the active marker and displays it on a computer monitor as a three-dimensional graph. Sit upright on the chair and fasten the body to the back of the chair with a strap to limit the movement of the body and face the measuring device with the desk in between. The inclination of the measuring device was adjusted to 45° and the distance to the subject was about 80cm. Three active markers were attached to the dorsal of index finger, the metacarpophalangeal joint, and the dorsal of wrist. The starting position was to place the hand on the desk and instruct it to 'reach out', reaching the paralyzed hand toward the target, touching the target with

Table 1. Introduction at the intervention program of IPSAG

	Treatment goals and Methods
Trunk	- Segmental and cooperative recovery of the trunk and pelvis - Rearrangement of the shoulder for the stability of the rib cage - Activation of contact ability of hand and ground to improve posture control ability
Shoulder	- Realignment and selective strengthening for stability of shoulder joint - Promote the movement of the shoulder complex to ensure stability and mobility - Training of functional tasks for mobility in various directions
Hand	- Contact hand-orientating response training by lengthening and activation of intrinsic muscles - Enhancing sensory stimulation and awareness of the affected hand - More sophisticated and detailed movement training through functional grip, release and manipulation

IPSAG: individual problem-solving approach group

Figure 1. zebris medical GmbH CMS10(left) and figure of zebris measurement for reaching motion in study(right)

the index finger, and returning to place, 5 times (Figure 1). In this study, analyzed the movement speed of reaching as the movement toward the target.

4-2. Manual Function Test (MFT)

MFT is a tool developed to measure UL function and movement ability of stroke patients and consists of three items: UL movement, grasping and finger manipulation. The result is recorded one point each time, if it is impossible, it is recorded as 0 point and the result value is calculated by totaling 32 points and converting it to 100 points.

5. Data analysis

The statistical analysis of this study was conducted using SPSS 18.0. To find out general characteristics of the study subjects, descriptive statistics frequency analysis was conducted. The chi-square test was used to test homogeneity and normality between the two groups. Paired t-tests were performed to compare changes before and after intervention in the group, and independent t-tests were performed for comparison after the intervention between the groups. The statistical significance level of all data was .05.

III. Results

1.General characteristics of the subject

A total of 25 subjects participated in this study, randomly assigned to IPSAG of 13 and COTG of 12. There were no significant differences between the groups according to gender, type of brain damage, affected side, average age, duration of disease, and MoCA-K (p>.05) (Table 2).

Table 2. General characteristics of the subjects

(N=25)

Variable		IPSAG (N=13)	COTG (N=12)	x^2/t	p
Gender	Male	9	9	.103	.75
	Female	4	3		
Type of brain damage	Hemorrhage	7	5	.371	.54
	Infarction	6	7		
Affected side	Left	6	6	.037	.85
	Right	7	6		
Average age	10s	0	1	-.54	.59
	20s	1	1		
	30s	2	2		
	40s	5	0		
	50s	2	3		
	60s	3	3		
	70s	0	2		
Duration of disease (month)	Less than 6	2	3	-.37	.97
	6~12	8	5		
	13~24	2	3		
	25~36	1	1		
MoCA-K		24.46±1.56	24.41±1.16	.08	.94

Mean ± SD: The values are mean (standard deviation), IPSAG: individual problem-solving approach group, COTG: conservative occupational therapy group, MoCA-K: Montreal of cognitive assessment in Korean version

2. Change in average reaching speed and MFT before and after intervention in groups

IPSAG showed a statistically significant difference in the change in the average speed of reaching before and after intervention (p<.05). In COTG, the average reaching speed was improved, but there was no statistically significant difference(p>.05). In IPSAG, there was a statistically significant difference in MFT (p<.05) and there was no statistically significant difference in COTG (p>.05) (Table 3).

3. Comparison of differences on average reaching speed and MFT after intervention between group

There was no statistically significant difference in average reaching speed and UL function in the change test for intergroup testing after intervention (p>.05) (Table 4).

Ⅳ. Discussion

Stroke is the result of permanent brain damage, but most patients recover little by little, most of which is caused by brain reorganization, or neuroplasticity. Nevertheless, one-third of stroke patients require continuous help with impairment of UL function.[20] Neurorehabilitation programs to improve affected UL function in stroke patients include Bobath approach, bilateral UL training, constraint induced movement therapy (CIMT), task-oriented approach, imagery training, and mirror therapy.[21] Especially, Bobath approach is a problem-solving approach that focuses on task performance consisting of selective movement, posture control, and coordinated movement.[22] In addition, rather than treating all patients with the same content, the patients should be able to combine a variety of treatment techniques in a flexible, wide variety of ways according to their needs.[23] In one study, subjects' brain activity increased after intensive UL treatment to match the individual's level of individual motor performance, and improved recovery of the UL after 3 months.[20] In addition, there were significant differences in UL function and ADL in a study of the Bobath approach in 61 stroke patients.[12] A six-week study in which hemiplegic patients were based on the Bobath approach reported a significant increase in hand and shoulder joint function in the study group compared to the general joint exercise group.[17] Reaching and grasping of human are the basic factors associated with all activities that require the movement of the UL in ADL, of which reach is the essential element to move the hand quickly toward the target to be grasped. In a study analyzing the reaching behaviors of hemiplegic patients and normal subjects, hemiplegic patients showed a significant decrease in

Table 3. Change in average reaching speed and MFT before and after intervention in groups (N=25)

Variable	IPSAG (N=13)			COTG (N=12)		
	Before	After	p	Before	After	p
ARS (mm/s)	184.23±107.34	257.69±192.95	.04*	145.83±139.55	194±201.58	.20
MFT (score)	13.53±8.54	14±8.28	.02*	10.83±10.04	11.33±9.80	.16

Mean ± SD: The values are mean ± standard deviation *p<0.05, ARS: average reaching speed, MFT: manual function test, IPSAG: individual problem-solving approach group, COTG: conservative occupational therapy group

Table 4. Comparison on average reaching speed and MFT after intervention between group (N=25)

Variable	IPSAG (N=13)		COTG (N=12)		p
	Before	After	Before	After	
ARS (mm/s)	184.23±107.34	257.69±192.95	145.83±139.55	194±201.58	.60
MFT (score)	13.53±8.54	14±8.28	10.83±10.04	11.33±9.80	.91

Mean ± SD: The values are mean ± standard deviation, ARS: average reaching speed, MFT: manual function test, IPSAG: individual problem-solving approach group, COTG: conservative occupational therapy group

exercise accuracy compared to control group. The movement pattern of the patients was significantly correlated with the level of motion impairment of the arm. Patients with severe disorders were more subdivided, highly variable, and less accurate than patients with moderate and mild disorders.[24]

Recently, objective assessment of UL movement has led to an increasing number of studies using kinematic morphological analysis.[25] One study suggests that the review of the effectiveness of Bobath approach should consider the therapist's skill and use UL measurement tools rather than subjective assessment tools[26]. Also, the report on interventions and measurements based on the Bobath approach suggested that further consideration is needed for clear treatment goals, therapist proficiency, subject-centered interventions, and proven and reliable measurement equipment.[27]

The purpose of this study was to investigate the effect of UL function based on IPSA on hemiplegic patients after stroke compared with COT. The subjects were divided into IPSAG and COTG according to the intervention. In the previous study, which presented the effect of reaching after intervention through motion analyzer, significant effects of speed and smoothness of affected UL movement were reported[28]. Also, a study reported that the speed of reaching motion was increased after the goal-oriented UL treatment that facilitate coordination of the proximal and distal part on the UL[29].

In this study, there was also a significant difference in the before and after interventional changes in the average reaching speed of IPSAG. It is believed that the results show, compared with COT, finding and resolving factors that limit hand movements for each patient improves the efficiency of patient's posture control and movement, and the effectiveness of intervention to help more automatically interact with environment. This supports the previous study that there is a clear correlation between quality and speed of movement.[6] The UL function also showed a difference in the study group, which means that the stability of the trunk and shoulder of IPSAG improved the range of shoulder movement. And that means the im-

provement of fine hand function according to the improvement of body awareness through the sensory input of the hand, too. Finally, comparing the differences after intervention changes between groups, there was no difference between ARS and MFT. This is thought to be the result of a period of intervention that is not enough to increase adaptation through IPSA. In addition, it is necessary to apply appropriate task-oriented training and training based on actual ADL including both hands.[30] The limitation of this study is that the number of subjects is small, so the generalization is limited according to the results of the study. In addition, follow-up studies to confirm the consistency of recovery after interventions are considered necessary in future studies. And we expect the study to analyze the mediation effect of IPSA by analyzing various data as well as the average reaching speed of UL through 3D motion analyzer.

References

1. Almhdaw K. Effects of occupational therapy task-oriented approach in upper extremity post-stroke rehabilitation. University of Minnesota, ProQuest Dissertations Publishing. 2011.
2. Nakayama H, Jgtgensen HS, Raaschou HO, et al. Recovery of upper extremity function in stroke patients: the copenhagen stroke study. Arch Phys Med Rehab. 1994;75(4):394-8.
3. Jeon SH. The effect of forward flexion exercise on functional posture control in stroke patients. Sahmyook University. Dissertation of Doctoral Degree. 2016.
4. Hess SA. Functional stability of the glenohumeral joint. Man Ther. 2000;5(2):63-71.
5. Archambault P, Pigeon P, Feldman AG, et al. Recruitment and sequencing of different degrees of freedom during pointing movements involving the trunk in healthy and hemiparetic subjects. Exp Brain Res. 1999;126(1):55-67.
6. Cirstea C, Levin M. Improvement of arm movement patterns and endpoint control depends on type of feedback during practice in stroke survivors. Neurorehabil Neural Repair. 2007;21(1):398-411.
7. Levin MF. Interjoint coordination during pointing movements is disrupted in spastic hemiparesis. Brain. 1996;119(1):281-93.
8. Yoo YY. The effect of scapula's anatomical positional

stability on stretching and shoulder motion function in hemiplegic patients. Gachon University. Dissertation of Master's Degree. 2007.

9. Ryerson S, Byl NN, Brown DA, et al. Altered trunk position sense and its relation to balance functions in people post-stroke. J Neurol Phys Ther. 2008;32(1):14-20.

10. Park HM, Chang WN. Effects of placing training of paretic upper arm on reaching pattern in patient with stroke: a case report. J Korean Soc Neur Ther. 2019;23(2):13-7.

11. Raine S. Current theoretical assumptions of the bobath concepts as determined by the members of BBTA. physiotherapy theory and practice. 2007;23(3):137-52.

12. Langhammer B, Stanghelle JK. Bobath or motor relearning programme? a comparison of two different approaches of physiotherapy in stroke rehabilitation: a randomized controlled study. Clin Rehabil. 2000;14(4):361−9.

13. Raine S, Meadows L, Lynch-Ellerington M. Bobath concept: Theory and clinical practice in neurological rehabilitation. Oxford, Blackwell. 2009.

14. Go GH. The Effect of therapeutic occupation on upper extremity function and quality of life for people with stroke. Hanseo University. Dissertation of Master's Degree. 2019.

15. Feys HM, De Weerdt WJ, Selz BE, et al. Effect of a therapeutic intervention for the hemiplegic upper limb in the acute phase after stroke. Stroke. 1998;29(4):785-92.

16. Jo MA. Effect of scapula setting on upper limb function and activities of daily living of chronic stroke patients. Daegu University. Dissertation of Master's Degree. 2011.

17. Lee JN. The effect of neurodevelopmental therapy on the improvement of upper limb function in stroke patients. Yonsei University. Dissertation of Master's Degree. 2003.

18. Jung YJ, Jung KM. The effect of scapula setting intervention on the function of upper extremity and walking in the patients with stroke. J Korean Soc Neur Ther. 2013;17(1):39-44.

19. Raine S. Defining the bobath concept using the delphi technique. physiotherapy research international. 2006;11(1):4−13.

20. Hubbard IJ, Carey LM, Budd TW, et al. A randomized controlled trial of the effect of early upper limb training on stroke recovery and brain activation. Neurorehabil Neural Repair. 2014;29(8):703−13.

21. Oujamaa L, Relave I, Froger J, et al. Rehabilitation of arm function after stroke. Literature review. Ann Phys Rehabil Med. 2009;52(3):269-93.

22. Graham JV, Eustace C, Brock K, et al. The bobath concept in contemporary clinical practice. Top Stroke Rehabil. 2009;16(1):57−68.

23. Schleichkorn J. The bobath: a biography of berta and karel bobath. NDTA and Therapy Skill Builder, Tuscon. 1992.

24. Cirstea MC, Levin MF. Compensatory strategies for reaching in stroke. Brain. 2000;123(5):940−53.

25. Yoon SY, Lee TY, Park SY, et al. Muscle activity and motor morphology analysis of drinking action. J Korean Occu Ther. 2008;16:77-88.

26. Huseyinsinoglu BE, Ozdincler AR, Krespi Y. Bobath concept versus constraint-induced movement therapy to improve arm functional recovery in stroke patients: a randomized controlled trial. Clin. 2012;26(8):705-15.

27. Vaughan-Graham J, Cott C, Wright FV. The bobath (ndt) concept in adult neurological rehabilitation: What is the state of the knowledge? A scoping review. Part II: intervention studies perspectives. Disabil Rehabil. 2015;37(21):1909-28.

28. Senesac CR, Davis S, Richards L. Generalization of a modified form of repetitive rhythmic bilateral training in stroke. Hum Mov Sci. 2010;29(1):137−48.

29. Cauraugh JH, Kim SB, Duley A. cupled bilateral movements and active neuromuscular stimulation: itralimb transfer evidence during bimanual aiming. Neurosci Lett. 2005;382(1-2):39−44.

30. Song BK, Kim AR, Kim JS, et al. A Systematic Review on The Task-Oriented Training Effect Applied to Hemiplegic Patients after Stroke. J Korean Soc Neur Ther. 2019;23(2):35-43.