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The Effect of Bilateral Upper Limb Training on Recovery of Upper Limb Function in Patients with Acute Stroke

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ABSTRACT

Background/Objectives: The purpose of this study was to survey the influence on action observation of meaningful tasks on upper limb function in patients with stroke. Thirty stroke patients were prospectively randomized to bilateral upper limb training task (BULTT) group or general upper limb rehabilitation (GULR) group.

Method/Statistical Analysis: We studied 30 acute stroke patients. The experimental group (N = 15) applied bilateral upper limb training task (BULTT) and the control group (N = 15) performed general upper limb rehabilitation (GULR) for the affected side. Both groups executed 5 times per week and 30 minutes per session for 4 weeks. To assess the effects of intervention, the paired t-test was used to contrast before and after intervention results of each group. The independent t-test test was used to contrast changes in outcome measures between the groups.

Findings: The Fugl-Meyer Assessment (FMA) before-test score BULTT group was 17.00 ± 3.74 and after-test score was 21.27 ± 4.62. Significant changes in the FMA were observed in both groups. However, the results from the observation of BULTT were most significant. The mean change in FMA score was 4.27 ± 2.09 in the BULTT group and 1.80 ± 1.78 in the GULR group, showing a statistically significant difference. The BULTT group showed a significant increase in upper limb function after training intervention.

Improvements/Applications: This study demonstrated that action observation of meaningful bilateral upper limb training in patients with stroke. We present evidence that action observation of meaningful tasks has a beneficial effect in occupational therapy for movement disorders after stroke.

Keywords: *stroke, bilateral upper limb training, upper limb motor function, meaningful tasks, Fugl-Meyer Assessment*

Introduction

Stroke is caused by vascular occlusion such as hypoxia, ischaemia, or infarction, or by intracranial hemorrhage. Cerebral infarction is the most frequently occurring type. This is related to the central nervous system being very sensitive to oxygen deficiency or ischemia in various organs of the body[1]. Stroke patients generally develop muscle weakness, coordination problems, abnormal muscle tension, and motor paralysis[2]. Stroke patients with these neurological symptoms have social, mental and physical impairments, of which 40% have some dysfunction and 15-30% have sensory disturbances[3,4]. A significant reduction in the function of the affected side is generally associated with reduced use of the injured upper limb in real life. Therefore, it can induce learned nonuse, which can result in weakened function of the affected side and increase the restriction of daily life[2,5].

Bilateral activity is based on the assumption that the right and left muscle groups are simultaneously activated

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and similar neural activation occurs in both cerebral hemispheres[6]. Simultaneous execution of both upper limbs can also increase activation of the affected cortical area, which can be attributed to the bilateral distribution of the channels that transmit commands and the common initiation of motion commands through simultaneous execution of both upper limbs[7,8]. It is known that the enhancement of the efferent connection of the ipsilateral upper limb by activation of the uninjured brain region improves motor control of the affected upper limb[9].

Activation of the primary motor and somatosensory cortex of the affected side is further enhanced by the simultaneous performance of the both upper limbs which is compared to the single side of the affected, which is related to the activation of both the cerebral hemispheres[7,10]. Also, when performing tasks with both hands, in order to move of both hands complex interactions between both cerebral hemispheres can occur and this interaction can promote the effect of the affected upper limb[11].

Many actions in real life are performed by coordination of both hands. Repeated, similar tasks used in daily life may improve function even in patients with severe upper limb paralysis[12]. This treatment approach using both hands is closely related to daily life and the affected side upper limb is improved functionally to the help rehabilitation and daily activities of stroke patients[13].

Several studies have demonstrated the effect of bilateral exercise to induce the recovery of motor function using both the affected and less affected upper limbs[14-16]. These studies have reported that bilateral activity in the early level of stroke rehabilitation improves symmetric body and reduces abnormal muscle tone[15]. In addition, it has been reported that complex interactions are activated in the cerebrum for the exercise planning of both upper limbs[16].

Therefore, based on the above facts, this study investigated the effect of bilateral upper limb training task on upper limb function in patients with acute stroke.

Materials and Method

Subjects: In this study, we randomly divided the 30 study subjects into two groups (Table 1) : the BULTT group and the GULR group. These participants met the selection criteria and gave voluntary knowledgeable consent to take part in the study. The incorporation criteria were as follows:

First, hemiplegic patients with stroke duration less than 6 months

Second, a score of ≥ 24 in the MMSE-K (Korean version of the Mini-Mental Status Examination)

Thirdly, a level of ≤ Brunnstrom recovery of upper limb stage 3

Fourth, in the line bicection test, patients without unilateral neglect

Fifth, patients without musculoskeletal disorders such as joint building or limited range of motion

Table 1: Individual Information of Patients

Characteristics		BULTT group (n = 15)	GULR group (n = 15)
Gender	Male	6	7
	Female	9	8
Age (y)		61.53 ± 8.81	62.00 ± 8.13
MMSE-K		27.60 ± 1.06	27.80 ± 1.37
Height(cm)		165.67 ± 7.19	166.00 ± 7.42
Weight(kg)		67.40 ± 12.35	66.87 ± 11.32
Onset of stroke months		3.60 ± 1.30	3.20 ± 1.37
Side of hemiplegia	right	11	9
	Left	4	6

M ± SD: mean ± standard deviation.

BULTT: bilateral upper limb training task, GULR: general upper limb rehabilitation

Materials - Fugl-Meyer Motor Function Assessment(FMA): Upper limb Subtest: FMA is used to classify hemiplegic patients with stroke as a Brunnstrom recovery stage and to assess the recovery of function[17]. Fugl-Meyer et al. developed an assessment tool by defining 50 detailed movements according to the six stages of recovery of Brunnstrom's hemiplegic patients. 0 ~ 2 points are given depending on the performance of the evaluation item. 0 point is not performed, 1 point is performed partially, and 2 points are divided into complete execution. The overall score ranges from 0 to 100, including upper and lower limbs. There are 33 items in the upper part of the test, which is 66 points. The details of upper limb examination are 18 items for shoulder/elbow/forearm, 5 items for wrist, 7 items for hand (finger), and 3 items for upper limb coordination ability[18]. Sanford et al. reported an inter-rater reliability of 0.96 for upper limb examination [19]. In this study, only upper limb test items were used for upper limb function evaluation.

Methods-Bilateral Upper Limb Training Task: Subjects were divided into BULTT group (15 patients) and GULR group (15 patients). The experiment was conducted for 5 weeks each week for 30 minutes for 4 weeks. The BULTT group performed the bilateral upper limb training task and the GULR group performed general upper limb rehabilitation.

The posture for bilateral upper limb activity is to sit on the backrest chair and place both upper limbs on the table, and the hip, knee, and ankle joints are flexed 90 degrees. And the patient is allowed to maintain the correct posture by inducing the patient to use the backrest or the footrest according to the physical condition so that the same weight is applied to both legs from the center of the chair.

Table 2 summarizes the results of the bilateral upper limb training task with reference to the programs of Desrosiers et al. and Lewis & Byblow[20,21].

Table 2: Bilateral Upper Limb Training Task

Program	Method
Wipping table with towel	The patient wipes the table by placing both hands with the fingers together locked or both hands without the fingers together locked in parallel on a towel, pushing and pulling the table forward, left and right. Elbow joints move with flexion and extension, and shoulder joints move with horizontal adduction and horizontal abduction. As the elbow joint moves, the scapular of the affected upper limb is not retracted.
Mimiceing the drinking	The patient mimics the action of drinking a cylindrical plastic cup with finger togerht locked to the mouth. Shoulder and elbow joints move with flexion.
Moving blocks to boxes	The patient should hold the block (4cm × 4cm × 4cm) placed in front of the table with finger together locked and move it into a box located at eye level of 30 cm. Keep your finger locked and move the elbows in the flexion direction. The block is picked up mainly with the less affected fingers. When placed in the box, the shoulder joint moves in the flexion direction and the elbow joint moves in the extension direction.

Analysis Methods

The results of the collected data were analyzed using SPSS (ver. 12.0) statistical program. The general characteristics of the subjects were descriptive statistics and chi-squared test was used for the homogeneity test between the BULTT group and the GULR group. Shapiro Wilk test was used to confirm normality, and the paired t-test was used to compare FMA before and after intervention. The independent t-test was also conducted to compare groups after intervention. The statistical significance level was 0.05.

Results and Discussion

Comparison of Results (Fma Score) Before and After The Intervention: Upper limb motor function in both groups before and after treatment is shown in Table 3.

The changes of FMA before and after the application of bilateral upper limb training task were significantly improved from 17.00 to 21.27 ($p < 0.001$). In addition, the change of FMA from general upper limb rehabilitation was improved from 17.27 to 19.07 ($p < 0.01$).

Table 3: Comparison of Results (FMA Score) Before and After the Intervention

	BULTT group (n = 15)		GULR group (n = 15)	
	Pre-test	**Post-test**	**Pre-test**	**Post-test**
FMA	17.00 (3.74)	21.27 (4.62)	17.27 (4.59)	19.07 (5.31)
P	.000***		.002**	

The values are mean (standard deviation), *p<0.05, **p<0.01, ***p<0.001 by paired t-test

FMA: Fugl-Meyer Assessment

BULTT: bilateral upper limb training task, GULR: general upper limb rehabilitation

Comparison of Results Between the BULTT Group and GULR Groups: The mean changes in upper limb motor function scores in the 2 groups are compared in Table 4.

The mean change in FMA was 4.27 ± 2.09 in the BULTT group and 1.08 ± 1.78 in the GULT group, showing a statistically significant difference. Mean change in the FMA was significantly greater in the BULTT group.

Table 4: Comparison of Results Between the BULTT Group and GULR Groups

	Mean Change	
	BULTT group (n = 15)	**GULR group (n = 15)**
FMA	4.27(2.09)	1.80(1.78)
P	.002**	

The values are mean (standard deviation), *p<0.05, **p<0.01, ***p<0.001 by independent t-test

FMA: Fugl-Meyer Assessment

BULTT: bilateral upper limb training task, GULR: general upper limb rehabilitation

Discussion

In this study, we investigated the effect of bilateral upper limb training on upper limb function in acute stroke patients. In the selection of the subjects, the MMSE-K revealed that the cognitive impairment was considered as a result of 24 out of 30 total score, or visual perception ability including neglect and homonymous hemianopsia in the line by section were excluded from this study. We also excluded patients with musculoskeletal disorders such as contracture of joints or limitation of range of motion, and patients with complete voluntary movement of the affected upper limb without assistance. The subjects selected for the study were less than 6 months in the stroke diagnosis. In addition, the subject is a patient with Brunnstrom recovery of upper limb stagy 3 or less who needs active assistance because of the voluntary movement of the affected upper limb and the difficulty of one hand moving of the affected limb without assistance. There were no cognitive impairment, visual perception disabilities, or musculoskeletal disorders.

Bilateral upper limb training was consisted of supplementing and modifying the less affected upper limb so as to lead to various movements of the affected upper limb, referring to the previous studies[20,21]. During the application of the program, the subjects crossed the fingers of both hands and performed activities with their hands clipped. The fingers together locked may prevent the associated reaction by reducing the spasticity of the flexion pattern of the affected upper limb by abduction of the affected fingers and also increasing the sensation and perception of the affected side since the fingers together locked are held in the midline of the body[22].

In this study, BULTT improved the upper limb function more than GULT, and there was a significant difference between the two groups before and after the intervention. When any activity begins on both sides, the motor cortex of both hemispheres simultaneously activates and inhibits the functions of the other side. Previous studies on stroke patients have emphasized the importance of simultaneous exercises on the bilateral upper limb and reported that normal movement of the upper limb through coordination of both hands plays an important role in the quality of performance in daily life[7]. Fey et al. reported improved upper limb function when repeated bilateral upper limb training was applied to stroke patients[12]. Lewis & Byblow also suggested using the affected and less affected upper limb simultaneously to improve the function of the upper limb.

Recovery of upper limb function has a direct impact on performing independent activities and activities of daily living. The results of this study show that BULTT performance in acute stroke patients is effective in improving the function of the affected upper limb in stroke patients.

In this study, generalized interpretation of all stroke patients is limited because only limited patients who meet the selection criteria were studied. Further evaluation of factors that may have an additional effect on upper limb function was not considered and further evaluation should be performed to further clarify the relationship between bilateral tasks and upper limb function. Therefore, additional studies should be conducted to investigate the effect of bilateral upper limb activity on patients' rehabilitation process in various aspects.

Conclusion

The purpose of this study was to investigate the effect of bilateral upper limb activity on upper extremity function into acute stroke patients. Thirty patients were selected based on the selection criteria, and 15 subjects were divided into two groups, one was an experimental group applying bilateral upper limb training task and the other was a general upper limb rehabilitation group. FMA was used to compare upper limb functions before and after intervention for 4 weeks. The results were as follows.

First, there was a significant change in upper limb function before and after intervention in BULTT and GULR, but it was more effective in BULTT (p<0.001)

Second, there was significant improvement in bilateral upper limb activities after intervention ($p<0.05$).

Second, the comparison between the two groups showed significant improvement in the BULTT group ($p<0.05$).

These results suggest that the upper limb function area of acute stroke patients with BULTT is improved. Therefore, it seems that BULTT can be used as a therapeutic method for the recovery of upper limb function in stroke patients, and further study on the effect of the patient on rehabilitation should be handled together.

Ethical Clearance: Not required

Source of Funding: Self

Conflict of Interest: Nil

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