

The effects of cognitive exercise therapy on chronic stroke patients' upper limb functions, activities of daily living and quality of life

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Abstract. [Purpose] This study aimed to examine the effects of task-oriented exercise therapy and cognitive exercise therapy on the recovery of hand function and the quality of life in chronic stroke patients. [Subjects and Methods] A total of 16 patients with chronic stroke were selected and divided into two groups. Group I (n = 8) received task-oriented exercise therapy and Group II (n = 8) received cognitive exercise therapy. This study was conducted for eight weeks. Upper limb function was assessed using the Fugl-Meyer assessment (FMA) and manual function test (MFT); activities of daily living were assessed using the motor activity log (MAL); and the quality of life was assessed using the stroke impact scale (SIS). The pre- and post-intervention results of these tests were analyzed. [Results] There were significant differences in all areas of upper limb function, activities of daily living, and quality of life between the two groups. There were significant differences between the two groups in the post-intervention upper limb function and quality of life. [Conclusion] Application of cognitive exercise therapy was found to effect functional recovery in stroke patients. Future research should focus on application of cognitive exercise therapy in diverse populations, and assess its clinical utilization.

Key words: Stroke, Cognitive exercise therapy, Quality of life

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INTRODUCTION

Upper extremity disorder, among the different neurological disabilities of stroke patients, is the most common sequela, and according to the report by Rodgers¹⁾, 85% of patients after the onset of a stroke experience damaged upper limb function. The function of the upper extremities plays an important role in the sophisticated task performance of activities of daily living²⁾ and it is closely related to participation in social activities³⁾; therefore, changes in upper extremity function greatly affect patients' quality of life⁴⁾. Therefore, a therapeutic approach to reduce the non-utilization of the upper extremities and develop their functional movement is required⁵⁾.

Recent research has shown that the cognitive and physical areas have a close relationship⁶⁾, but what is greatly emphasized traditionally in neurological rehabilitation is

mostly motor system, and perceptual-cognitive perspectives of functions tend to be disregarded⁷⁾. Perception-cognition includes attention. Such a loss of attention decreases the technicality of dual tasks about stroke patients' arm movements due to reductions in autonomy of motor control and disorders in the motor mechanism of the pyramidal tract⁸⁾.

Page et al.⁹⁾ noted that imagining and imitating motions had positive effects on treatment because of performances based on past experiences. Kim¹⁰⁾ observed there are stages of attentive perceptions, memories, emotions, and behaviors between sensory input and motor output process-regulating motor execution, and brain damage destroys each stage. Furthermore, a specific rehabilitation therapeutic approach has yet not been developed for each process. However, cognitive exercise treatment can support such content.

Cognitive exercise treatment has been presented by Carlo Perfetti of Italy, who introduced a theory of the learning process based on Anokhin's theory of self-regulation of a conditioned reflex. Cognitive exercise treatment is a motor learning model that emphasizes high-level cognitive function¹¹⁾ and occurs through the integration of perception-cognition-activity processes, such as motor regulation¹²⁾. Activation of the brain's cognitive process, which represents perception, memory, attention, language, and decision, is the core of the training¹³⁾.

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Table 1. Characteristics of study participants

Parameters	Group I (n=8)	Group II (n=8)
Age (years)	56.1±7.1	57.6±5.7
Gender (male/female)	4/4	5/3
Height (cm)	163.5±8.8	162.0±6.3
Weight (kg)	62.1±7.0	60.1±7.2
Paretic side (Rt/Lt)	3/5	3/5
Etiology (Hemorrhage/Infaction)	4/4	3/5

All data are expressed as means with standard deviation (M±SD)

Group I: task-oriented exercise therapy, Group II: cognitive exercise therapy

Jung¹⁴⁾ reported there were significant differences in stroke patients' speeds in stretching, quick reaction, and cognition of distance between before and after cognitive motor treatment, and there was a synergetic effect when cognitive-perceptual training was conducted together¹⁵⁾. When compared with traditional treatment, performance improved in training with cognitive strategies, and exercise image protocol as a specific cognitive strategy method was able to improve the mobility of stroke patients and their upper limb function¹⁶⁾. Cognitive rehabilitation, dual task training, training using computer games, and cognitive or motor-cognitive interventions, such as virtual reality, might strengthen physical functions^{17, 18)}.

There are diverse therapeutic approaches for stroke patients' functional recovery, but research on the effectiveness of cognitive exercise treatment approaches is still lacking. Accordingly, this study intended to compare a task-oriented exercise treatment group and a cognitive exercise treatment group to examine how such treatment methods affected the paretic side upper extremity's functional recovery and patients' quality of life.

SUBJECTS AND METHODS

Subjects

This study involved 16 chronic stroke patients. The criteria for subject selection are as follows: Those who were diagnosed with hemiplegia resulting from a stroke and whose onset of a stroke was six months or longer before; those whose mini-mental state examination-Korean (MMSE-K) score was 23 points or higher; those whose arm and hand functions were in the fourth stage or higher in Brunnstrom's recovery stages; those who had endurance to continue treatment for 30 min or longer; and those who had no unilateral neglect. The subjects voluntarily consented to participate prior to this study. Data collection was conducted after approval from Dongshin University's Institutional Review Board was obtained. Table 1 shows the general characteristics of the subjects.

Methods

The subjects selected a card among cards on which odd and even numbers were written to allocate randomly subjects to either Group I (n = 8) or Group II (n = 8). Task-oriented exercise treatment and cognitive exercise treatment methods in this study were used by modifying the method

by Lee¹¹⁾. Group I conducted range of motion exercise of the shoulder joints and task-oriented exercise treatment training, which involved moving the distal area after stabilizing the proximal area, such as receiving manual therapy, moving and piling cups, putting up and down a pegboard, moving a small ball, leafing through a book, threading beads, putting in rings, putting coins in a coin bank, and writing letters.

Group II conducted cognitive tasks using spatial and tactile senses. They conducted spatial tasks using tabulate, which was divided into three sections, bogen with markings, and bridge of 12° arc with markings as tasks, which required identification using sensory modes centered on distance, direction, form, and kinesthetic senses.

Tabulate allowed the therapist to adjust the degree of upper limb joints according to the degree of perceiving the form by moving the fingers according to the shape of the panel with the patient's eyes closed.

Bogen was used to determine and identify exercise range precisely, have the patient perceive differences between fingers and the wrist, and for the therapist to move the wrist and fingers so the patient identified the joint angle with the eyes closed.

Bridge was used to connect the thumbs with the surface of the bridge, thereby demanding tactile identification or kinesthetic sensing by moving without contacting, thereby having the patient recognize pronation and supination movements of the forearms. Finally, the patient moved the upper limbs, as well as was asked about movement and directionality of the joints for the joint angle perception training.

As tasks that required identification using sensory modes, such as pressure, weight, tactile sense, and friction, sponge, tactile panel, and platform tactile tasks, were conducted, the patient sat in a proper position with the eyes closed and the patient's shoulder joint or elbow joint covered with a sponge. The therapist had the patient compare differences between pressure sensations of the paretic and non-paretic side. The patient was also asked to differentiate between the sponge hardness.

Diverse tactile panels with different qualities and shapes were prepared, and the patient perceived differences in the surface quality by moving the fingers.

A platform was used for the identification of the wrist joint exercise. When the subject was able to adjust the platform, different weights were attached and the subject was asked to identify on which side a weight was hung. The patient was asked to identify differences between several different

weights. The patient was also asked to identify the height of a stick placed below a platform or to identify the hardness of different cushions.

Training of the two groups was conducted five times per week, 60 min each time for eight weeks. Changes in upper limb functions were examined with the Fugl-Meyer assessment (FMA) and manual function test (MFT). The FMA used only the upper limb assessment items. With a three-point scale, when the patient was unable to perform, zero points were given, when the patient was able to partially perform, one point was given, and when the patient was completely able to perform, three points were given, with 66 points representing a perfect score¹⁹. MFT is comprised of an exercise of the upper limbs (four items), figuring out (two items), and finger manipulation (two items), and the score ranges from zero to 32 points²⁰. For the evaluation of daily living activities, the motor activity log (MAL) was used. The MAL is classified into the quality of movement (QOM) regarding whether the paretic side upper limb is qualitatively well used and regarding the amount of use (AOU) on whether it is quantitatively used much. Such QOM and AOU scores were on a six-point scale from zero point to five points and they may be expressed in total scores by adding the scores of each item²¹. To assess quality of life, the stroke impact scale (SIS) was used. The SIS is composed of 60 questions: 59 questions (eight items) and one question measuring the subject's stroke recovery degree. The score is given from one point at the minimum to five points at the maximum. The item related to recovery after a stroke is composed of zero points at the minimum to 100 points at the maximum²². All assessments were carried out before and after training.

SPSS version 12.0 for Windows was used for statistical analysis. A χ^2 test, Fisher's exact test, and t-test were conducted for normality tests of the variables of the subjects and their general characteristics. A paired t-test was used to analyze changes within each group after training. An independent t-test was performed to examine changes between the groups after training. A statistical significance level was set at $\alpha = 0.05$.

RESULTS

The FMA and MFT, representing changes in upper limb functions, the MAL, representing changes in daily living activities, and the SIS, representing changes to quality of life were analyzed within the groups and there was a significant improvement in both groups after training compared to before training at the baseline ($p < 0.05$). In particular, an improvement in Group II was considerably greater ($p < 0.01$). According to the result of a comparison between the groups, there were significant differences among the FMA, MFT, and SIS results ($p < 0.05$). Nonetheless, there was no statistically significant difference between the groups regarding the MAL ($p > 0.05$) (Table 2).

DISCUSSION

Cognitive exercise therapy is an innovative approach for retraining motor functions of patients with hemiplegia after a stroke²³, and Miyamoto et al.²⁴ noted the purpose

Table 2. Change of upper extremity function, daily living, quality of life between experimental groups (M \pm SD) (score)

Parameters		Group I (n=8)	Group II (n=8)
FMA	Pre	50.5 \pm 6.8	53.5 \pm 3.2
	Post	58.7 \pm 2.5*	62.2 \pm 1.3**
MFT	Pre	24.3 \pm 3.1	25.5 \pm 3.8
	Post	25.2 \pm 3.1*	30.3 \pm 1.4***
MAL (QOM)	Pre	82.3 \pm 22.5	86.5 \pm 20.4
	Post	112.3 \pm 23.1***	121.8 \pm 24.7***
MAL (AOU)	Pre	53.8 \pm 40.9	52.7 \pm 14.6
	Post	102.5 \pm 34.9**	116.5 \pm 29.0***
SIS	Pre	57.6 \pm 14.5	55.4 \pm 6.4
	Post	63.2 \pm 12.5*	76.7 \pm 5.6***

All data are expressed as means with standard deviation (M \pm SD)

Group I: task-oriented exercise therapy, Group II: cognitive exercise therapy, FMA: Fugl-Meyer assessment, MFT: manual function test, MAL: motor activity log, QOM: quality of movement, AOU: amount of use, SIS: stroke impact scale
Tested by paired t-test (*; $p < 0.05$, **; $p < 0.01$, ***; $p < 0.001$), Independent t-test (#; $p < 0.05$, ##; $p < 0.01$)

of the exercise was an appropriate intervention within the cognitive process of motor learning, such as perception, attention, memory, visual sense, and language. Stimulating the physical and mental functions of a patient together directly affects reorganization of the brain after damage²⁵) and in the rehabilitation of patients whose brains were damaged, cognitive and kinematic aspects should be considered²⁶). Therefore, this study applied cognitive exercise treatment to stroke patients, thereby examining its effects on upper limb function recovery and quality of life, as well as proposing it as a strategy for treatment.

The FMA and MFT were performed to measure the effects on upper extremity functions, and there were statistically significant differences between the two groups and a statistically significant improvement after the experiment in both Group I and Group II. There was great change in Group II, which showed that cognitive exercise therapy was effective for improving paretic side upper limb functions.

Okita et al.²⁷) observed the score of the MFS, a 100-point conversion score of the MFT, improved by 44 points after cognitive exercise treatment of the upper extremities, noting cognitive exercise therapy for the upper limbs was an effective approach to promote the recovery of hemiplegic patients' upper limb functions. Miyaguchi and Okita²⁸) applied upper limb cognitive exercise therapy to patients whose Brunnstrom stage was three and achieved remarkable improvements in MFS scores, which was consistent with the result of the present study.

Jung¹⁴) reported the speed of stretching, quick reaction, and increase in distance activated cognitive processes to perceive precise movements and inhibited abnormal elements into proper movements. Morioka et al.²⁹) reported that during spatial task performance, a part of cognitive exercise therapy for healthy people, blood flow amounts in the premotor cortex for motor learning and in the dorsolateral prefrontal cortex

taking charge of occupational memory function significantly increased. Such a result plays an important role in adjusting muscular activity and movement, as well as learning and remembering exercise techniques³⁰). Therefore, cognitive task training, which applies contact and spatial tasks, may be more effective for the recovery of abnormal motor functions.

A difference between cognitive exercise therapy and other treatment strategies is the former places importance on changes in cognitive processes through internal observations. Movement, language, attention, image, and learning aspects are determined together, analyzing qualitative and quantitative elements. Motor function recovery is related to cognitive processes of the brain and the quality of recovery depends on whether such cognitive elements have been realized²³).

There was no significant difference between the two groups regarding changes to upper extremity use frequency of the paretic side and in qualitative utilization according to the result of measuring MAL during the performance of daily activities. Qualitative changes in paretic side upper limb utilization amount and movement within each group showed significant differences, with more changes in Group II.

Bang et al.³¹) observed that motor learning of the upper limbs improved stroke patients' activities of daily living³²). There was a greater change in Group II than in Group I, because by developing the ability to organize factors for spatial, temporal, and intensity degrees in the exercise order necessary for interaction between the body and the environment³³), exercise patterns of the paretic side qualitatively improved³²) and participation degree of daily life of the paretic upper limb has enhanced.

Changes to quality of life in the two groups were measured using the SIS and there were significant differences between the two groups. In addition, there were statistically significant differences within each group after the experiment. Ahn et al.³⁴) observed that performance ability of the paretic upper limb highly correlated with patients' activities of daily living and quality of life. Bae³⁵) noted that decreases in abnormal motor functions improved the degree of satisfaction with life, which is consistent with the present study result. A high significance level in Group II suggests that activation of diverse cognitive processes in patients allowed them to pay attention to their body and express themselves, which positively affected their subjective thoughts about physical and functional recovery by obtaining information on their movements and feelings through internal observations.

The limitation of this study is it was conducted for a short treatment period of eight weeks and post-evaluation to determine whether the effect of treatment continued was carried out. In addition, the number of subjects was small and therefore, generalizing the outcome of this study to stroke patients as a whole is difficult. Most previous studies are case-based studies and it was not possible to compare the statistical significances of the results. Moreover, materials to prove subjective changes patients feel themselves through their actual movements to examine treatment effects of cognitive exercise therapy are lacking.

The theory of cognitive exercise treatment will be able

to be utilized to analyze patients' conditions from different viewpoints from existing treatment methods. Miyamoto et al.²⁴) observed the effects of cognitive exercise therapy as an innovative approach to promote hemiplegic patients' motor recovery were expected. Therefore, to prove the effect of cognitive exercise therapy, study tools should be developed and experimental paper cases should be studied much to verify the objective statistical significance of different factors related to rehabilitation.

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