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The Effect of Cognitive Rehabilitation Program Combined with Physical Exercise on Cognitive Function, Depression, and Sleep in Chronic Stroke Patients

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Objective: This study was conducted to verify the effectiveness of a cognitive rehabilitation program consisting of physical exercises and mental activities for patients with chronic stroke with mild cognitive impairment (MCI). We aimed to investigate how this cognitive rehabilitation program affects patients' cognitive ability, depression, and sleep quality.

Design: One group pretest-posttest design

Methods: The study was conductedon 12 patients who participated in thecognitive rehabilitation complex exercise program for 16 weeks. The Korean version of the Montreal Cognitive Assessment (MoCA-K), Hamilton Depression Rating Scale (K-HDRS), and Pittsburgh Sleep Quality Index (PSQI) were used to evaluate the measured variables before and after study participation. The cognitive rehabilitation complex exercise program included 30 minutes of cognitive exercise and 30 minutes of Brill Exercise. The Wilcoxon signed-rank test was used to compare the variables before and after program participation. Cronbach's α was used to assess the reliability of the test variables.

Results: The post-program assessment showed a statistically significant increase in the MoCA-K score, which measures cognitive function ($Z=-2.628$, $P=0.009$). For depression ratings, there was a statistically significant decrease in the K-HDRS score ($Z=-2.041$, $P=0.041$). For sleep quality, although there was a numerical increase in the PSQI score, the difference was not statistically significant ($Z=-0.702$, $P=0.483$). The reliability test confirmed that all the individual test variables exhibited high reliability (cognitive function, 0.859; depression, 0.872; sleep, 0.822).

Conclusions: We found that cognitive rehabilitation program used in this study had a positive effect on the cognitive function and depression in patients with chronic stroke with MCI.

Key Words: Cognitive function, Cognitive rehabilitation, Depression, Sleep, Stroke

Introduction

Cerebrovascular disease is the fourth leading cause of death in Korea, and in 2020, the number of deaths due to cerebrovascular disease approaches 21,860, and the domestic mortality rate is 42.6 per 100,000 people[1]. Sudden neurological symptoms such as loss of motor function, paresthesia, cognitive impairment, speech impairment, and coma generally occur in these stroke patients[2].

Cognitive impairment is a common impairment after stroke, and the degree of cognitive impairment predicts independent functional level, social integration, and early mortality[3, 4]. Moreover, cognitive impairment can affect not only the independent daily activities of life, but also the ability to perform basic tasks in stroke patients [3]. Therefore, cognitive impairment should be considered important in the rehabilitation

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process for the social integrationof stroke patients [3].

Mild cognitive impairment (MCI) refers to an intermediate stage of transition from normal to dementia, with mild memory impairment compared to the same age group, but normal daily life performance, and subjective memory decline, but the general cognitive function is in the normal range[5-8]. At this time, if appropriate intervention is not provided, cognitive function deteriorates very quickly[5, 8].

High-risk factors for MCI include old age, poor education, living alone, low social support, hypertension, diabetes, hyperlipidemia, stroke, decreased physical activity, decreased physical function, depression, and smoking[6, 9-12]. Therefore, as interest in interventions to improve MCI's cognitive and emotional functioning grows, many approaches are being tried. However, specific treatments are difficult to substantiate, and research findings vary depending on the intervention strategy[13-17]. According to the results of a meta-analysis study on the treatment of MCI, non-pharmaceutical treatments such as cognitive training, cognitive rehabilitation, and cognitive stimulation therapy for the elderly with MCI have been proven to be effective in improving cognitive function[6, 18]. Moreover, according to a previous study of a cognitive function enhancement program for patients diagnosed with MCI, research results suggest that it improves cognitive function or delays functional decline[6, 19-21].

Depression is the most emotional symptom faced by stroke patients, and 47% of post-stroke depression occurs regardless of left and right cerebral hemispheres, and 46% of stroke patients report experiencing acute depression[22, 23]. It was reported that post-stroke depression is closely related to cognitive function, and cognitive function was statistically significantly decreased in stroke patients with depression compared to stroke patients without depression[24-26].

Depression in stroke patients is an important variable related to sleep quality[27]. Psychological and mental problems caused by symptoms in stroke patients interfere with sleep at night, and sleep disturbances have adverse effects physically and mentally as well as fatigue[28, 29]. In the case of hospitalized acute cerebral infarction patients, 68% of them complained of insomnia, and 49% of them reported that insomnia persisted after 18 months[30, 31].

Sleep disturbance is related to daily living performance, anxiety, psychiatric drug use, dementia, etc. after stroke, and has a poor prognosis for rehabilitation treatment by decreasing neurological, cognitive, and mental functions after stroke[31, 32]. Therefore, sleep disorder treatment for active rehabilitation treatment of stroke patients is necessary to maintain physiological and mental homeostasis to provide patients with opportunities for rest and stability[31, 33]. Sleep disturbance and fatigue in stroke patients are factors that affect daily life and quality of life[30].

In addition, the movements are safe, easy to follow, and simple. Therefore, the Brill Exercise is not a simple stretching, but an effective exercise method that reflects all recent trends in musculoskeletal treatment [40, 41]. Because the Brill Exercise can be performed in a sitting or lying position, it is considered to be suitable as a complex cognitive intervention exercise for stroke patients with impaired movement.

In this study, there have been many studies that applied cognitive rehabilitation programs to stroke patients[5, 42], but it is judged that studies that comprehensively deal with the effects on cognitive function, depression, and sleep are still insufficient. In addition, many cognitive rehabilitation programs used in other studies applied only cognitive and emotional activities excluding physical activities. Therefore, this study aimed to develop a cognitive rehabilitation program that helps to strengthen attention and execution ability for chronic stroke patients with MCI, and a cognitive rehabilitation complex exercise program including the Brill Exercise method. Furthermore, the purpose of this study is to apply for a cognitive rehabilitation complex exercise program and to verify the effect on cognitive function, depression, and sleep.

Method

Participants

In this study, 12 chronic stroke patients with MCI who visited the rehabilitation treatment room of the public health center, G Metropolitan City participated. Subjects were informed sufficiently about the purpose and procedure by the ethical standards of the Declaration of Helsinki. The progress of this study was conducted

after the subjects obtained voluntary consent about the program participants and completed the program consent form.

The criteria for the selection of study subjects are as follows. 1) Those who have passed 6 months or more since the onset of the initial stroke, 2) Those who do not have problems with communication, 3) A person who understands the purpose of the research and voluntarily agrees to participate in the research, 4) A person who does not interfere with walking and movement, 5) Those who have not participated in other cognitive enhancement programs, 6) People diagnosed with a stroke, 7) Those who can continue to participate in this program, 8) Those who do not have respiratory problems, 9) Those who do not undergo kidney dialysis, 10) Those who do not have heart disease, 11) Those who are not at risk of having epilepsy or seizures, 12) Those with no recurrence of stroke, 13) Those who have a doctor's prescription for passive and active exercise, 14) A person who can respond to this evaluation sheet.

The criteria for exclusion of study subjects are as follows. 1) People diagnosed with dementia, 2) Those who are pregnant or breastfeeding, 3) Those diagnosed with schizophrenia or a mental disorder, 4) Individuals receiving treatment for cognitive impairment, 5) Individuals receiving treatment for depression, 6) Individuals receiving sleep therapy, 7) Those diagnosed with hearing impairment, 8) A person diagnosed with a facial disorder, 9) A person diagnosed with cancer, 10) people with intellectual disabilities, 11) person with developmental disabilities.

Study design

For the participants of this study, cognitive function was evaluated with the Korean version of Montreal cognitive assessment (MoCA-K) at week 1, and depression was evaluated with the Korean version of the Hamilton depression rating scale (HDRS). Sleep quality was evaluated with the Pittsburgh sleep quality index (PSQI). Interventions were made through a cognitive rehabilitation complex exercise program twice a week for 16 weeks and the evaluation was completed.Each week, 30 minutes of the cognitive rehabilitation program and 30 minutes of Brill Exercise were performed in parallel, and the total training time was 60 minutes. Moreover, individual early and late result tables were provided to the study subjects so that they could compare before and after the application of the program (Table 1).

Intervention

Physical exercise program

The Brill Exercise is an exercise method developed by a doctor specializing in physical therapy that treats the root cause of pain by correcting the musculoskeletal structure for each body part, such as the head, neck, shoulder, arm, wrist, knee, and foot. [40, 41]. The Brill Exercise is made up of easy-to-perform movements, providing an illustrated guide with exercises to encourage patients to do them often at home.

Cognitive rehabilitation program

Based on the program of previous studies, the present researchers modified and supplemented the cognitive rehabilitation program to suit reality[6, 43]. The cognitive rehabilitation program started by asking the date to promote orientation. Through singing and dancing, interest was aroused and natural movements were induced. And it helped to improve memory through origami, and activated the brain using hand muscles, and helped to make movements of the muscles.

Outcome measurements

The measurement tools used in this study were further analyzed for reliability. According to previous studies, the reliability of MoCA was higher than 0.73, and as a result of the measurement by this researcher, it was 0.859, which was very high[3, 44, 45]. In the case of depression, the previous study showed high reliability of 0.760, and this study also showed high reliability of 0.872[46]. Finally, in the case of sleep, very high reliability of 0.900 was shown, and in this study, reliability of 0.822 was shown[47]. Therefore, it was judged that it was very suitable for this study because the evaluation papers for all three factors showed high reliability.

Table 1. Cognitive Rehabilitation Complex Exercise Program Composition

Session	Cognitive rehabilitation program (30 minutes)	Brill Exercise(30 minutes)
1st Week	- Program Objectives and Course Introduction - Conceptual explanation of cognition - Conduct pre-test (MoCA-K, HAM-D, PSQI)	
2nd Week	- What year, month, day, and day of the week is today? - Spot the difference (puzzle) - Dog face origami - Song: Who are you? (Introduce yourself)	- Warm-up stretches and facials exercise
3rd Week	- What year, month, day, and day of the week is today? - Spot the difference (puzzle) - Hat origami - Song and dance:Head, Shoulders, Knees, Feet	- Brill Exercise: neck Part
4th Week	- What year, month, day, and day of the week is today? - Ship origami - Hat origami - Song: clench your fists and open your hands	- Brill Exercise: shoulders Part
5th Week	- What year, month, day, and day of the week is today? - A picture (pictorial) puzzle - Song and dance:Round and round - Description of Initial Evaluation Results	- Brill Exercise: Arm, Elbow, Wrist Part
6th Week	- What year, month, day, and day of the week is today? - A picture (pictorial) puzzle - Paper disk origami - Song: With you	- Brill Exercise: Hand, Wrist Part
7th Week	- What year, month, day, and day of the week is today? - Spot game - Cicada origami - Song and dance:Stop as it is	- Brill Exercise: Back (Middle) Part
8th Week	- What year, month, day, and day of the week is today? - Finding words - Frog origami	- Brill Exercise: Back (Lower) Part
9th Week	- What year, month, day, and day of the week is today? - Finding words - Bumblebee origami - Song: Number song	- Brill Exercise: buttocks, thighs Part 1
10th Week	- What year, month, day, and day of the week is today? - Finding words - Parrot origami - Song: Orchard Road	- Brill Exercise: buttocks, thighs Part 2
11th Week	- What year, month, day, and day of the week is today? - Word search - Angel Fish Origami - Song and dance: Hokey Pokey	- Brill Exercise: knee Part 1
12th Week	- What year, month, day, and day of the week is today? - Line drawing - Watermelon origami - Song: Brother thinking	- Brill Exercise: knee Part 2
13th Week	- What year, month, day, and day of the week is today? - Find the heart maze - Heart bookmark origami - Song and dance: Turn around	- Brill Exercise: Foot Part
14th Week	- What year, month, day, and day of the week is today? - Bingo game - LocustsOrigami - Song:Dokdo is our land	- Brill Exercise: Calf, Ankle Part 1
15th Week	- What year, month, day, and day of the week is today? - Find the brain maze - Dagger origami - Song and dance: Pong dang Pong dang	- Brill Exercise: Calf, Ankle Part 2
16th Week	- What year, month, day, and day of the week is today? - Conduct post-test(MoCA-K, HAM-D, PSQI)	

Korean version of the Montreal cognitive assessment (MoCA-K)

The MoCA-K was developed to evaluate MCI and was used as an evaluation method in several previous studies[3, 44, 45, 48]. It is composed of 7 sub-items of spatiotemporal/executive power (5 points), vocabulary (3 points), attention (6 points), sentence power (3 points), abstraction (2 points), recall (5 points), and orientation (6 points). The normal score is 23 or more out of a total of 30 points, and if it is 22 or less, it is a target for MCI. Another test for MCI is the Korean version of the Mini-Mental State Examination (MMSE-K), but there was a study showing that the MoCA-K was more sensitive than the Simplified Mental State Test for stroke patients with cognitive impairment[3, 45]. And since the Montreal cognitive assessment item evaluated for the cognitively impaired stroke group was 0.736, which showed moderate or higher reliability, this study tried to evaluate MCI with the MoCA-K[44, 45]. The reliability of each item in the normal cognitive stroke group was 0.642 in the temporal and spatial, 0.671 in the vocabulary, 0.640 in the attention, 0.679 in the sentence, 0.671 in the abstraction, 0.679 in the recall, and 0.659 in the orientation[3]. In the case of the reliability of each item of the cognitive evaluation conducted for the cognitively impaired stroke group, the temporal and spatial 0.747, the vocabulary 0.724, the attention 0.706, the sentence power 0.719, the abstraction power 0.732, the recall 0.731, the orientation 0.732[3].

Korean version of Hamilton depression rating scale (K-HDRS)

The Korean version of the Hamilton depression rating scale also called the Hamilton depression rating scale (HDRS) or Hamilton rating scale for depression (HRSD), is an observer rating scale created by Hamilton in 1960 and is the most widely used scale to evaluate depression[49]. Currently, the 17-item revised version is the most widely used, and this evaluation tool evaluates and scores the severity of emotional status, guilt, suicide accidents, insomnia, nervousness or delay in thinking, anxiety, weight loss, and physical symptoms.A score of 0 to 6 is normal, 7 to 17 is mild depression, 18 to 24 is moderate depression, and 24 or more is severe depression. Therefore, the total score ranges from 0 to 52, with higher scores indicating more severe depression. The internal consistency reliability examined by Cronbach's alpha was 0.760, which was good. As a result of examining the total score of K-HDRS and the reliability between raters of each item, the correlation of the total score was very high at 0.940[46, 50].

Pittsburgh sleep quality index (PSQI)

There are a total of 19 self-evaluation questions. If possible, five questions rated by the person sleeping with the subject are included. Only self-assessment questions are relevant to grading. The self-evaluation items are combined to achieve 7 points, each with a range of 0 to 3 points. In all cases, a score of '0' indicates no difficulty, and a score of '3' indicates serious difficulty. The seven scores are added to form one overall score, with a score range of 0 to 21. A score of 0 indicates that there is no difficulty, and a score of 21 indicates that there is serious difficulty in all areas. Evaluation items include subjective sleep quality, sleep latency, sleep duration, habitual sleep effect, sleep disturbance, sleep drug use, and daytime dysfunction. The English version of the PSQI has been proven to be stable, reliable, and valid in several studies, and it has been reported to have a sensitivity of 89.6% and a specificity of 86.5% in distinguishing between a satisfactory sleep group and an unsatisfactory sleep group[47, 51]. Therefore, this study used PSQI to evaluate sleep quality.

Statistical analysis

The data collected in this study were analyzed using the SPSS (version 22.0, IBM Corp., USA). The general characteristics of subjects were analyzed through frequency analysis, and descriptive statistics were used to calculate the mean and standard deviation for all measured variables. To compare and test the pre-post values of the cognitive rehabilitation complex exercise program, Wilcoxon signed-rank test, a non-parametric analysis methodwas used. In addition, the reliability test for each measurement variable was analyzed using Cronbach's α, and all statistical significance levels were set to $p<0.05$.

Results

General Characteristic of Subject

Among 12 chronic stroke patients with MCI, there were more males by gender, with 5 females and 7 males. The mean age was 63.00±11.00 years. There were 2 individuals with no disability grade, 1 individual with grade 1, 4 individuals with grade 2, 3 individuals with grade 3, 1 individual with grade 5, and 1 individual with grade 6. The type of disability was physical disability in 3 patients and brain lesions in 9 patients. Education level was 6 elementary school graduates, 3 middle school graduates, 1 high school graduate, and 2 college graduates or higher. Complications were hypertension (9 individuals), diabetes (6 individuals), and cardiovascular disease (8 individuals). For daily living ability, 8 people can walk outdoors, 2 people can sit, and 2 people can use a bed or wheelchair. Depression was not depressed 7 people, and slightly anxious or depressed 5 people. There were 10 people who usually exercised physically and 2 people who did not. In this study, Inbody (Inbody370, Biospace, Korea) was used to investigate the general characteristics of subjects in detail. The general characteristics of the study subjects are as follows (Table 2).

Comparison of Measured Variables within Groups

There were significant differences in spatiotemporal execution ability, attention, and sentence power in each of the MoCA-K items, and overall, the MoCA-K total score ($Z=-2.628$, $P=0.009$) also showed a significant difference. There was also a statistically significant difference in depression ($Z=-2.041$, $P=0.041$). In the case of sleep, there was a significant difference in the factors disturbing sleep, but the overall PSQI score ($Z=-0.702$, $p=0.483$) increased numerically, but there was no significant difference (Table 3).

Discussion

Since MCI, unlike dementia, retains insight and learning functions, prevention and intervention for cognitive improvement are very important before progressing to dementia[6]. Therefore, in this study, the cognitive rehabilitation program was applied to stroke patients with MCI, and the effect on cognitive function, depression, and sleep was investigated. The purpose of this study was to improve cognitive function by applying an integrated cognitive rehabilitation program suitable to the subject's level for stroke patients with MCI, who had learning function before their cognitive function became irreversible. Furthermore, considering that there is a limit to the concentration of the subject, the program time was composed of 60 minutes by adding the Brill Exercise method that induces physical activity.

The MMSE-K is more common as an evaluation

Table 2. General Characteristics of Participants

Characteristics	Minimum value	Maximum value	Mean±SD
Age (years)	40.00	79.00	63.00±11.00
Body moisture(kg)	22.40	37.10	30.68±5.11
Protein(kg)	5.90	10.00	8.09±1.36
Minerals(kg)	2.10	3.50	2.88±0.44
Body fat(kg)	9.80	30.20	20.07±6.23
Muscle mass(kg)	28.60	47.70	39.26±6.59
Total weight without fat(kg)	30.40	50.60	41.67±6.90
Weight(kg)	42.10	80.80	61.73±10.64
Skeletal muscle(kg)	15.90	27.90	22.38±4.13
BMI(kg/m^2)	16.80	29.50	24.11±3.73
Body fat percentage(%)	19.50	45.30	32.12±6.83

SD: Standard Deviation

Table 3. Comparison of Measured Variable Results within Groups

		Pre (Mean±SD)	Post (Mean±SD)	Diff (Mean±SD)	Z	*p*
MoCA-K	Temporal/spatial	3.25±1.29	4.17±1.47	−0.92±1.20	−2.209	0.027*
	Vocabulary	2.42±0.67	2.58±0.67	−0.17±0.58	−1.000	0.317
	Attention	3.92±1.62	4.67±1.61	−0.75±1.06	−2.041	0.041*
	Sentence	1.58±1.00	2.42±0.67	−0.84±0.94	−2.271	0.023*
	Abstract	1.42±0.79	1.50±0.67	−0.08±0.67	−0.447	0.655
	Delayed recall	2.33±1.44	2.00±1.91	0.33±1.44	−0.741	0.458
	Orientation	5.00±1.13	5.42±1.24	−0.42±0.79	−1.667	0.096
	Total	20.00±4.53	23.25±4.43	−3.25±3.05	−2.628	0.009*
K-HDRS	Total	10.33±6.43	5.92±6.97	4.42±7.14	−2.041	0.041*
PSQI	Subjective quality of sleep	1.00±0.85	0.42±0.67	0.58±1.08	−1.588	0.112
	Sleep latency	1.33±1.07	1.33±0.65	0.00±0.74	0.000	1.000
	Sleep period	0.58±0.79	1.08±1.00	−0.50±1.00	−0.957	0.339
	Habitual sleep effect	0.08±0.29	0.00±0.00	0.08±0.29	−1.000	0.317
	Sleep disturbance	1.42±0.52	1.00±0.74	0.41±0.52	−2.236	0.025*
	Sleep drug use	0.58±1.17	0.25±0.87	0.33±1.37	−1.089	0.276
	Daytime dysfunction	0.67±0.49	0.67±0.99	0.00±0.95	0.000	1.000
	Total	5.67±3.8	4.75±2.49	0.91±3.48	−0.702	0.483

*$p < 0.05$, SD: Standard Deviation

MoCA-K: Korean version of Montreal Cognitive Assessment, K-HDRS: Korean version of Hamilton depression rating scale, PSQI: Pittsburgh sleep quality index

paper for cognitive function. However, because of examining previous studies, the reliability of MoCA-K was 0.736 and that of MMSE-K was 0.672, indicating that MoCA-K had higher reliability. Therefore, in this study, MoCA-K was judged to be more suitable than MMSE-K[3]. As a result of this study, the subjects who participated in the cognitive rehabilitation program improved their cognitive function scores by more than 3 points after the intervention, from 20.00±4.53 points to 23.25±4.43 points. The score was 1.98, which was similar to the result reported that it improved to 5.18±1.40 points[42]. Another previous study showed similar results to this study, from 15.20±4.83 points to 18.00±5.67 points[5]. Therefore, when the MoCA-K score of 23 or higher was considered normal, the cognitive scores of the subjects of this study increased statistically after the intervention, so it is considered that the application of the program of this study has a positive effect.

In a study on the effect of group occupational therapy programs to improve cognitive function of patients with mild dementia, the cognitive function of patients with mild dementia increased statistically significantly after the implementation of the group occupational therapy program compared to before implementation. It was effective in motor coordination ability, thinking organization ability, and attention concentration[52, 53]. Similar to previous studies, the results of this study showed particularly significant differences in spatiotemporal execution ability, attention, and sentence power[52, 53]. However, among the cognitive function domains, the results of the remaining domains except for delayed recall showed an increase, but there was no significant difference. The reason is thought to be that it could not show much difference from the posterior value due to the high prior value.

On the other hand, the composition of various programs aroused the interest of the subjects, and

various programs were tried to increase delayed recall, but as a result, they did not have a positive effect. It is reported that as many as 60% of patients over the age of 60 complain of memory problems themselves [54, 55]. This is thought to be related to the general characteristics of the study subjects, whose average age was 63, and the level of education, 50% of which were elementary school graduates. Therefore, it is considered necessary to develop a program that can develop delayed recall in the future.

It was reported that stroke patients were overall more depressed in all aspects of depression than the normal elderly group[56, 57]. Cognitive function and depressive symptoms are closely related and known to interact with each other.

In other words, there are many aspects of therapeutic intervention that are shared, and a single treatment may achieve a common effect in both aspects[57]. Therefore, in this study, both areas of cognitive function and depression were evaluated. As a result, in the depression domain, the scores of the subjects participating in the cognitive rehabilitation program showed a significant decrease from 10.33 points to 5.92 points. Since the subjects of this study generally complained of depression, it was judged that the intervention of depression was more urgent to reduce cognitive decline[42, 53]. The decrease in the subjects' depression score was similar to previous studies that combined music and exercise, which are emotional activities that can induce interest through cognitive rehabilitation programs, so it is thought that close relationships between subjects were formed and had a positive effect on depression[44, 53, 58-60].

When applying for the laughter therapy program, there was a statistically significant decrease from 6.98 points to 6.04 points in the sleeping area[61], but the results of this study showed a significant difference from 1.42 points in the sleep disturbance area alone to 1.00 points afterward. The average sleep score of the subjects who participated in the program showed a slight decrease from 5.67 to 4.75, but there was no significant difference.This is thought to be because the program was constructed regarding previous studies related to sleep, but various interventions for the sleeping area were insufficient, and in the case of participants, there were limitations such as having to change the lifestyle they maintained for a long time[30, 47, 62]. However, since the results of this study showed an effect in the sleep disturbance area, it is suggested to conduct an expanded study including variables that affect sleep in a future study.

Despite these results, this study has several limitations. First, the experiment was conducted on only 12 people at one health institution, and there is a limit to generalizing to stroke patients with all MCIs because the sample size for the study was not satisfied. Second, because there was no control group due to the single-group pre-post design, internal and external validity are lacking. This problem is considered to require a continuous test study with a larger sample size in the future and should be addressed by a randomized study design with a control group. Third, the possibility of intervening in third variables such as education and economic level, age, and the presence or absence of a spouse that could affect the research results of the subjects during the cognitive rehabilitation program could not be excluded. Fourth, since the level of cognitive function may be different depending on the time of diagnosis of MCI, it is necessary to verify the application effect by adjusting and configuring the type and difficulty of cognitive tasks for each subject when configuring the program. Lastly, due to the nature of the study, it was measured only at the end of the 16-week cognitive rehabilitation program without an interim evaluation, so continuous follow-up would be necessary.

Conclusion

The cognitive rehabilitation complex exercise program applied in this study is expected to be usefully utilized as a rehabilitation program to improve cognitive function and depression in the local community and clinical practice. Furthermore, this study can provide basic data to improve the cognitive and emotional complex health problems of chronic stroke patients. It is thought that it can contribute to the development of cognitive rehabilitation programs in the future by suggesting the need for research to develop various cognitive rehabilitation programs for chronic stroke patients.

Conflict of Interest

The authors declared no potential conflicts of interest concerning the research, authorship, and/or publication of this article.

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