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Effectiveness of Virtual Reality Based Cognitive Rehabilitation on Cognitive Function, Motivation and Depression in Stroke Patients

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Abstract

Background/Objectives: The aim of this study was to investigate the effects of virtual reality cognitive training on cognitive function, rehabilitation motivation, and depression in patients with sub-acute stroke.

Method/Statistical Analysis: Total 22 patients with sub-acute stroke were included in our study. All stroke patients were classified either into experimental group (n = 11) or control group (n = 11). The experimental group performed virtual reality cognitive training on each session during 30 min/day, and control group conducted conventional cognitive therapy on each session during 30 min/day. The outcome measures were the LOTCA (Lowenstein Occupational Therapy Cognitive Assessment), VQ (Volitional questionnaire), BDI (Beck Depression Inventory) before and after intervention.

Findings: The both groups showed significant improvements in cognitive function before and after intervention ($p<.05$). The experimental group showed significant reduction in depression before and after the intervention ($p<.05$), but there was no significant change in the control group ($p>.05$). In comparisons for change score between the two groups, the experimental group showed a significant greater improvements in cognitive function and rehabilitation motivation than control group ($p<.05$).

Improvements/Applications: These findings suggest that virtual reality cognitive training may have a effects of the improvements of cognitive function and rehabilitation motivation than conventional cognitive therapy in sub-acute stroke.

Keywords: *Virtual Reality, Stroke, Cognitive function, Rehabilitation Motivation, Depression.*

Introduction

Stroke reduces the efficiency of synaptic connections in the brain's nervous system due to damage in the brain's blood vessels[1]. Cognitive impairment was reported to be between 12-56%[2], and the slower the recovery in cognitive function, the slower the patient's depression, the lower the motivation, and the lower the quality of life not only for the patient but for the family[3].

Cognition as meaning encompassing attention, memory, problem-solving skills, judgment, and high-dimensional thinking has been found to be a major factor in predicting an independent daily life ability, related to depression levels or recidivism in stroke[4]. Thus, various rehabilitation approaches for physical and functional recovery of people with post-stroke cognitive decline are essential[5-6].

The therapeutic approach of cognitive rehabilitation can be divided into traditional cognitive rehabilitation and computerized cognitive rehabilitation[7]. Computerized

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cognitive rehabilitation is applied by strengthening memory, attention, etc. by performing games or tasks in the software using digital programs[8-9].

The advantages of computerized cognitive rehabilitation over traditional cognitive rehabilitation are objectively measuring the amount of cognitive training or the degree of improvement of cognitive function, providing immediate feedback to patients, interesting and easy to adjust difficulty to patient level[10].

Virtual reality is defined as a human-computer interface in which users interact with the environment in real time within a computer-generated virtual environment. The term was first mentioned by Jarson Lanier in 1989 and has since been developed globally[11]. While most studies of the effects of virtual reality cognitive training have been reported on stroke patients with unilateral spatial neglect, it is not well known how it affects cognitive functions, rehabilitation motivation and depression[12-18].

Therefore, this study wanted to know the effects of virtual reality cognitive training on cognitive function, rehabilitation motivation, and depression in patients with subacute stroke.

Method

This study was conducted on 22 patients with sub-acute stroke who were admitted to a rehabilitation hospital. The inclusion criteria were: (1) those diagnosed with stroke by a doctor, (2) those who had one month or more of a stroke, those who were less than six months old, and (3) Korean Mini-Mental Status Examination (K-MMSE) scores of 18 or 23 points, those who were able to perform according to their instructions, and (4) those whose medical conditions were stable. The criteria for exclusion were: (1) persons with severe unilateral spatial neglect, (2) persons unable to maintain independent seating, (3) persons with speech and hearing impairments, and (4) persons with illiteracy. All subjects voluntarily agreed to participate in the study after hearing a full explanation of the research involved. And after written consent, research was conducted.

Lowenstein Occupational Therapy Cognitive Assessment (LOTCA) was used to measure cognitive function. The inter-inspection reliability of this assessment was reported as 0.82 to 0.97[20]. The Voluntary Questionnaire (VQ) was used to quantify the rehabilitation motivation of stroke patients. The confidence between the examiners in the will questionnaires is between .75 and .90, the intrinsic value of the 14 items[21]. Beck Depression Inventory (BDI) was used to quantify the level of depression[22]. The classification of the level of depression based on the score is 0 to 9 without depression, 10 to 15 without depression, 16 to 23 with serious depression, and 24 to 63 with severe depression. Cronbach's alpha the examiners in BDI is.942[23].

All subjects were assigned to experimental group (n = 11) or control group (n = 11). The two militaries received usual occupational therapy for 30 minutes a day, five times a week and four weeks. The experimental group received 30 minutes more per session of virtual reality cognitive training, while the control group received 30 minutes of conventional cognitive therapy. The control group received traditional cognitive therapy. Traditional cognitive therapy was determined based on previous studies, where activities through pencils and paper were conducted in the occupational therapy room[24-26].

The experimental group mediated the virtual reality programs using software from the cognitive rehabilitation training system (Moto Cog, Cybermedic, Korea). The system is a program developed to improve the cognitive function of patients who need rehabilitation. The cognitive rehabilitation training system consists of basic training, a game course, a mission course, and a cognitive training program. To carry out a cognitive training program, the game course and a cognitive training program were introduced for intervention. The subjects of the experiment were trained, defining the composition of the intervention time for each half-hour session as 10 minutes for the game course and 20 minutes for the cognitive training program.

All the data collected were analyzed as SPSS 21. The statistical significance level of the study was set to .05. The general characteristics of the subject were identified by frequency analysis. The comparison of general characteristics, cognitive function, reproducibility, and depression in the two groups was analyzed with either the Mann Whitney U test or the Chi-Square test, and the change before and after intervention was confirmed by the Wilcoxon-signed rank Test.

Result and Discussion

1. **General Characteristics:** There was no significant difference in the general characteristics of the

subject between the two groups (p>.05) [Table 1]. There was no significant difference in the cognitive function, rehabilitation motivation, and in depression between the two group before intervention (p>.05) [Table 2].

2. **Changes of cognitive function, rehabilitation motivation, and depression within groups before and after intervention:** The total score of LOTCA before and after intervention in the experimental group, except for motor praxis, showed significant improvement in the orientation, visual perception, spatial perception, visuo-motor organization, and thinking operation among the sub-items (p<.05), indicating significant positive changes in rehabilitation motivation and depression (p<.05). The total score of LOTCA before and after intervention in the control group, except for motor praxis, showed significant improvement in orientation, visual perception, spatial perception, visuo-motor organization, and thinking operation among the sub-items (p<.05), indicating a significant improvement in the rehabilitation motivation (p<.05) [Table 3].
3. **Comparison of cognitive function, rehabilitation motivation, and depression between two groups after intervention:** Comparing the changes before and after the intervention of the two groups, the experimental group had significantly greater improvements in the LOTCA than in the control group, the visual perception, spatial perception, visuo-motor organization and rehabilitation motivation (p<.05) [Table 4].
4. **Relationship between rehabilitation motivation and depression in subjects:** Before intervention, the correlation between the rehabilitation motivation of 22 subjects and the depression was significant (r = -.521, p<.05) [Table 5].

Table 1. General characteristics

	Experimental Group (n = 11)	Control Group (n = 11)	p
Age (Year), Mean±Sd	58.18±8.22	59.09±11.65	.835
Gender			
Male	6	7	.665
Female	5	4	
Injury type			
Ischemic	7	7	1.000
Hemorrhagic	4	4	
Affected side			
Right	7	6	.665
Left	4	5	
Lesion location			
Cortical	5	5	.842
Subcortical	2	3	
Mixed	4	3	
Education level			
Middle school	2	1	.809
High school	5	6	
College	4	4	
Onset duration (days), mean±SD	78.36±20.93	75.00±38.34	.554
K-MMSE, mean±SD	21.18±1.66	21.45±1.75	.613

Footnotes. K-MMSE = Korean Mini-Mental State Examination.

Table 2. Comparison of cognitive function, rehabilitation motivation, and depression between two groups before intervention

		Experimental Group (n=11)	Control Group (n=11)	p
		Mean±SD	Mean±SD	
LOTCA	Total	76.73±4.29	76.36±5.20	.553
	OR	11.09±1.04	11.18±1.83	.919
	VP	9.91±1.87	10.18±1.47	.763
	SP	8.73±1.27	8.45±1.57	.893
	MP	11.55±0.69	11.82±0.60	.418
	VO	16.36±2.98	16.09±2.34	.763
	TO	19.09±1.58	18.64±2.46	.690
VQ		33.64±7.47	33.00±7.14	.717
K-BDI		11.27±3.80	11.09±3.53	.869

Footnotes. LOTCA = Lowenstein Occupational Therapy Cognitive Assessment; OR = Orientation; VP = Visual Perception; SP = Spatial Perception; MP = Motor Praxis; VO = Visuomotor Organization; TO = Thinking Operation; VQ = Volitional questionnaire; K-BDI = Korean Beck Depression Inventory.

Table 3. Changes of cognitive function, rehabilitation motivation, and depression within groups before and after intervention

		Experimental Group (n = 11)		p	Control Group (n = 11)		p
		Before	After		Before	After	
		Mean±SD	Mean±SD		Mean±SD	Mean±SD	
LOTCA	Total score	76.73±4.29	86.82±2.82	.003**	76.36±5.20	82.55±4.59	.003**
	OR	11.09±1.04	12.00±0.77	.015*	11.18±1.83	12.73±1.42	.007**
	VP	9.91±1.87	12.45±1.13	.003**	10.18±1.47	11.27±1.10	.010*
	SP	8.73±1.27	10.82±1.47	.003**	8.45±1.57	9.45±1.63	.005**
	MP	11.55±0.69	12.00±0.00	.059	11.73±0.47	12.00±0.00	.083
	VO	16.36±2.98	19.36±2.34	.003**	16.09±2.34	17.45±1.75	.007**
	TO	19.09±1.58	20.18±1.94	.008**	18.64±2.46	19.55±2.46	.021**
VQ		33.64±7.47	37.36±6.56	.003**	33.00±7.14	34.91±7.54	.004**
K-BDI		11.27±3.80	9.64±3.04	.011*	11.09±3.53	9.91±2.51	0.121

Footnotes. *p<0.05, **p<0.01, LOTCA = Lowenstein Occupational Therapy Cognitive Assessment; OR = Orientation; VP = Visual Perception; SP = Spatial Perception; MP = Motor Praxis; VO = Visuomotor Organization; TO = Thinking Operation; VQ = Volitional questionnaire; K-BDI = Korean Beck Depression Inventory.

Table 4. Comparison of cognitive function, rehabilitation motivation, and depression between two groups after intervention

		Experimental group (n = 11)	Control group (n = 11)	p
		Change values	Change values	
		Mean±SD	Mean±SD	
LOTCA	Total	10.09±3.27	6.18±2.93	.012*
	OR	0.91±0.83	1.55±1.04	.140
	VP	2.55±1.21	1.09±0.83	.006**
	SP	2.09±0.70	1.00±0.63	.002**
	MP	0.45±0.69	0.27±0.47	.573
	VO	3.00±1.26	1.36±1.03	.006**
	TO	1.09±1.04	0.91±1.04	.857
VQ		3.73±2.45	1.91±1.45	.045*
K-BDI		-1.64±1.57	-1.18±2.23	.284

Footnotes. *p<0.05, **p<0.01, LOTCA = Lowenstein Occupational Therapy Cognitive Assessment; OR = Orientation; VP = Visual Perception; SP = Spatial Perception; MP = Motor Praxis; VO = Visuomotor Organization; TO = Thinking Operation; VQ = Volitional questionnaire; K-BDI = Korean Beck Depression Inventory.

Table 5. Relationship between rehabilitation motivation and depression in subjects

	Volitional Questionnaire	
Korean Beck Depression Inventory	r	-.521
	p	.013*

Footnotes. *p<0.05

Discussion

Results of table 2 were similar to those of Kim et al.[19], who reported improvements in cognitive function in both groups, which conducted virtual reality training and occupational therapy (cognitive training) in acute stroke patients. Kim[18] had significant improvement in cognitive function through intervention three times a week and twice a day for chronic stroke patients, but the control group that received conventional rehabilitation did not show significant improvement.

While the experimental group showed a significant decrease in depression before and after intervention, the control group showed a decrease in the BDI score. First of all, in comparing the variation between the two groups, rehabilitation motivation is concerned with the significantly greater improvement in the experimental group than in the control group. The pre-intervention values indicate a relationship between the motivation and the depression, so authors think virtual reality training has had a positive effect on reducing depression. In studies such as Kim et al.[28], the reproducibility of stroke patients also shows a significant association between depression and quality of life, supporting the results of this study.

The experimental group showed significantly greater improvement in cognitive function than the control group. Subtitles showing greater change were visual perception, spatial perception, and visuo-motor organization. The improvement in this area of cognitive function is a virtual reality-based repetitive cognitive training that combines the effects of eye-hand coordination, attention, categorization ability, memory, recognition, calculation ability, visual perception, and language applied for 20 minutes at each session, and the effects of eye-hand coordination required to perform a specific task that has been performed for 10 minutes per session.

Brain damage causes the efficient fall into the neural circuitry between cerebral cortex, brain stem, and cranial nerve, resulting in a decrease in automatic eye-hand coordination function, which is thought to indicate meaningful improvement in visual and spatial perception through virtual reality cognitive training[27].

The limitations of this study are as follows. First, sample size was small. Second, the intervention period was relatively short at one month, and did not measure how long the effect of virtual reality cognitive training would last.

Conclusion

These results suggest that virtual reality cognitive training is more positive for the cognitive function and rehabilitation motivation of sub-acute stroke patients than conventional cognitive therapy. In future studies, limitations such as small sample size and missing follow-up are thought to be supplemented to require randomized controlled study.

Ethical Clearance: Not required

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Conflict of Interest: Nil

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