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Correlation of Cognitive Function, Activities of Daily Living and Driving Performance in Stroke Hemiplegic Patients

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Abstract

Purpose : This study aims to evaluate the correlation of cognitive function, activities of daily living (ADL), and driving performance in stroke hemiplegic patients residing in Korea.

Methods : Subjects of the study were 18 stroke hemiplegic patients admitted to hospitals situated in Seoul. A clock drawing test (CDT), a modified Barthel index (MBI), and a virtual reality driving simulator (Eca faros-driving simulator) were used to examine their cognitive function, their ADL ability, and their driving skills, respectively.

Results : Driving skills of stroke hemiplegic patients were shown to be associated with the CDT evaluation tool ($r=-.777$) ($p<.001$), but they were found to have any correlation with MBI ($r=-.022$) ($p>.05$). Additionally, an individual's CDT showed that the driving simulator evaluation result (pass/fail) could be discriminated with a sensitivity of 100.0 %, a specificity of 40.0 %, and an accuracy of 66.7 %. The result confirmed that the CDT is a useful evaluation tool for screening driving ability in people with stroke. But the MBI did not show any significant results (sensitivity of 62.5 %, specificity of 40.0 %, and predicted the results of the simulator with 50.0 % of accuracy) ($p>.05$).

Conclusion : This study shows that cognitive function influences the driving performance in people with stroke. Driving skills of stroke hemiplegic patients are seen to be highly related to CDT. In the field of driving rehabilitation, these findings could be useful for evaluating driving skills relating to CDT. Furthermore, the study results will set a guideline for domestic occupational therapists to use the evaluation tool for assessing driving abilities in people with stroke.

Key Words : activities of daily living, cognitive function, driving performance, stroke

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Ⅰ. Introduction

Driving is a complicated high-level performance that requires motor control abilities including muscular strength, coordination, range of motion, and cognitive abilities including attention and judgment (Anstey et al., 2005). Additionally, driving is an important activity that enhances independent move, social interaction, and integration in the local community and improves people's satisfaction by helping out the occupational activity, shopping, and social participation in their daily activities (Johnston et al., 2005; Lane & Benoit, 2011).

In the case of patients with central nervous system disorders like stroke, their diseases influence driving performance abilities including motor control, cognition, and perception that causes driving cessation (Akinwuntan et al., 2002; Marshall et al., 2007). Driving performance of stroke patients requires cognitive abilities, such as attention, reaction time, visual attention, thinking ability, and environmental perception during driving. Particularly, their cognitive abilities are one of the most important factors to draw their driving performance behavior (Akinwuntan et al., 2012). Due to disorders of cognitive abilities, stroke patients can experience driving cessation (Marshall et al., 2007).

The damage of cognitive functions is a disability that most stroke patients have, and about 25 % of patients who have had a stroke for over 3 months show a serious level. Partial damage to cognitive functions appears on 50~75 % of patients (Desmond et al., 2000). The damage cognitive function is one of the factors that increase the ratio of traffic accident risk and has a bad influence on driving (Rizzo et al., 2001). More so, overall driving performance ability is evaluated using activities of daily living (ADL) and instrumental activities of daily living scales, which can judge whether people are eligible to drive through comprehensive driving evaluation (Dickerson et al., 2014).

Stroke patients' cognitive function relating to driving ability can be analyzed with a clock drawing test (CDT), which is known to evaluate a patient's driving performance in the way of checking his or her space perception ability and he mineglect during their driving (Manning et al., 2014). Freund (2005) reported that the CDT based scale is a reliable and useful evaluation tool to identify subjects who need the evaluation for driving rehabilitation. Furthermore, Shulman (2000) reported that CDT is needed for driving rehabilitation because it presents cognitive factors appropriately in the course of evaluating clock drawing.

MBI used in evaluating ADL is a useful tool to evaluate a stroke patient's basic activity level (Shah et al., 1989). The MBI provides a therapist with information on a stroke patient's general functions, thus, it's an appropriate evaluation tool to determine a suitable moment for the patient's driving rehabilitation despite that it's not a tool to measure a particular driving skill (Akinwuntan et al., 2006). According to Park's research (2017), the MBI score is a useful evaluation tool to predict a recommended time of driving rehabilitation for stroke patients.

As such, evaluating cognitive abilities including visual perception and ADL for driving performance is very important in predicting and determining whether a stroke patient can drive. Nevertheless, there is not much research on the analysis of correlations between cognitive functions, ADL, and driving performance with the use of MBI and CDT. Therefore, this study tries to analyze the correlations between stroke patients' cognitive abilities, ADL, and driving performance.

Ⅱ. Methods

1. Subjects

Subjects of the study were patients admitted to the rehabilitation hospital B and hospital J, both situated in Seoul, Korea, which gave their consent to participate fully in the study. This study was deliberated and approved by the institutional review board of Soonchunhyang University

(SCH-IRB), and the criteria for inclusion in the trial and general features of subjects are as follows (Table 1).

1) A patient diagnosed with a stroke by a neurologist or a physiatrist
2) A patient that experienced a stroke at least 6 months ago
3) A patient with driving experience of 1 year or longer
4) A patient with a mini-mental status examination-Korea (MMSE-K) score of 20 or above and understood the trial and was capable of executing the trial

Table 1. General demographic characteristics of participants (n=18)

Characteristics		Subjects (n)	Percent (%)
Gender	Male	14	77.7
	Female	4	22.2
Age (year)	40~49	6	33.3
	50~59	8	44.4
	≥60	4	22.3
Diagnosis	Left hemiplegia	11	61.1
	Right hemiplegia	7	38.9
MMSE-K	≥24	13	72.2
	20~23	5	27.8
MBI	≥91	4	22.2
	75~90	8	44.4
	50~74	6	33.4

MMSE-K; mini mental status examination-Korea, MBI; modified barthel index

2. Procedures

One examiner had a 1:1 interview. Before the interview, the researcher practiced several times to fully understand the procedure and to have an effective interview. The researcher fully explained the purpose and method of the study to the subjects and thus, obtained their consent. The researcher conducted the CDT and MBI to evaluate the subject's cognitive function and ADL ability. The subjects who completed all the tests took the Eca faros-driving simulator test for evaluating its driving performance.

3. Instrumentation

1) Clock drawing test

A CDT is a tool for evaluating the cognitive function (Shulman, 2000). In this study, the production task-based clock drawing method, developed by Yim (2010) was used. The subject was instructed verbally by the evaluator not to show the model of the watch and asked to draw an analog watch under one condition. Free drawing conditions were used for the CDT and the 15-point rating method suggested by Freedman et al. (1994) was used for the rating system. Inter-tester reliability (ICC = 2.1) of CDT showed .75 ($p<.01$) and the correlation coefficient between the MMSE-K and the CDT showed $r = .77$ ($p<.01$) (Lee et al., 2011).

2) Modified Barthel index

MBI is a tool for evaluating the degree of independence

of patients with stroke and was developed by Shah (1989). It consists of 10 kinds of specific daily activities, each of which gives five levels of scores, with a total of 100 points. The level of dependence based on the sum of the MBI scores is 0~24 points for total dependence, 25~49 points for severe dependence, 50~74 points for mild dependence, and 91~99 points for minimal dependence. Inter-rater reliability was showed .90~.98 (Jung et al., 2007).

3) Eca faros-driving stimulator

The virtual reality driving simulator used in this study is the ultra-car system developed by Eca faros-driving simulator (Fig 1). In this study, items of the driving simulator program were reconstructed based on the test items and scorecard of the actual road driving test of Korea to raise its validity. The test items of the road driving test presented in Appendix 26 of the Enforcement Rules of the Road Traffic Act include 12 scoring items (check before departure, driver's posture, start, acceleration and speed maintenance, braking, steering, car body sensing, transit discrimination, course change, driving straight and left, right turn, parking, etc.). In this study, the intermediate course (practice driving and evaluation) was selected from the driving simulator programs that can evaluate 12 evaluation items. The scoring was made with 12 items including the check before departure, driver's posture, start, acceleration and speed maintenance, braking, steering, car body sensing, transit discrimination, course change, driving straight and left, right turn, parking, and others, based on 100 points, and when the score is 70 or above, it was considered to be pass and fail for any less.

Fig 1. Eca faros-driving simulator

4. Statistical analysis

The results were analyzed using the windows SPSS 24.0 statistical program. To verify statistical significance, the significance level was set to .05. Descriptive statistical analysis was used to present the general information of the subjects, and Spearman's correlation analysis was used to examine how the relationship between the subjects' cognitive function, ADL ability, and driving performance would affect their driving performance. Additionally, to see if the cognitive function and ADL ability could be used to assess driving performance, Wilks's Lambda test was conducted.

Ⅲ. Results

1. Correlation between cognitive function, ADL ability and driving performance

The correlation between the measured cognitive function, ADL ability of the subjects, and their driving performance, CDT was -.777 ($p<.01$), and MBI was −.022 (Table 2).

Table 2. Correlation between cognitive function, ADL ability and driving performance (n=18)

	CDT	MBI	DS (P&F)
CDT	1		
MBI	.071	1	
DS (P&F)	-.777*	-.022	1

*p<.01, CDT; clock drawing test, MBI; modified Barthel index, DS (P&F); driving simulator (pass & fail)

2. Discriminant analysis of cognitive function, ADL and driving Performance

Wilks's Lambda test was performed on stroke patients for the discriminant analysis of cognitive function, ADL ability, and driving performance. The cognitive function showed that the sensitivity (100.0 %) and specificity (40.0 %) for the CDT were found to be significant, but the ADL ability showed that the sensitivity (62.5 %) and specificity (40.0 %) for the MBI were not found to be significant (Table 3).

Table 3. Discriminant analysis of cognitive function, ADL and driving performance (n=18)

		Driving simulator result			
		Pass (n=8)	Fail (n=10)	*p*	Acuracy (%)
CDT	Pass (n=8)	8 (100.0)	0 (0)	.028	66.7
	Fail (n=10)	6 (60.0)	4 (40.0)		
MBI	Pass (n=8)	5 (62.5)	3 (37.5)	.865	50.0
	Fail (n=10)	6 (60.0)	4 (40.0)		

CDT; clock drawing test, MBI; modified Barthel index

Ⅳ. Discussion

This study examined and evaluated the relationship between cognitive function, ADL ability, and driving performance of stroke patients.

First, as for the correlation between cognitive function and driving performance, CDT was -.777 ($p<.01$) and statistically significant, but the correlation was not found in MBI (-.022, p=932). Such results were consistent with the evaluation tools shown to have the highest correlations in the previous studies on the prediction of driving performance (Manning et al., 2014). These results indicated that cognitive function is an important factor in driving performance, and it is also an evaluation tool that can be used to predict the driving performance of stroke patients.

The fact that MBI did not show a significant result, may indicate that the participants of this study have low MBI scores, and especially, those with 50~74 MBI scores seem to have an influence on statistical significance. In the research that analyzed the driving performance ability of stroke patients in Korea using a driving simulator and MBI, the cut-off MBI score was over 86.5 in the driving simulator (Park, 2017). Regarding the MBI scores of the participants of this study, the number of those with over 86.5 was 5, and the number of those with under 86.5 was 13. Those who passed the driving simulator evaluation were four participants who have over 86.5 MBI scores. This is a similar result to previous studies. To compensate this, it seemed necessary to analyze additionally based on MBI cut-off score 86.5.

In the analysis of the results of cognitive function evaluation tools and results of the driving simulator test (pass/fail) to discriminate between and examine CDT and driving performance, the result was found to be significant except for MBI. As per the CDT, it was seen to have a sensitivity of 100.0 %, a specificity of 40.0 %, and an accuracy of 67.7 %, and this supports the study of Freund et al. (2005). The CDT was verified effective as a driving performance evaluation through previous overseas studies, but there is no study on domestic stroke patients using the CDT. Additionally, the previous studies on the elderly's driving performance ability with the use of the CDT mostly analyzed the correlation between the frequency of annual traffic accidents and the fr

equency of traffic violations, but there were not enough studies on the driving simulator (Diegelman et al., 2004; Freund et al., 2005). Therefore, this study is important because it verifies the clinical usefulness of the CDT by confirming that CDT is a suitable tool in evaluating domestic stroke patients' driving performance ability. Also, the CDT is a useful tool to determine the driving performance of stroke patients. The CDT could be used to screen people not suitable for actual road driving while evaluating their driving performance for the field of driving rehabilitation.

This study has some limitations. The number of participants is small, and the analysis of stroke is not done on each part of the body, so it is difficult to generalize the result. If the evaluation tool was a visual perception tool such as DTVP-A, the visual perception ability like hemineglect could be researched more accurately. This study confirmed the importance of cognitive function on driving performance of stroke patients and also found that the CDT, cognitive function evaluation tool, were useful in the prediction of driving performance. Finally, the results of this study are useful in deducing the possibility of actual road driving of stroke patients willing to resume their driving privileges.

Ⅴ. Conclusion

This study aimed at evaluating the correlation between cognitive function, ADL ability, and driving performance in stroke patients. The conclusions as per this study are as follows. First, the driving skills of stroke hemiplegic patients were shown to be associated with the CDT evaluation tool. Second, the driving skills of stroke hemiplegic patients were found to be highly related to CDT. Since the results of the cognitive function evaluation tool were shown to be significant in evaluating the driving performance of stroke patients, cognitive function has proven to be highly related to driving performance. Also, it was shown that cognitive function was highly correlated to the CDT, in turn, making it a suitable tool for evaluating a patient's driving performance. Finally, this study can confirm the cognitive elements needed for driving in the situation that stroke patients' driving rehabilitation is considered important, and is expected to become a useful resource for various driving evaluations and driving rehabilitation relating to cognitive functions.

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