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Original Article

Clinical usefulness of the clock drawing test applying rasch analysis in predicting of cognitive impairment

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Abstract.   [Purpose] This study examined the clinical usefulness of the clock drawing test applying Rasch analysis for predicting the level of cognitive impairment. [Subjects and Methods] A total of 187 stroke patients with cognitive impairment were enrolled in this study. The 187 patients were evaluated by the clock drawing test developed through Rasch analysis along with the mini-mental state examination of cognitive evaluation tool. An analysis of the variance was performed to examine the significance of the mini-mental state examination and the clock drawing test according to the general characteristics of the subjects. Receiver operating characteristic analysis was performed to determine the cutoff point for cognitive impairment and to calculate the sensitivity and specificity values. [Results] The results of comparison of the clock drawing test with the mini-mental state showed significant differences in according to gender, age, education, and affected side. A total CDT of 10.5, which was selected as the cutoff point to identify cognitive impairment, showed a sensitivity, specificity, Youden index, positive predictive, and negative predicive values of 86.4%, 91.5%, 0.8, 95%, and 88.2%. [Conclusion] The clock drawing test is believed to be useful in assessments and interventions based on its excellent ability to identify cognitive disorders.
Key words: Clock drawing test, Cognitive disorders, Screening

INTRODUCTION

Cognitive impairment caused by various diseases associated with the aging of the population has become a recent concern[1]. Neurological examinations for screening cognitive impairment have been used in many fields[2]. Although many studies have been done on patients with cognitive disorders, a clinical screening tool for specific cognitive characteristics has not been developed[3].

Stroke patients show cognitive disorders during the neurological recovery process, making early intervention through screening necessary[4]. The mini-mental state evaluation (MMSE), which is commonly used for screening cognitive impairment, has been studied in patients with dementia[5]. Simple methods of screening for stroke patients with cognitive characteristics and objective inspection tools are needed.

The clock drawing test (CDT) developed by applying Rasch analysis can screen patients with cognitive impairment in a short time. The appropriate items and rating scales for the CDT were selected according to the characteristics of cognitive problems in a previous study[6]. On the other hand, additional studies are needed to improve the clinical utility of the CDT. Therefore, the aim of this study was to confirm the clinical usefulness of the CDT by applying Rasch analysis to predict cognitive impairment.

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Table 1. Difference between the MMSE and CDT according to general characteristics of the participants (n=182)

Characteristics		N	MMSE (M ± SD)	Post hoc	CDT (M ± SD)	Post hoc
Gender	Male	117	23.2 ± 5.9	(a>b)	10.6 ± 3.8	(a>b)
	Female	65	21.5 ± 5.3		8.7 ± 4.0	
Age (years)	49 or less	23	25.0 ± 5.5	(a, b, d>e)	12.1 ± 2.9	(a, b>e)
	50–59	44	24.6 ± 3.9		11.3 ± 3.2	(a>d)
	60–69	53	21.5 ± 6.7		9.5 ± 4.3	
	70–79	45	22.6 ± 5.1		9.1 ± 3.7	
	80 or more	17	17.6 ± 5.4		6.8 ± 3.8	
Education (school)	No education	15	21.9 ± 4.1	(d, e>b)	6.4 ± 3.7	(d, e>a, b)
	Elementary	55	20.3 ± 6.2		8.7 ± 3.9	
	Middle	18	23.0 ± 3.9		9.2 ± 3.5	
	High	47	23.8 ± 5.5		11.0 ± 3.6	
	University or more	47	24.1 ± 5.9		11.5 ± 3.4	
After stroke (months)	3 or less	56	21.8 ± 5.5		9.1 ± 4.3	
	4–6	25	22.3 ± 6.0		9.6 ± 4.2	
	7–12	25	23.0 ± 5.2		10.4 ± 3.8	
	13–24	37	25.1 ± 3.4		10.9 ± 3.2	
	25 or more	39	21.3 ± 7.4		10.0 ± 3.9	
Dominant hand	Right	173	22.6 ± 5.7		9.8 ± 3.9	
	Left	4	21.5 ± 8.3		9.5 ± 5.5	
	Both	5	24.4 ± 6.0		12.2 ± 3.6	
Affected side (brain)	Right	93	23.1 ± 5.4		10.1 ± 3.9	
	Left	80	22.3 ± 6.1		10.0 ± 3.9	(a, b>c)
	Both, etc.	9	20.2 ± 7.3		6.7 ± 3.8	
Type of damage	Infarction	134	22.7 ± 5.7		9.9 ± 4.0	
	Hemorrhage	47	22.6 ± 6.1		9.9 ± 3.9	
	Other	1	16.0 ± 0.0		8.0 ± 0.0	

Item number in areas (a=1, b=2, c=3, d=4, e=5)

SUBJECTS AND METHODS

The subjects in this study were 187 stroke patients. The study participants were enrolled from patients at 10 rehabilitation hospitals in South Korea. All subjects provided written informed consent to participate in this study in accordance with the ethical standards of the Declaration of Helsinki. Participants without visual problems or a history of other neurological diseases other than stroke were included.

The MMSE is the most widely used assessment tool for the screening of cognitive abilities[7]. In this study, 187 patients were evaluated by the CDT developed through Rasch analysis along with the MMSE. The MMSE was used to screen for the cognitive dysfunction of the participations. The data were analyzed according to the general characteristics of the subjects to increase the clinical utility of the CDT. In addition, the cutoff point was classified to identify cognitive impairment in the CDT, and the sensitivity and specificity were analyzed. The CDT composed of 16 items in 6 areas could objectively evaluate the cognitive characteristics based on the task to be carried out[6].

Statistical analysis was performed using PASW Statistics, Version 18.0 (SPSS Inc., Chicago, IL, USA). Analysis of variance was performed to examine the significance of the MMSE and CDT according to the general characteristics of the subjects. Receiver operating characteristic (ROC) analysis was performed to produce a cutoff point for cognitive impairment and calculate the sensitivity and specificity values. ROC analysis was used to determine the optimal cutoff values and the cognitive dysfunction of bias in this study.

RESULTS

A comparison of the MMSE and CDT in accordance with the general characteristics of the subjects showed significant differences according to gender, age and education for both tools (Table 1). In both tools, males showed higher cognitive skills than women. In the case of age, those 70–80 years of ages showed significant differences compared with younger patients. In

Table 2. Prediction of cognitive impairment in accordance with the CDT (n=182)

CDT (total score)	MMSE (total score)		Predictive value (%)
	Cognitive impairment (<24)	Normal (≥24)	
≤10	76	4	PPV=95.0
>11	12	90	NPV=88.2
Youden index (%)	Sensitivity=86.4, specificity=95.7		

PPV: positive predictive value; NPV: negative predictive value

the case of education, patients with no education or an elementary school education showed significant differences compared with those with a high school or college education. Analysis of the duration after stroke revealed a significant difference between the tools, but there were no significant differences according to time period.

A total CDT score of 10.5, which was selected as the cutoff point to identify cognitive impairment, showed sensitivity, specificity, and Youden index values of 86.4%, 91.5%, and 0.8. In addition, the CDT showed positive and negative predictive values of 95% and 88.2%, respectively, compared with the MMSE (Table 2).

DISCUSSION

This study was performed to enhance the clinical usefulness of the CDT by applying Rasch analysis for predicting of cognitive impairment. The CDT can enable the assessment and early intervention in patients with cognitive impairment[8].

The usefulness of CDT for the screening of cognitive impairment has been reported. In particular, the CDT applying Rasch analysis is an objective and reliable assessment tool, and it enables the ability of individuals can be evaluated mathematically[9, 10]. Examination of the validiry of the CDT by comparison with the MMSE showed similar significant differences according to gender, age, and education. The CDT and MMSE reflect different cognitive characteristics, which may have affected the results. These results showed that the CDT could be a useful tool for the screening of cognitive impairment[5, 11].

Rasch analysis was applied to the CDT for tool development because it enables the ability of individuals be measured accurately by based on the item response theory. The clinical advantage of the CDT in screening for cognitive disorders was confirmed through ROC analysis[12]. The standard CDT determines that a patient may have a cognitive impairment when the patient scores have less than 10 points. The positive predicted value was 95.0%, which represents the probability of cognitive dysfunction for positive test results, and the negative predictive value was 88.2%, which represents the probability of cognitive function being normal for negative test results; these values were based on a cutoff of 10 points. The CDT is believed to be useful in assessments and interventions based on its excellent ability to identify cognitive impairment[6, 13–15].

An ideal screening evaluation tool should be simple and fast. In addition, it must not be sensitive to different environments, and the sensitivity and specificity must be high[16]. Therefore, the CDT applying Rasch analysis is a useful tool for screening high-risk patients with cognitive impairment. Nevertheless, a follow-up study of the CDT for patients with a variety of diseases will be needed.

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