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Effect of Education on Discriminability of Montreal Cognitive Assessment Compared to Mini-Mental State Examination

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Conflict of Interest
The authors have no financial conflicts of interest.

ABSTRACT

Background and Purpose: The Montreal Cognitive Assessment (MoCA) has been known as a screening test for detecting mild cognitive impairment (MCI) better than Mini-Mental State Examination (MMSE). However, in previous domestic studies, no significant difference was found in the discriminability between MoCA and MMSE. Researchers have suggested that this might be because older Koreans are less educated than older Westerners. This study was conducted to examine the effect of education on the discriminability of MoCA compared to the MMSE.
Methods: Participants were 123 cognitively normal elderly, 118 with vascular MCI, 108 with amnestic MCI, 121 with vascular dementia, and 113 with dementia of the Alzheimer's type. The Korean-MoCA (K-MoCA) and Korean-MMSE (K-MMSE) were administered. Multiple regression analyses and receiver operating characteristic (ROC) curve analyses were performed.
Results: In all participants, education significantly affected both K-MoCA and K-MMSE scores along with age. The effect of education was re-examined by subgroup analysis after dividing subjects according to the level of education. Effect of education on K-MoCA and K-MMSE was only shown in the group with <9 years of education. ROC curve analyses revealed that the discriminability of K-MoCA to differentiate between vascular MCI and normal elderly was significantly higher than that of K-MMSE. When re-examining subgroups divided by education level, however, this higher discriminability of K-MoCA disappeared in the group with <9 years of education.
Conclusions: These results indicate no difference in discriminating cognitive deficits between K-MoCA and K-MMSE in Korean elderly with <9 years of education.

Keywords: MoCA; MMSE; Discriminability; Education; MCI

INTRODUCTION

The Montreal Cognitive Assessment (MoCA)[1] was developed as a screening test for mild cognitive impairment (MCI).[2] It is one of the representative screening tests used in clinical

Author Contributions

Conceptualization: Kang Y; Formal analysis: Kim H; Data curation: Kim H, Yang S, Park J, Kang Y; Funding acquisition: Kang Y; Methodology: Kim H, Yang S, Kang Y; Project administration: Kang Y; Writing - original draft: Kim H; Writing - review & editing: Kim H, Kang Y, Kim BC, Yu KH.

settings. It includes more subtests for assessing frontal and executive function than the Mini-Mental State Examination (MMSE).[3,4] Many studies have reported that the MoCA is superior to the MMSE in detecting MCI[5-9] and vascular cognitive impairment.[10,11]

A domestic study[12] also reported that the MoCA was more useful than MMSE in discriminating between normal elderly and amnestic MCI. However, another domestic study[13] did not find a significant difference in discriminating vascular MCI from normal elderly individuals between the MoCA and MMSE. The researchers suggested that this was because the level of education of the elderly in Korea was lower than that of the elderly who participated in foreign studies. In other words, since the MoCA includes difficult items that elderly individuals with low educational attainment cannot perform well, it can be predicted that if the MoCA is conducted for elderly people with low educational attainment, it will not be different from the discriminability of the MMSE, which consists of relatively easy items. Indeed, studies conducted in Western countries using the MoCA and MMSE have shown that participants have an average of 14–15 years of education,[9,14,15] while studies conducted in Korea show an average education level of 5–8 years.[12,13,16-18] According to data from the Ministry of Health and Welfare, only 17.2% of older Koreans in 2008 and 34% in 2020 have had a high school or higher education.[19] Although the number of highly educated elderly is increasing in Korea, it is clear that administering MoCA for the elderly with low education in the dementia field has far more cases in Korea than in Western countries.

Therefore, this study aimed to confirm the effect of education on MoCA compared to MMSE in Korean elderly, many of whom had low education. This study also aimed to compare differences in discriminability between MoCA and MMSE according to education level in more detail.

METHODS

Participants

A total of 583 subjects were analyzed (271 males and 312 females), with an average age of 74.19±8.71 years and 8.37±4.48 years of education. There were 123 subjects who were considered cognitively normal (CN), 118 with vascular mild cognitive impairment (VaMCI), 108 with amnestic mild cognitive impairment (amMCI), 121 with vascular dementia (VaD), and 113 with dementia of the Alzheimer's type (DAT). Participants of the CN group who fulfilled Christensen's health screening criteria[20] were recruited through community outreach. The VaMCI and VaD groups included patients with cognitive impairment due to vascular disease based on the diagnostic criteria of the American Heart Association-American Stroke Association.[21] Petersen's criteria were used for amMCI. The clinical diagnosis of DAT was based on the National Institute on Aging-Alzheimer's Association workgroup.[22] All patients underwent a clinical interview with a neurologist, a neurological examination, brain imaging, and neuropsychological tests. The final diagnosis was made by a neurologist. The MCI groups (VaMCI and amMCI) included patients with a Clinical Dementia Rating (CDR)[23] score of 0 or 0.5 (MCI/suspicion of dementia) and the dementia group had a CDR score of 1.0 or 2.0.

Measures

The Korean-MoCA (K-MoCA)[13] and Korean-MMSE (K-MMSE)[24] were administered to all participants with an interval of at least 2 hours between the two tests. The total score was 30 points for each of the 2 tests. For MCI and dementia groups, a comprehensive

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neuropsychological assessment (Seoul Neuropsychological Screening Battery, 2nd Edition; SNSB-II)[25] and the short version of Geriatric Depression Scale (SGDS)[26] were administered. Caregivers of the patient groups also completed the Korean-Instrumental Activities of Daily Living (K-IADL).[27]

Statistical analysis

A one-way analysis of variance (ANOVA) was used to examine differences in demographics and other variables among groups, followed by Bonferroni's *post hoc* comparison test. Pearson's χ^2 test was used to examine differences in sex composition among groups. In addition, multiple regression analysis was conducted to confirm effects of demographic variables on K-MoCA and K-MMSE scores. A receiver operating characteristic (ROC) curve analysis was performed and the area under the curve (AUC) was calculated to examine the discriminability of K-MoCA and K-MMSE while controlling for effects of age and education level as covariates. In addition, AUCs of MoCA and MMSE scores were compared using Hanley and McNeil's method.[28] SPSS 25.0 was used for ANOVA, Pearson's χ^2, and multiple regression analysis and the SAS program (SAS ver. 9.2; SAS Institute Inc., Cary, NC, USA) was used for ROC analysis.

Ethics statement

The study protocol was reviewed and approved by the Institutional Review Board (IRB) of Hallym University Sacred Heart Hospital (HIRB-2019-03-011-001).

RESULTS

Demographic characteristics and SGDS, K-IADL, and CDR scores of participants are shown in **Table 1**. No significant difference was found in the sex ratio or education level among groups. There was no difference in age among CN, amMCI, and VaD groups. However, the VaMCI group was younger than others, with the DAT group being the oldest. A comparison of differences in depression (SGDS), level of impairment in daily living (K-IADL), and severity of dementia (CDR-Global Score/Sum of Boxes [GS/SB]) among patient groups except CN showed that the VaD group scored higher SGDS than others. The K-IADL and CDR-GS/SB scores were significantly higher in dementia groups (VaD and DAT) than in MCI groups (VaMCI and amMCI).

Table 1. Demographical characteristics, SGDS, CDR, K-MoCA, and K-MMSE of participants

Variables	CN[a] (n=123)	VaMCI[b] (n=118)	amMCI[c] (n=108)	VaD[d] (n=121)	DAT[e] (n=113)	*F* or χ^2	*Post hoc* (Bonferroni)
Age (yr)	74.15±7.31	70.08±9.57	73.80±8.56	74.44±8.73	78.63±7.14	15.34***	b<a=c=d<e
Sex (M/F)	55/68	62/56	46/62	61/60	47/66	χ^2=4.39	ns
Education (yr)	8.59±3.26	8.64±4.48	8.67±4.78	7.44±4.73	8.58±4.98	1.68	ns
SGDS	NA	5.09±4.08	4.96±3.99	7.27±4.68	4.65±4.18	9.44***	b=c=e<d
K-IADL	NA	0.11±0.12	0.18±0.12	0.98±0.53	0.90±0.48	179.97***	b=c<d=e
CDR-GS	NA	0.48±0.11	0.50±0.05	0.93±0.17	0.92±0.19	362.94***	b=c<d=e
CDR-SB	NA	1.49±0.99	2.01±1.08	5.24±1.55	5.44±1.60	281.76***	b=c<d=e
K-MoCA	21.00±3.98	19.59±5.21	19.23±4.85	13.60±4.93	13.90±4.50	75.81***	a>b=c>d=e
K-MMSE	26.07±2.59	25.29±3.38	24.22±3.50	20.47±4.47	20.67±3.30	70.98***	a=b>d, a>c>e, b=c>d=e

SGDS: short form of the Geriatric Depression Scale, CDR: Clinical Dementia Rating, K-MoCA: Korean Montreal Cognitive Assessment, K-MMSE: Korean-Mini Mental State Examination, CN: cognitively normal, VaMCI: vascular mild cognitive impairment, amMCI: amnestic mild cognitive impairment, VaD: vascular dementia, DAT: dementia of Alzheimer's type, K-IADL: Korean-Instrumental Activities of Daily Living; CDR-GS: Clinical Dementia Rating-Global Score; CDR-SB: Clinical Dementia Rating-Sum of Boxes, NA: not applicable, ns: not significant.
***p<0.001.

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Table 2. Results of multiple regression analysis of age, education, and sex for predicting K-MoCA and K-MMSE test scores

Group	K-MoCA or K-MMSE	Variables	*F*	*B*	SE	β	*t*
Total	K-MoCA	Age	100.80***	−0.19	0.02	−0.30	−8.57***
		Education		0.56	0.05	0.44	12.15***
		Sex		−0.22	0.41	−0.02	−0.55
	K-MMSE	Age	58.33***	−0.10	0.02	−0.20	−5.48***
		Education		0.38	0.04	0.41	10.30***
		Sex		0.21	0.33	0.03	0.63
<9 years of education	K-MoCA	Age	29.94***	−0.18	0.04	−0.25	−4.77***
		Education		0.73	0.11	0.37	6.87***
		Sex		−1.18	0.58	−0.11	−2.01
	K-MMSE	Age	18.40***	−0.11	0.03	−0.17	−3.11*
		Education		0.59	0.10	0.35	6.17***
		Sex		−0.28	0.52	−0.03	−0.54
≥9 years of education	K-MoCA	Age	14.59***	−0.18	0.03	−0.36	−6.54***
		Education		0.15	0.10	0.08	1.47
		Sex		0.40	0.54	0.04	0.74
	K-MMSE	Age	6.01*	−0.08	0.02	−0.23	−4.01***
		Education		−0.04	0.07	−0.03	−0.54
		Sex		0.43	0.38	0.07	1.14

K-MoCA: Korean-Montreal Cognitive Assessment, K-MMSE: Korean-Mini Mental State Examination, SE: standard error.
*p<0.05, ***p<0.001.

Table 2 presents results of multiple regression analysis of age, education, and sex for predicting K-MoCA and K-MMSE test scores. For all participants, results showed that the regression function was statistically significant for K-MoCA (F [3,579]=100.80, p<0.001) and K-MMSE (F [3,579]=58.33, p<0.001) scores. A detailed analysis of B coefficients of regression functions showed that education level was the best predictor of the K-MoCA score (B=0.56, t [1,579]=12.15, p<0.001) and the K-MMSE score (B=0.38, t [1,579]=10.30, p<0.001). Age was also found to have a significant effect on K-MoCA (B=−0.19, t [1,579]=−8.57, p<0.001) and K-MMSE (B=−0.10, t [1,579]=−5.48, p<0.001) scores. However, sex did not significantly predict K-MoCA and K-MMSE scores.

To examine the effect of education level on K-MoCA and K-MMSE in more detail, the total group was divided into two groups (<6 years of education vs. ≥6 years of education and <9 years of education vs. ≥9 years of education). Multiple regression analysis was conducted again for each group. As with the total group, regression functions for both <6 years and ≥6 years groups were statistically significant for education level and age in K-MoCA and K-MMSE. However, when the total group was divided into a group with <9 years of education and a group with ≥9 years of education, the two groups showed different results. In the <9 years group, as with the total group, education level was more predictive of K-MoCA (B=0.73, t [1,277]=6.87, p<0.001) and K-MMSE (B=0.59, t [1,277]=6.17, p<0.001) scores than age (K-MoCA: B=−0.18, t [1, 277]=−4.77, p<0.001 and K-MMSE: B=−0.11, t [1,277]=−3.11, p<0.05), but sex did not significantly predict K-MoCA or K-MMSE scores. However, in the ≥9 years group, age had a significant effect on K-MoCA (B=−0.18 t [1,298]=−6.54, p<0.001) and K-MMSE (B=−0.08, t [1,298]=−4.01, p<0. 001) scores, but education level no longer had a significant effect on either test. Sex did not have a significant effect on K-MoCA or K-MMSE score either.

ROC curve analysis of all participants revealed that both K-MoCA and K-MMSE detected CN from MCI groups (VaMCI and amMCI), CN from dementia groups (VaD and DAT), VaMCI from the VaD group, and amMCI from the DAT group with good (0.8≤AUC<0.9) or excellent (0.9≤AUC<1.0) levels.[29] In addition, the AUC for the K-MoCA was significantly larger than that for the K-MMSE in differentiating VaMCI from CN (0.88 [95% CI: 0.83–0.92] vs. 0.85

Table 3. Discriminative values (AUC scores) of K-MoCA and K-MMSE in group comparison

Group	K-MoCA			K-MMSE			K-MoCA vs. K-MMSE	
	AUC	95% CI		AUC	95% CI		χ^2	*p*-value
		LL	UL		LL	UL		
Total								
CN vs. VaMCI	0.88	0.83	0.92	0.85	0.80	0.90	5.79	0.02
CN vs. amMCI	0.88	0.83	0.92	0.89	0.85	0.93	3.08	0.08
CN vs. VaD	0.96	0.94	0.98	0.95	0.92	0.97	2.64	0.10
CN vs. DAT	0.97	0.95	0.98	0.97	0.96	0.99	0.62	0.43
VaMCI vs. VaD	0.90	0.86	0.94	0.90	0.86	0.94	0.003	0.95
amMCI vs. DAT	0.92	0.89	0.95	0.90	0.86	0.94	2.29	0.13
<9 years of education								
CN vs. VaMCI	0.93	0.88	0.98	0.92	0.87	0.97	0.51	0.47
CN vs. amMCI	0.91	0.85	0.96	0.91	0.85	0.96	0.00	0.96
CN vs. VaD	0.96	0.93	0.99	0.96	0.93	0.99	0.01	0.91
CN vs. DAT	0.97	0.94	1.00	0.97	0.94	0.99	0.04	0.85
VaMCI vs. VaD	0.89	0.84	0.95	0.91	0.86	0.96	0.66	0.42
amMCI vs. DAT	0.92	0.87	0.97	0.91	0.86	0.96	0.42	0.52
≥9 years of education								
CN vs. VaMCI	0.92	0.88	0.96	0.89	0.84	0.94	4.54	0.03
CN vs. amMCI	0.94	0.90	0.98	0.95	0.91	0.98	0.78	0.38
CN vs. VaD	0.98	0.95	1.00	0.98	0.95	1.00	0.07	0.79
CN vs. DAT	0.99	0.98	1.00	1.00	0.99	1.00	1.23	0.27
VaMCI vs. VaD	0.99	0.98	1.00	0.98	0.95	1.00	2.34	0.13
amMCI vs. DAT	0.98	0.97	1.00	0.96	0.92	0.99	3.61	0.06

AUC: area under the curve, K-MoCA: Korean-Montreal Cognitive Assessment, K-MMSE: Korean-Mini Mental State Examination, CI: confidence interval, LL: lower limit, UL: upper limit, CN: cognitively normal, VaMCI: vascular mild cognitive impairment, amMCI: amnestic mild cognitive impairment, VaD: vascular dementia, DAT: dementia of Alzheimer's type.

[95% CI: 0.80–0.90], χ^2=5.79, *p*=0.02]. However, there was no difference in differentiating amMCI from CN, VaD from CN, DAT from CN, VaMCI from VaD, or amMCI from DAT.

To investigate the effect of education on the discriminability of the 2 tests in more detail, based on results of the regression analysis, ROC analysis was conducted again for the group with <9 years of education and the group with ≥9 years of education, respectively. In both groups, K-MoCA (AUC: 0.89–0.99) and K-MMSE (AUC: 0.89–1.00) discriminated CN from MCI groups (VaMCI and amMCI), CN from dementia groups (VaD and DAT), and MCI groups (VaMCI and amMCI) from dementia groups (VaD and DAT) with an excellent level. Like results of the total group, in the <9 years group, the K-MoCA differentiated VaMCI from CN better than K-MMSE (0.92 [95% CI: 0.88–0.96] vs. 0.89 [95% CI: 0.84–0.94], χ^2=4.54, *p*=0.03]. However, in the ≥9 years group, the K-MoCA and the K-MMSE did not show any significant differences in discriminability (**Table 3**).

DISCUSSION

This study was conducted to investigate effect of educational level on the MoCA and to find out in detail the difference in the discriminability of MoCA according to education level by comparing it with the MMSE. Results showed that in the total group, the higher the level of education and the younger the age, the higher the K-MoCA score. The effect of education level on the MoCA test score was greater than that of age. These results are consistent with those of previous studies[8,30] showing that years of education has a more significant effect on MoCA scores than age. As a result of dividing the entire group based on 6 years of elementary school education or 9 years of middle school education, in consideration of the Korean education system, it was found that the effect of education on MoCA was significant only

in the <9 years group but not in the ≥9 years group, whereas the effect of educational level was significant in both <6 years and ≥6 years groups. In addition, in the ≥9 years group, educational level did not have a significant effect on the MMSE score. These results indicate that the effect of education on MoCA and MMSE scores might disappear for test subjects with education beyond middle school graduation. This is a new finding that has not been found by previous studies reporting that education level affects MoCA and MMSE scores.[8,13,24,30,31]

ROC analysis results showed that, regardless of education level, the K-MoCA screened MCI (VaMCI and amMCI) and dementia groups (VaD and DAT) from the CN and discriminated VaMCI from VaD as well as amMCI from DAT sensitively. Results of this study also demonstrated that the discriminability of the K-MoCA was higher than that of the K-MMSE in distinguishing VaMCI from CN. These results suggest that the K-MoCA is more useful than K-MMSE in screening for vascular cognitive impairment. However, it is worth noting that the superiority of MoCA over the MMSE appeared only in the group with ≥9 years of education. It was not maintained in the group with <9 years of education, which accounted for the majority of the elderly in Korea. The MoCA contains more subtests related to executive functions than the MMSE.[10,32,33] The executive function is significantly related to educational level[34-37] and the neuropsychological characteristic of VaMCI is an executive dysfunction.[38-40] Therefore, it can be explained that the MoCA is superior to the MMSE in screening for VaMCI, in which the executive dysfunction is characteristically observed. In addition, the superiority of MoCA appears differently depending on the level of education. Since the original MoCA was validated for individuals with an average education level of approximately 13 years,[1] Julayanont et al.[41] have suggested that the performance of MoCA for people with low education or literacy could be underestimated. Considering that compulsory education in Korea is applied up to middle school and that many of the elderly visiting hospitals have <9 years of education, clinicians in Korea should not overlook the effect of a patient's education level on her/his MoCA score.

This study was significant in that it confirmed the discriminability of K-MoCA and compared the K-MMSE's discriminability according to education level in various patient group such as VaMCI, amMCI, VaD, and DAT. It was a novel finding that MoCA and MMSE scores were affected by education level in the group with <9 years of education but not in the ≥9 years group and that the MoCA better differentiated VaMCI and CN than the MMSE in the group with ≥9 years of education but not in the group with <9 years of education. Unlike previous studies,[6,7,12,18,42] the current study found that the K-MoCA did not show a significant difference from the K-MMSE in discriminating amnestic MCI from CN in any age groups. The reason for this has not been clarified yet. Future studies are needed to find the answer by examining the effect of education on each cognitive domain in more detail using MoCA index scores.

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