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ORIGINAL ARTICLE

The MMSE and MoCA for Screening Cognitive Impairment in Less Educated Patients with Parkinson's Disease

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ABSTRACT

Objective To explore whether the Mini-Mental State Examination (MMSE) and Montreal Cognitive Assessment (MoCA) can be used to screen for dementia or mild cognitive impairment (MCI) in less educated patients with Parkinson's disease (PD).

Methods We reviewed the medical records of PD patients who had taken the Korean MMSE (K-MMSE), Korean MoCA (K-MoCA), and comprehensive neuropsychological tests. Predictive values of the K-MMSE and K-MoCA for dementia or MCI were analyzed in groups divided by educational level.

Results The discriminative powers of the K-MMSE and K-MoCA were excellent [area under the curve (AUC) 0.86–0.97] for detecting dementia but not for detecting MCI (AUC 0.64–0.85). The optimal screening cutoff values of both tests increased with educational level for dementia (K-MMSE < 15 for illiterate, < 20 for 0.5–3 years of education, < 23 for 4–6 years, < 25 for 7–9 years, and < 26 for 10 years or more; K-MoCA < 7 for illiterate, < 13 for 0.5–3 years, < 16 for 4–6 years, < 19 for 7–9 years, < 20 for 10 years or more) and MCI (K-MMSE < 19 for illiterate, < 26 for 0.5–3 years, < 27 for 4–6 years, < 28 for 7–9 years, and < 29 for 10 years or more; K-MoCA < 13 for illiterate, < 21 for 0.5–3 years, < 23 for 4–6 years, < 25 for 7–9 years, < 26 for 10 years or more).

Conclusion Both MMSE and MoCA can be used to screen for dementia in patients with PD, regardless of educational level; however, neither test is sufficient to discriminate MCI from normal cognition without additional information.

Key Words Mini-Mental State Examination; Montreal Cognitive Assessment; Parkinson's disease; dementia; mild cognitive impairment.

Cognitive impairment is common in patients with Parkinson's disease (PD), and its prevalence has been reported to be up to 80%.[1] Recently, diagnostic criteria for dementia or mild cognitive impairment (MCI) were proposed by the Movement Disorders Society Task Force and are widely used.[2,3] The level II assessments provide much more diagnostic accuracy and quantitative information; however, the detailed neuropsychological tests recommended by the level II assessments require considerable time and cost. For these reasons, the guidelines also suggest level I criteria using the following short tests: the Mini-Mental State Examination (MMSE) for dementia, the Montreal Cognitive Assessment (MoCA) or Scales for Outcomes in PD-Cognition (SCOPA-Cog) for MCI. The MMSE has been widely used for diagnosing dementia based on the level I criteria,[2] and the MoCA has been reported to reflect cognitive status better in patients with PD.[4-10]

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Almost all of the published data for the MMSE or the MoCA to evaluate cognitive function in patients with PD were obtained from well-educated subjects; however, a large portion of elderly patients of many countries have a low level of education. For example, a community-based cohort of Korean elderly demonstrated that 44.1% of the cohort population aged 60 or more have been educated for 6 or fewer years.[11] Therefore, additional data are necessary to use the MMSE or MoCA to screen for cognitive impairment in less educated patients with PD.

In this study, we explored whether the Korean MMSE (K-MMSE) and Korean MoCA (K-MoCA) are possible screening tests for dementia or MCI in Korean PD patients with a low level of education.

MATERIALS & METHODS

Subjects

We reviewed the medical records of patients with PD who visited a tertiary referral center. We selected patients who had their cognitive status assessed by a comprehensive neuropsychological battery from Jan 2014 to Dec 2015. PD was diagnosed according to the clinical criteria of the UK PD Brain Bank,[12] and patients who underwent deep brain stimulation or were aged less than 50 or more than 85 were excluded from the study. To rule out patients with dementia with Lewy bodies, we also excluded patients who had visual hallucinations or dementia occurring before or within 1 year following the onset of parkinsonism.[13] Patients who showed abnormalities in thyroid function test or vitamin B 12 levels; subjects who were treated with drugs affecting cognitive status such as benzodiazepines or antipsychotics were also excluded. Subjects having focal brain lesions or white matter hyperintensity corresponding to grade 2 or 3 of the Fazekas scale on a MRI scan were also excluded from this study.[14]

This study was approved by the Institutional Review Board (IRB) and was exempt from the requirement for informed consent by the IRB because of its retrospective design.

Neuropsychological assessment

The neuropsychological assessments were administered by experienced clinical psychologists. All subjects were tested with the K-MMSE and K-MoCA at the start of the assessment.[15,16] Items on the tests that required literacy (i.e., reading and writing items for the K-MMSE and trail-making test and phonemic fluency item for the K-MoCA) were not examined in illiterate subjects. The neuropsychological battery consisted of 10 tests for 5 cognitive domains: attention (forward digit span[17] and trail-making test A[17]), language function (Korean version of the Boston Naming Test[17] and similarity test of Wechsler Adult Intelligence Scale-Fourth Edition[18]), visuospatial ability [copying the Rey Complex Figure Test[17] and clock copying (CLOX2)[19]], memory (20-minute delayed recall using the Seoul Verbal Learning Test[17] and Rey Complex Figure Test[17]), and executive function [semantic fluency for animal using Controlled Oral Word Association Test[17] and clock drawing test (CLOX1)[19]]. Cognitive performances were calculated into age- and education-adjusted z scores using previously published normative data.[15,16,18,19] The duration of education was considered 0 years for illiterate patients and 0.5 years for patients who could read and write but had not received any formal education. Activities of daily living (ADL) were evaluated by Clinical Dementia Rating (CDR), and a score of 1 or more on the CDR was considered impaired ADL.[20]

Diagnostic criteria for MCI and dementia

Dementia was diagnosed using the level II assessment recommended by the Movement Disorder Society Task Force with modifications.[2] The criteria of the present study were as follows: 1) the mean z score of 2 tests of each cognitive domain was lower than mean–1.5 SD of normative data on at least 2 domains, and 2) an impairment of daily activity was indicated by CDR.

MCI was diagnosed according to the criteria proposed by the Movement Disorder Society Task Force (level II category).[3] MCI was diagnosed when the following criteria were met: 1) performance on at least 2 of the 10 tests was lower than mean–1.5 SD of normative data, and 2) activity of daily living was not impaired.

Statistical analyses

A one-way analysis of variances and chi-square test were used to compare the demographic characteristics among groups. Post-hoc analyses were conducted using Bonferroni's method. Logistic regression analyses were performed to explore the influence of

demographic factors such as age, sex difference, and education level on the discriminative power of the K-MMSE or K-MoCA. The usefulness of the each test was evaluated by the area under the curve (AUC), sensitivity, specificity, and positive (PPV) and negative predictive value (NPV). The optimal screening cutoff value was defined as the lowest score that yielded sensitivity and NPV > 80%, and the optimal diagnostic cutoff value was defined as the highest score that yielded specificity and PPV > 80%, if possible. The point with maximal accuracy was found using the Youden Index. Statistical analyses were performed using SPSS Statistics 21 (IBM SPSS Inc., Armonk, NY, USA), and $p < 0.05$ was considered statistically significant.

RESULTS

Study subjects and demographic data

A total of 505 patients were collected from medical records. According to the diagnostic criteria, the participants were classified into 3 groups: normal cognition ($n = 255$), MCI ($n = 161$), and dementia ($n = 78$). Eleven patients who reported impaired ADL but showed cognitive deficits in only one domain were excluded from this study.

The demographic data of the subjects are presented in Table 1. Compared with non-demented patients, the patients with dementia aged more, suffered longer with PD, and had more severe motor symptoms. The patients with normal cognition were significantly more educated than were those with MCI.

Cognitive performances of the subjects

Performances on the K-MMSE, K-MoCA, and neuropsychological subtests of groups are presented in Table 2. The cognitive performances showed a tendency to decline according to the cognitive deterioration on almost all of the subanalyses.

Demographic factors influencing the K-MMSE or K-MoCA score

The results of the logistic regression analyses are presented in Table 3. Duration of education influenced the predictive value of the MMSE and K-MoCA to diagnose MCI or dementia consistently. Age was a confounding factor in the analysis for the MoCA and MCI; however, age did not affect the other analyses. Sex differences also did not affect the prediction of cognitive levels.

K-MMSE and K-MoCA for screening dementia

The discriminative values of the K-MMSE and K-MoCA to distinguish dementia from MCI or normal cognition are presented in Table 4. The AUC values were higher than 0.9 for the K-MMSE and K-MoCA in all education levels except for illiterate patients. For the K-MMSE, the optimal screening cutoff was < 15 for illiterate patients (AUC 0.86, sensitivity 0.80, specificity 0.82), < 20 for those educated for 0.5–3 years (AUC 0.95, sensitivity 0.86, specificity 0.85), < 23 for 4–6 years of education (AUC 0.92, sensitivity 0.84, specificity 0.84), < 25 for 7–9 years of education (AUC 0.95, sensitivity 0.90, specificity 0.85), and < 26 for 10 or more years of education (AUC 0.97, sensitivity 0.97, specificity 0.85). For the K-MoCA, the optical screening cutoff was < 7 for illiterate patients (AUC 0.86, sensitivity 0.80, specificity 0.77), < 13 for those educated for 0.5–3 years (AUC 0.93, sensitivity 0.86, specificity 0.88), < 16 for 4–6 years of education (AUC 0.91, sensitivity 0.84, specificity 0.89), < 19 for 7–9 years of education

Table 1. Demographic data of the subjects

	PD-N ($n = 255$)	PD-MCI ($n = 161$)	PD-D ($n = 78$)	*p* value	Group comparison‡
Male/female, *n*	145/110	92/69	42/36	0.88*	PD-N = PD-MCI = PD-D
Age, yr	69.3 ± 7.5	70.5 ± 7.3	74.2 ± 6.3	< 0.001†	PD-N = PD-MCI < PD-D
Education, yr	9.3 ± 4.7	7.7 ± 5.4	8.3 ± 5.5	0.004†	PD-N > PD-MCI
Duration of PD, yr	3.6 ± 3.5	4.8 ± 4.5	6.7 ± 4.5	< 0.001†	PD-N = PD-MCI < PD-D
UPDRS motor score	23.7 ± 11.6	24.6 ± 11.9	32.3 ± 10.0	0.006†	PD-N = PD-MCI < PD-D
Hoehn & Yahr stage	1.9 ± 0.6	2.1 ± 0.6	2.7 ± 0.7	0.003†	PD-N = PD-MCI < PD-D
LED, mg/day	208 ± 363	430 ± 479	602 ± 352	0.027†	PD-N < PD-D
BDI score	14.1 ± 9.9	12.2 ± 9.0	18.1 ± 11.9	0.19†	PD-N = PD-MCI = PD-D

Data are expressed as the mean ± SD. *chi-square test, †ANOVA, ‡by Bonferroni's method. PD: Parkinson's disease, PD-N: Parkinson's disease with normal cognition, PD-MCI: Parkinson's disease with mild cognitive impairment, PD-D: Parkinson's disease with dementia, UPDRS: Unified Parkinson's Disease Rating Scale, LED: levodopa equivalent dose, BDI: Beck's Depression Inventory.

Table 2. Cognitive performances according to the cognitive level and duration of education

Years of education	PD-N (*n* = 255)	PD-MCI (*n* = 161)	PD-D (*n* = 78)	*p* value	Group comparison
MMSE	27.0 ± 2.5	23.9 ± 4.0	18.5 ± 4.5	< 0.001	PD-N > PD-MCI > PD-D
Illiteracy	20.3 ± 3.7	15.5 ± 2.9	12.8 ± 2.4	0.001	PD-N > PD-MCI = PD-D
0.5–3	25.6 ± 2.5	21.8 ± 3.2	15.6 ± 3.3	< 0.001	PD-N > PD-MCI > PD-D
4–6	26.5 ± 2.3	24.1 ± 2.5	18.4 ± 4.6	< 0.001	PD-N > PD-MCI > PD-D
7–9	26.9 ± 2.1	25.4 ± 2.7	20.6 ± 2.9	< 0.001	PD-N > PD-MCI > PD-D
≥ 10	28.1 ± 1.4	26.3 ± 2.0	20.1 ± 4.3	< 0.001	PD-N > PD-MCI > PD-D
MoCA	23.2 ± 4.4	18.6 ± 5.4	12.1 ± 5.2	< 0.001	PD-N > PD-MCI > PD-D
Illiteracy	12.1 ± 1.9	8.4 ± 3.8	5.0 ± 2.3	0.002	PD-N > PD-MCI > PD-D
0.5–3	20.1 ± 4.0	14.9 ± 3.7	9.1 ± 3.8	< 0.001	PD-N > PD-MCI > PD-D
4–6	21.5 ± 4.3	18.5 ± 3.5	11.9 ± 4.9	< 0.001	PD-N > PD-MCI > PD-D
7–9	23.0 ± 3.1	19.9 ± 3.7	13.9 ± 4.4	< 0.001	PD-N > PD-MCI > PD-D
≥ 10	25.6 ± 3.0	22.5 ± 3.2	14.2 ± 4.9	< 0.001	PD-N > PD-MCI > PD-D
Attention domain*	0.23 ± 0.94	-0.26 ± 0.88	-0.75 ± 0.88	< 0.001	PD-N > PD-MCI > PD-D
Illiteracy	-0.02 ± 0.61	-0.30 ± 0.57	-0.66 ± 0.63	0.222	PD-N = PD-MCI = PD-D
0.5–3	0.25 ± 1.28	-0.30 ± 0.92	-0.71 ± 0.66	0.030	PD-N > PD-D
4–6	0.10 ± 0.75	-0.18 ± 0.86	-0.53 ± 0.79	0.025	PD-N > PD-D
7–9	0.17 ± 0.67	-0.36 ± 0.85	-0.53 ± 0.49	0.001	PD-N > PD-MCI = PD-D
≥ 10	0.55 ± 0.72	-0.12 ± 0.61	-0.81 ± 0.74	< 0.001	PD-N > PD-MCI > PD-D
Language function*	0.17 ± 0.71	-0.87 ± 0.77	-1.70 ± 1.03	< 0.001	PD-N > PD-MCI > PD-D
Illiteracy	-0.31 ± 0.90	-0.84 ± 0.64	-1.79 ± 0.53	0.01	PD-N > PD-D
0.5–3	-0.18 ± 0.72	-1.28 ± 0.82	-1.84 ± 0.78	< 0.001	PD-N > PD-MCI = PD-D
4–6	-0.03 ± 0.54	-0.88 ± 0.73	-1.67 ± 1.00	< 0.001	PD-N > PD-MCI > PD-D
7–9	0.18 ± 0.66	-0.86 ± 0.75	-0.81 ± 0.90	< 0.001	PD-N > PD-MCI = PD-D
≥ 10	0.35 ± 0.72	-0.65 ± 0.74	-1.90 ± 1.13	< 0.001	PD-N > PD-MCI > PD-D
Visuospatial function*	0.12 ± 0.78	-1.37 ± 1.69	-3.72 ± 2.84	< 0.001	PD-N > PD-MCI > PD-D
Illiteracy	-0.39 ± 0.55	-0.81 ± 1.00	-1.91 ± 1.07	0.035	PD-N > PD-D
0.5–3	-0.08 ± 0.92	-1.73 ± 0.96	-2.31 ± 1.48	< 0.001	PD-N > PD-MCI = PD-D
4–6	0.11 ± 0.79	-1.35 ± 1.50	-2.84 ± 1.62	< 0.001	PD-N > PD-MCI > PD-D
7–9	0.21 ± 0.74	-1.00 ± 2.01	-3.42 ± 2.64	< 0.001	PD-N > PD-MCI > PD-D
≥ 10	0.16 ± 0.77	-1.46 ± 2.00	-4.88 ± 3.41	< 0.001	PD-N > PD-MCI > PD-D
Memory*	-0.03 ± 0.76	-1.07 ± 0.77	-1.76 ± 0.61	< 0.001	PD-N > PD-MCI > PD-D
Illiteracy	-0.48 ± 0.54	-0.57 ± 0.70	-0.84 ± 0.13	0.6	PD-N = PD-MCI = PD-D
0.5–3	-0.23 ± 0.92	-0.87 ± 0.68	-1.36 ± 0.51	< 0.001	PD-N > PD-MCI = PD-D
4–6	0.13 ± 0.72	-0.88 ± 0.88	-1.61 ± 0.38	< 0.001	PD-N > PD-MCI > PD-D
7–9	-0.13 ± 0.78	-1.33 ± 0.64	-1.65 ± 0.41	< 0.001	PD-N > PD-MCI = PD-D
≥ 10	-0.07 ± 0.72	-1.28 ± 0.69	-2.13 ± 0.56	< 0.001	PD-N > PD-MCI > PD-D
Executive function*	0.02 ± 1.04	-0.66 ± 0.95	-1.73 ± 0.83	< 0.001	PD-N > PD-MCI > PD-D
Illiteracy	0.07 ± 0.92	-0.87 ± 0.88	-2.30 ± 0.34	0.001	PD-N = PD-MCI > PD-D
0.5–3	0.48 ± 1.31	-0.48 ± 1.01	-1.07 ± 0.76	< 0.001	PD-N > PD-MCI = PD-D
4–6	-0.22 ± 1.14	-0.65 ± 1.13	-1.55 ± 0.97	0.001	PD-N = PD-MCI > PD-D
7–9	-0.04 ± 0.93	-0.63 ± 0.87	-1.41 ± 0.74	< 0.001	PD-N > PD-MCI = PD-D
≥ 10	0.04 ± 0.97	-0.70 ± 0.86	-2.05 ± 0.65	< 0.001	PD-N > PD-MCI > PD-D

*z score. PD-N: Parkinson's disease with normal cognition, PD-MCI: Parkinson's disease with mild cognitive impairment, PD-D: Parkinson's disease with dementia, MMSE: Mini-Mental State Examination, MoCA: Montreal Cognitive Assessment.

(AUC 0.92, sensitivity 0.90, specificity 0.83), and < 20 for 10 or more years of education (AUC 0.96, sensitivity 0.83, specificity 0.92).

K-MMSE and K-MoCA for screening MCI

The discriminative values of the K-MMSE and K-MoCA to distinguish MCI from normal cognition were calculated after excluding patients with dementia from the data (Table 5). The AUC varied between 0.64 and 0.85 for the K-MMSE and between 0.70 and 0.83 for the K-MoCA throughout all education levels. In the case of the K-MMSE, the optimal screening cutoff was < 19 for illiterate patients (AUC 0.85, sensitivity 0.86, specificity 0.75), < 26 for those educated for 0.5–3 years (AUC 0.83, sensitivity 0.87, specificity 0.61), < 27 for 4–6 years of education

Table 3. Multivariate logistic regression models to predict the cognitive level in patients with Parkinson's disease

Variables	Odds ratio	95% CI	*p* value
MMSE			
MCI (Hosmer-Lemeshow test, χ^2 = 7.28, p = 0.51)			
MMSE	0.67	0.60–0.74	< 0.001
Education	1.06	1.00–1.12	0.04
Age	0.98	0.95–1.01	0.2
Female sex	0.82	0.50–1.36	0.4
Dementia (Hosmer-Lemeshow test, χ^2 = 9.34, p = 0.31)			
MMSE	0.55	0.49–0.63	< 0.001
Education	1.32	1.19–1.45	< 0.001
Age	0.99	0.94–1.05	0.8
Female sex	1.07	0.49–2.36	0.9
MoCA			
MCI (Hosmer-Lemeshow test, χ^2 = 7.61, p = 0.47)			
MoCA	0.74	0.69–0.80	< 0.001
Education	1.12	1.05–1.19	0.001
Age	0.97	0.93–1.00	0.03
Female sex	0.82	0.49–1.35	0.4
Dementia (Hosmer-Lemeshow test, χ^2 = 4.84, p = 0.78)			
MoCA	0.62	0.56–0.69	< 0.001
Education	1.35	1.22–1.49	< 0.001
Age	0.98	0.93–1.04	0.6
Female sex	0.92	0.41–2.09	0.8

CI: confidence interval, MMSE: Mini-Mental State Examination, MCI: mild cognitive impairment, MoCA: Montreal Cognitive Assessment.

(AUC 0.76, sensitivity 0.86, specificity 0.55), < 28 for 7–9 years of education (AUC 0.64, sensitivity 0.84, specificity 0.39), and < 29 for 10 or more years of education (AUC 0.77, sensitivity 0.88, specificity 0.44). For the K-MoCA, the optical screening cutoff was < 13 for illiterate patients (AUC 0.81, sensitivity 0.93, specificity 0.38), < 21 for those educated for 0.5–3 years (AUC 0.83, sensitivity 0.93, specificity 0.43), < 23 for 4–6 years of education (AUC 0.70, sensitivity 0.89, specificity 0.43), < 25 for 7–9 years of education (AUC 0.74, sensitivity 0.88, specificity 0.34), and < 26 for 10 or more years of education (AUC 0.77, sensitivity 0.84, specificity 0.60).

DISCUSSION

The present study is the first to evaluate the discriminative value of the MMSE and MoCA in less educated patients with PD. The results demonstrated the excellent discriminative power of the K-MMSE and K-MoCA in screening for dementia, regardless of education level. Both tests could be useful but are insufficient to distinguish MCI from normal cognition.

Although the age, sex difference, and level of education were reported as factors influencing the normative value for the K-MMSE or K-MoCA,[16,21] the logistic regression analyses showed that the duration of education was the only factor associated with the score on both tests. Age influenced the K-MoCA score in the analysis for predicting MCI alone, but sex did not affect the association. This result was in agreement with previously reported normative data that also showed the strongest effect of education level on the K-MMSE and K-MoCA scores.[16,21] Therefore, in the present study, the discriminative values were calculated for each group divided by the educational level.

In the group of highly educated patients (≥ 10 years), the cutoff values for detecting dementia or MCI were similar to those of previous reports. For dementia, the cutoff scores of the present study were MMSE < 26 and MoCA < 20. A New Zealand group reported cutoff scores of MMSE < 26 (AUC 0.91, sensitivity 0.86, specificity 0.75) and MoCA < 21 (AUC 0.97, sensitivity 0.81, specificity 0.95),[4] and a study in Greek patients suggested a MoCA score < 21 (sensitivity 0.82, specificity 0.90) as an optimal cutoff.[22] In contrast, an American research group reported a much higher screening cutoff value for detecting dementia: MMSE < 29 and MoCA < 25.[5] This gap might be due to an extremely high level of education (mean 16 years), differences in group comparisons (dementia vs. normal cognition with-

Table 4. Discriminative values of the MMSE and the MoCA for the diagnosis of dementia in Parkinson's disease

Years of education	*n**	AUC	Optimal screening value					Optimal diagnostic value					Maximal accuracy				
			Cutoff	Sensitivity	Specificity	PPV	NPV	Cutoff	Sensitivity	Specificity	PPV	NPV	Cutoff	Sensitivity	Specificity	PPV	NPV
MMSE																	
Illiteracy	5/22	0.86	< 15	0.80	0.82	0.50	0.95	< 11	0.20	0.100	0.100	0.85	< 15	0.80	0.82	0.50	0.95
0.5–3†	14/58	0.95	< 20	0.86	0.85	0.57	0.96	< 19	0.79	0.98	0.92	0.95	< 19	0.79	0.98	0.92	0.95
4–6	19/79	0.92	< 23	0.84	0.84	0.55	0.96	< 21	0.74	0.96	0.85	0.94	< 22	0.79	0.91	0.68	0.95
7–9	10/86	0.95	< 25	0.90	0.85	0.41	0.99	< 20	0.40	0.99	0.80	0.93	< 25	0.90	0.85	0.41	0.99
≥ 10	30/171	0.97	< 26	0.97	0.85	0.54	0.99	< 24	0.77	0.98	0.85	0.96	< 26	0.97	0.85	0.54	0.99
MoCA																	
Illiteracy	5/22	0.86	< 7	0.80	0.77	0.44	0.94	< 5	0.60	0.91	0.60	0.91	< 10	0.100	0.64	0.39	0.100
0.5–3†	14/58	0.93	< 13	0.86	0.88	0.63	0.96	< 8	0.43	0.98	0.86	0.88	< 13	0.86	0.88	0.63	0.96
4–6	19/79	0.91	< 16	0.84	0.89	0.64	0.96	< 14	0.63	0.96	0.80	0.92	< 16	0.84	0.89	0.64	0.96
7–9	10/86	0.92	< 19	0.90	0.83	0.38	0.99	< 16	0.80	0.98	0.80	0.98	< 16	0.80	0.98	0.80	0.98
≥ 10	30/171	0.96	< 20	0.83	0.92	0.64	0.97	< 18	0.73	0.97	0.82	0.95	< 20	0.83	0.92	0.64	0.97

*dementia/(mild cognitive impairment + normal cognition), †0.5 year of education: not taken any formal education but able to read and write. MMSE: Mini-Mental State Examination, MoCA: Montreal Cognitive Assessment, AUC: area under the curve, PPV: positive predictive value, NPV: negative predictive value.

Table 5. Discriminative values of the MMSE and the MoCA for diagnosis of mild cognitive impairment in Parkinson's disease

Years of education	*n**	AUC	Optimal screening value					Optimal diagnostic value					Maximal accuracy				
			Cutoff	Sensitivity	Specificity	PPV	NPV	Cutoff	Sensitivity	Specificity	PPV	NPV	Cutoff	Sensitivity	Specificity	PPV	NPV
MMSE																	
Illiteracy	14/8	0.85	< 19	0.86	0.75	0.86	0.75	< 17	0.71	0.88	0.91	0.64	< 19	0.86	0.75	0.86	0.75
0.5–3†	30/28	0.83	< 26	0.87	0.61	0.70	0.81	< 23	0.63	0.86	0.83	0.69	< 23	0.63	0.86	0.83	0.69
4–6	35/44	0.76	< 27	0.86	0.55	0.60	0.83	< 22	0.17	0.98	0.86	0.60	< 26	0.66	0.75	0.68	0.74
7–9	25/61	0.64	< 28	0.84	0.39	0.36	0.86	< 24	0.24	0.98	0.86	0.76	< 29	0.96	0.28	0.35	0.94
≥ 10	57/114	0.77	< 29	0.88	0.44	0.44	0.88	< 25	0.19	0.98	0.85	0.71	< 28	0.70	0.72	0.56	0.83
MoCA																	
Illiteracy	14/8	0.81	< 13	0.93	0.38	0.72	0.75	< 11	0.64	0.88	0.90	0.58	< 11	0.64	0.88	0.90	0.58
0.5–3†	30/28	0.83	< 21	0.93	0.43	0.64	0.86	< 15	0.47	0.93	0.88	0.62	< 17	0.67	0.82	0.80	0.70
4–6	35/44	0.70	< 23	0.89	0.43	0.55	0.83	< 15	0.11	0.98	0.80	0.58	< 21	0.80	0.57	0.60	0.78
7–9	25/61	0.74	< 25	0.88	0.34	0.36	0.88	< 17	0.28	0.100	0.100	0.77	< 22	0.68	0.69	0.47	0.84
≥ 10	57/114	0.77	< 26	0.84	0.60	0.51	0.88	< 21	0.32	0.92	0.67	0.73	< 25	0.74	0.72	0.57	0.85

*mild cognitive impairment/normal cognition, †0.5 year of education: not taken any formal education but able to read and write. MMSE: Mini-Mental State Examination, MoCA: Montreal Cognitive Assessment, AUC: area under the curve, PPV: positive predictive value, NPV: negative predictive value.

out MCI), and different diagnostic criteria for dementia. For MCI, the optimal screening cutoff values of the present study (MMSE < 29 and MoCA < 26) were identical or similar to those of previous reports (MMSE < 29 and MoCA < 26;[4] MMSE < 30 and MoCA < 27;[5] MMSE < 30 and MoCA < 27;[8] MoCA < 27[9]). These studies were conducted with different diagnostic criteria for PD-MCI; therefore, future work should determine whether these differences influence the cutoff values of MMSE or MoCA.

Both the K-MMSE and K-MoCA showed excellent discriminative power to predict dementia, regardless of educational level. In the illiterate group, the MoCA is not recommended, although the discriminative power of the K-MoCA for dementia was good (AUC 0.86) and was similar to that of the K-MMSE. Although two items of each test were not examined in illiterate patients, the remaining 28 points on both tests appeared to be sufficient for screening for dementia.

For screening MCI, the K-MMSE and K-MoCA showed good to fair discriminative powers, except for the analysis of K-MMSE and 7–9 years of education. Both tests were comparable in detection ability but were not sufficient for the excellent prediction of MCI. This suboptimal specificity was also observed in early publications. Hoops et al.[5] reported that the tests were not excellent for the prediction of MCI (AUC: MMSE 0.72, MoCA 0.74). Chou et al.[7] also suggested that the MoCA has limited diagnostic accuracy for PD-MCI (sensitivity 0.59, specificity 0.69). However, Dalrymple-Alford et al.[4] showed superior discriminative power of the MoCA (AUC 0.90) for MCI compared with the MMSE (AUC 0.78), and Gill et al.[8] reported that both tests have good power (AUC: MMSE 0.90, MoCA 0.85). As in variable cutoff values for MMSE and MoCA, there are many factors affecting this result, such as the level of education, diagnostic criteria of study subjects, and other factors; therefore, more data are required to address this disagreement.

This study had several limitations. Although this study included the largest number of subjects, the sample sizes of each educational group were small. Second, there could be some error regarding the data of educational level because these data were collected based on patients' or caregivers' reports. Third, there is no consensus on the cutoff value (1–2 SD) of each test for diagnosing MCI in patients with PD. We used 1.5 SD in this study, although 1 or 2 SD was used in other studies.

This study showed that the MMSE and MoCA could be useful tools for screening for dementia in patients with PD, regardless of educational level. However, the tests are not sufficient to discriminate MCI from normal cognition without additional information.

Conflicts of Interest

The authors have no financial conflicts of interest.

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