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Montreal Cognitive Assessment in Detecting Cognitive Impairment in Chinese Elderly Individuals: A Population-Based Study

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Abstract

The Montreal Cognitive Assessment (MoCA) has been proved brief and sensitive to screen for mild cognitive impairment (MCI) and early dementia in some developed countries or areas. However, little MoCA data are available from mainland China. In this study, the MoCA was applied to 8411 Chinese community dwellers aged 65 or older (6283 = cognitively normal [CN], 1687 = MCI, and 441 = dementia). The MoCA norms were established considering significant influential factors. The optimal cutoff points were 13/14 for illiterate individuals, 19/20 for individuals with 1 to 6 years of education, and 24/25 for individuals with 7 or more years of education. With the optimal cutoffs, the sensitivity of the MoCA was 83.8% for all cognitive impairments, 80.5% for MCI and 96.9% for dementia, and the specificity for identifying CN was 82.5%. These indicate that with optimal cutoffs, the MoCA is valid to screen for cognitive impairment in elderly Chinese living in communities.

Keywords

Montreal Cognitive Assessment, norms, screening, validity, mild-cognitive impairment, dementia

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Introduction

Normal aging, mild cognitive impairment (MCI), and dementia represent a continuum of cognitive states in the elderly individuals. Identification of MCI and its subtypes is important because it can lead to early therapeutic intervention. However, commonly used instruments, such as the Mini-Mental State Examination (MMSE),[1] are insensitive to MCI.[2-4] The Montreal Cognitive Assessment (MoCA), which was published in 2005, was specially developed for detection of MCI and early dementia.[5] Its final English version is a one-page 30-point screening test, with a cutoff of 25/26 and 1-point correction for persons educated no more than 12 years. Its sensitivity is 83% to 96% for MCI, and its specificity is 50% to 95% for cognitively normal participants in some developed countries or areas.[5-11]

However, the MoCA still has problems. One is that little MoCA data are available from eastern countries, especially mainland China, where conventions and language differ markedly from those in the West. The other is that though performance of the MoCA has been verified in clinical settings in numbers of previous studies, its validity remains unproven in large general populations where the low prevalence of disease challenges the efficiency of assessment tools. Therefore, we applied the MoCA to establish normative data in older community dwellers residing in multiple areas of China and to determine its optimal cutoff points. Using adjusted cutoffs, validity of the MoCA was explored for detecting MCI and dementia.

Methods

Participants

This study is a part of China Cognition and Aging Study (China Coast) which is a longitudinal national study on the MCI and dementia based on hospital and community population. A multistage, stratified, cluster sampling design was adopted

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in the community population. This study included 2 samples recruited from urban and rural areas, respectively. First, since China is a vast country which has a significant disparity in geography, climate, diet, culture, and economy, we choose 5 representative regional centers across china (Beijing, Zhengzhou, Guangzhou, Changchun, and Guiyang). The urban samples were recruited in Beijing, Zhengzhou, Guangzhou, and Changchun, while the rural samples were recruited in Beijing, Zhengzhou, Guangzhou, and Guiyang. Second, 7 urban districts and 6 rural counties were randomly selected. Finally, within selected districts and counties, 30 urban communities and 45 rural villages were randomly sampled. The eligible samples for inclusion were (1) 65 years old and older, (2) the Han Chinese, (3) listed in the census of the community registry office and living in the target community for at least 1 year preceding the survey date, and (4) free of comorbid conditions that could affect assessment. Those listed in the census but institutionalized were not included in the study. Our analysis included 8411 participants (81.9% of the total 10 276 community participants). They were divided into 3 categories according to cognitive level according to established criteria: 6283 cognitively normal people (CN), 1687 patients with MCI, and 441 with dementia. In current study, patients (n = 441) with dementia were divided into 3 subtypes: patients with Alzheimer disease (AD; n = 293), those with vascular dementia (VD; n = 110), and those with other dementia (n = 38). Among the 1865 participants excluded, 1562 were missing any data which could influence the evaluation; 303 were with mood disorders or psychiatric conditions severe enough to account for cognitive dysfunctions (eg, delirium, major depression, schizophrenia) because there have been unique screening measures for them and these patients are not our target participants.

Assessment

Detailed data on sociodemographic characteristics, lifestyle, medical history, current medications, and family history were collected. Questions about cognitive impairment included the time and mode of onset, possible triggers, affected domains, progression pattern, impact on daily activities, changes in mood or behavior, and response to treatment received. Then standardized general and detailed neurological examinations were performed on the participant. All participants underwent the MoCA Beijing version (www.mocatest.org). There are some cultural and linguistic modifications from the original English version, including (1) In the short-term memory recall task, 2 of the 5 words were replaced by more familiar words to elderly Chinese. Velvet was changed to silk and daisy to chrysanthemum. (2) In the verbal fluency task, phonemic letter fluency was replaced by animal category fluency test. The reason is Chinese words beginning with the same character tends to have interrelated meanings. Moreover, there are not enough words beginning with a character to test fluency. (3) English letters were replaced by Chinese ordinal characters in the trail-making test because many elderly Chinese cannot read English letters. (4) For the same reason, Arabic numerals replaced English letters in the attention task. A battery of neuropsychological and functional evaluations were also performed, including the World Health Organization–University of California Los Angeles Auditory Verbal Learning test,[12] the Chinese version of Mini-Mental State Examination,[13] the Clinical Dementia Rating (CDR),[14] Hachinski ischemic score,[15] the Functional Activities Questionnaire,[16] and the Centre for Epidemiological Studies Depression scale.[17] Laboratory tests and neuroimaging examinations were done when applicable. The MoCA was administered to a subgroup of 35 participants (12 CN, 12 patients with MCI, and 11 with dementia), twice at 1-month intervals to assess test–retest reliability. All data were collected by investigators specially trained for this study, including doctors, nurses, and medical students.

Diagnosis

At the end of each workday, the expert panel and interviewers reviewed all information collected and assigned final diagnoses. All diagnoses were determined by a team with at least 3 experienced physicians specialized in cognitive disorders. Diagnoses were made mainly based on the CDR and FAQ and were independently from the MoCA and MMSE. Other tests were considered for further analysis and for the subtype diagnosis.

Participants were considered as cognitively normal when they scored 0 on all the 6 domains assessed in CDR. Criteria for MCI included all the following elements: memory or cognitive complaint and at least one domain of CDR scored $\geq$0.5; global CDR score = 0.5 or 0; essentially preserved daily activities and social functions; no dementia. Both amnestic and nonamnestic MCI participants were included. Dementia was diagnosed according to *Diagnostic and Statistical Manual of Mental Disorders* (Fourth Edition, *DSM-IV*) criteria.[18] Alzheimer disease was diagnosed according to the criteria for probable AD as defined by the National Institute of Neurological Disorders and Stroke–Alzheimer's Disease and Related Disorders Association (NINCDS-ADRDA).[19] Vascular dementia was diagnosed according to the criteria for probable VD as defined by the National Institute of Neurological Disorders and Stroke–Association Internationale pour la Recherche et l' Enseignement en Neurosciences (NINDS-AIREN).[20] Participants with either MCI or dementia were considered cognitively impaired.

Data Analysis

Test–retest reliability of the MoCA was assessed using the intraclass correlation coefficient. The internal consistency was assessed with Cronbach α. Relationship between continuous variables was estimated using the Spearman correlation coefficient. Differences among groups were examined by general linear model for continuous variables and confounding factors were controlled with covariate analysis. Crosstab analyses were used for categorical variables. Significant demographic influential factors were considered in establishing normative data. Receiver–operating characteristic curves and area under

Table 1. Demographics Characteristics and Psychometric Measures

	Total n = 8411	CN n = 6283	MCI n = 1687	Dementia n = 441
Age,[a] years				
Estimated mean ± SE	73.0 ± 0.9	72.0 ± 0.8	75.1 ± 0.9	78.9 ± 1.5
Range	65-103	65-100	65-99	65-103
Gender,[b] weighted % ± SE				
Male	46.3 ± 0.6	47.9 ± 0.6	43.7 ± 0.9	31.3 ± 2.6
Female	53.7 ± 0.6	52.1 ± 0.6	56.3 ± 0.9	68.7 ± 2.6
Residence,[c] weighted % ± SE				
Urban	61.1 ± 15.8	64.3 ± 15.9	52.0 ± 15.8	49.9 ± 13.4
Rural	38.9 ± 15.9	35.7 ± 15.9	48.0 ± 15.8	50.1 ± 13.4
Education,[d] years				
Estimated mean ± SE	5.8 ± 1.1	6.7 ± 1.1	3.5 ± 1.0	2.5 ± 0.5
Range	0-22	0-22	0-20	0-19
MMSE[d]				
Estimated mean ± SE	24.3 ± 0.9	26.3 ± 0.6	20.4 ± 1.1	11.1 ± 1.0
Range	1-30	10-30	1-30	0-24
MoCA[d]				
Estimated mean ± SE	21.0 ± 1.3	23.8 ± 0.9	14.1 ± 1.3	5.9 ± 1.3
Range	0-30	7-30	1-29	0-23

Abbreviations: CN, cognitively normal people; MCI, mild-cognitive impairment; MMSE, Mini-Mental State Examination; MoCA, Montreal Cognitive Assessment; SE, standard error.
[a] CN < MCI < dementia, $P < .01$.
[b] CN < MCI < dementia, $P < .01$.
[c] CN < MCI = dementia, $P < .01$.
[d] CN > MCI > dementia, $P < .01$.

the curve (AUC) were used to compare the efficiency of the MoCA for differentiating cognitive impairments from CN with that of the MMSE. Optimal cutoff points for the MoCA were determined using the maximum value of (sensitivity + specificity − 1) in discriminating between CN and all cognitive impairments. With adjusted cutoff points, psychometric values for the MoCA were calculated in detecting MCI and dementia of different etiologies, including the specificity, sensitivity, positive likelihood ratio (PLR), and negative likelihood ratio (NLR). SPSS, version 15 (SPSS Inc; Chicago, Illinois) with complex sampling process was used to design and analyze the data. Data were treated as a stratified, 2-stage design. Weights were formed by multiplying selection probabilities produced from each sampling stage together with the inverse of the participation rate among eligible individuals. Estimates of means and proportions were weighted to the target population. Standard errors (SEs) were estimated using Taylor series approach.

Ethics Approval

The study was approved by the Ethics Committee of the Xuan Wu Hospital, Capital Medical University. All participants gave their written consent.

Results

Demographics

Demographic characteristics, the MMSE score, and the MoCA score of the participants are presented in Table 1. As expected, patients with MCI were significantly older than CN and were significantly younger than patients with dementia. Percentage of females was significantly higher in the dementia group and significantly lower in the CN group compared with the MCI group. Percentage of the rural was significantly higher in the dementia group than the MCI group and the CN group. Patients with MCI were significantly more educated than patients with dementia and significantly less educated than CN.

Reliability and Correlation With the MMSE

Test–retest intraclass correlation coefficient of the MoCA was excellent (0.96, 95% confidence interval [CI] 0.93-0.98) and internal consistency reliability (Cronbach α) was acceptable (0.85, 95% CI 0.845-0.855), indicating the MoCA is a stable and consistent tool. The Spearman correlation coefficient between the MoCA score and the MMSE score was good (0.83, 95% CI 0.82-0.84), demonstrating adequate level of concurrent validity.

Demographic Factors Influencing the MoCA

Years of education ($r = .65$, 95% CI 0.64-0.66, $P < .01$) and age ($r = -.32$, 95% CI [–0.30]-[–0.34], $P < .01$) were correlated with the MoCA score. A general linear model proved the significant effect of education, age, place of residence, and sex on MoCA in CN group. Individuals with lower education level performed worse than individuals with higher education level.

Table 2. Montreal Cognitive Assessment Norms According to Age, Sex, Education, and Urban or Rural Residence[a], n = 6283

	65-69 n = 2375		70-74 n = 2001		75-79 n = 1294		80 and over n = 613	
Age, years	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
Education, years								
0								
Male	n = 12	n = 36	n = 23	n = 50	n = 25	n = 46	n = 14	n = 20
n = 226	21.9 ± 0.6	21.0 ± 0.3	22.0 ± 0.4	19.8 ± 0.4	21.5 ± 1.3	17.1 ± 0.6	19.3 ± 0.4	16.0 ± 1.2
Female	n = 68	n = 210	n = 127	n = 160	n = 112	n = 159	n = 70	n = 87
n = 993	21.3 ± 0.7	17.8 ± 0.4	21.1 ± 1.2	16.8 ± 0.3	20.2 ± 1.0	16.6 ± 0.4	19.1 ± 0.6	15.9 ± 0.5
1-5								
Male	n = 41	n = 114	n = 84	n = 103	n = 83	n = 88	n = 65	n = 41
n = 619	24.8 ± 0.8	22.9 ± 0.6	24.7 ± 0.4	22.9 ± 0.3	23.7 ± 0.4	21.7 ± 0.5	22.9 ± 0.3	20.9 ± 0.6
Female	n = 98	n = 234	n = 147	n = 99	n = 90	n = 53	n = 51	n = 10
n = 782	24.2 ± 0.8	21.5 ± 0.4	23.9 ± 0.7	19.6 ± 0.5	22.6 ± 0.6	19.6 ± 0.4	21.9 ± 0.5	17.6 ± 1.4
6-9								
n = 2123	n = 577	n = 413	n = 521	n = 172	n = 273	n = 47	n = 97	n = 23
	26.2 ± 0.3	24.5 ± 0.6	25.6 ± 0.5	23.4 ± 0.4	25.0 ± 0.4	23.0 ± 0.6	23.4 ± 0.4	20.6 ± 0.5
10 and over								
n = 1540	n = 509	n = 63	n = 496	n = 19	n = 310	n = 8	n = 128	n = 7
	27.4 ± 0.2	26.1 ± 0.5	27.1 ± 0.3	25.5 ± 0.8	26.8 ± 0.3	24.5 ± 1.0	26.5 ± 0.4	23.2 ± 1.4

Abbreviation: SE, standard error.

[a] Data reported as n (unweighted sample size), estimated mean ± SE. Montreal Cognitive Assessment (MoCA) data were not exhibited considering gender in participants with more than 5 years of education because the gender difference in MoCA score was not clinically significant in these participants, while it was in those with 5 years of education or less.

Table 3. Discriminative Validity of the MoCA (with 95% confidence interval) Between Different Cognitive Disorders and CN

Groups Compared	Sensitivity, %	Specificity, %	PLR	NLR
CN versus cognitive impairments	83.8 (82.4-85.2)	82.5 (81.7-83.3)	4.79 (4.55-5.04)	0.20 (0.18-0.21)
CN versus MCI	80.5 (78.7-82.1)	82.5 (81.7-83.3)	4.60 (4.36-4.84)	0.24 (0.22-0.26)
CN versus Dementia	96.9 (95.0-98.0)	82.5 (81.7-83.3)	5.53 (5.26-5.82)	0.04 (0.02–0.06)
CN versus AD	96.6 (94.2-98.0)	82.5 (81.7-83.3)	5.52 (5.24-5.81)	0.04 (0.02-0.07)
CN versus VD	97.1 (92.7-98.9)	82.5 (81.7-83.3)	5.54 (5.24-5.86)	0.04 (0.01-0.09)

Abbreviations: AD, Alzheimer disease; CN, cognitively normal people; MCI, mild cognitive impairment; MoCA, Montreal Cognitive Assessment; NLR, negative likelihood ratio; PLR, positive likelihood ratio; VD, vascular dementia.

Older individuals performed worse than younger individuals. Urban residents scored better than rural residents even after controlling for age, education, and sex (difference of estimated mean = 2.5, $P < .01$). Men scored better than women even after controlling for age, years of education, and place of residence in individuals with 5 years of education or less (difference of estimated mean = 1.6, $P < .01$). However, the gender difference in MoCA score was not clinically significant in participants with more than 5 years of education (difference of estimated mean = 0.3, $P = .10$).

Normative Data of the MoCA

Table 2 shows normative data of the MoCA grouped by age, sex, education, and place of residence of the 6283 cognitively normal participants, exhibiting a low average and broad range in both years of education and MoCA score.

Optimal Cutoff Points and Validity of the MoCA

Using the recommended 1-point correction for individuals with 12 years or less of education and a cutoff of 25/26, the MoCA could detect 98.4% of cognitively impaired participants but with a specificity of only 52.2% for identifying CN. Therefore, the cutoff points need to be adjusted. Considering that education was the strongest noncognitive factor influencing the MoCA, the optimal MoCA cutoff points were determined according to education level. For individuals with no formal education, the most appropriate MoCA cutoff was 13/14 (n = 2279, sensitivity 80.9% and specificity 83.2%); for individuals with 1 to 6 years of education, the most appropriate MoCA cutoff was 19/20 (n = 3085, sensitivity 83.8% and specificity 82.5%); and for individuals with 7 or more years of education, it was 24/25 (n = 3047, sensitivity 89.9% and specificity 81.5%).

Applying the adjusted cutoff points, as shown in Table 3, the sensitivity of the MoCA was 83.8% for all cognitive

impairments, 80.5% for MCI and 96.9% for dementia (96.6% for AD and 97.1% for VD), and the specificity for identifying CN was 82.5%. The MoCA showed acceptable PLRs and good NLRs for MCI and good PLRs and excellent NLRs for dementia.

After controlling for the 4 significant influential factors of years of education, age, place of residence and sex, as shown in Table 1, both the mean MoCA scores (estimated mean ± SE score, 23.2 ± 0.2 for CN, 15.8 ± 0.5 for MCI, and 8.8 ± 1.1 for dementia) and the mean MMSE scores (estimated mean ± SE score, 25.9 ± 0.2 for CN, 21.5 ± 0.5 for MCI, and 13.1 ± 0.9 for dementia) of 3 groups differed significantly from one another ($P < .01$). Comparing the MCI and CN groups, the estimated mean difference in MoCA score (7.4) was larger than that in MMSE (4.4). Figure 1 presents that the AUC was much larger for the MoCA than MMSE in differentiating MCI from CN (0.899, 95% CI 0.891-0.907 vs 0.842, 95% CI 0.831-0.852; $P < .05$). There was no significant AUC difference between the MoCA and MMSE in differentiating dementia from CN (0.986, 95% CI 0.982-0.990 vs 0.985, 95% CI 0.981-0.989; $P > .05$). Therefore, the MoCA was better able to differentiate MCI from CN and similarly powerful in screening for dementia compared with the MMSE.

Discussion

Though the MoCA has been used in some clinical settings in China, its norms have never been established in large sampled older community dwellers. In this study, we applied the MoCA to individuals from multicenter communities of China and norms were established for the MoCA in elderly Chinese. These reference values can be used to evaluate how well an individual compares with the general cognitively intact population.

It is well known that validity of cognitive screening tools can be influenced by demographic variables. In previous studies, educational level was consistently believed to be the strongest noncognitive factor affecting MoCA score. As for age and gender, the results were conflicting.[7,8,11] In present study, however, all 4 factors (education, age, urban or rural residence, and sex) showed significant and direct effect on the MoCA score. Less education correlated with worse performance of the MoCA. The MoCA score declined with age increase. Urban residents scored much better than rural residents. Though small, the gender difference in MoCA score was still statistically and clinically significant in participants with less education. More demographic factors affected the MoCA in this study possibly because older Chinese, rural residents, and women tended to have less exposure to current information and lower socioeconomic status, which could all interfere with their ability to complete questionnaires. Therefore, all these 4 factors should be taken into account when establishing normative data for the MoCA.

In addition, we want to stress that the average MoCA score of CN was much lower in this study (23.7) than in the original study (above 28).[5] This could be caused by the very low scores

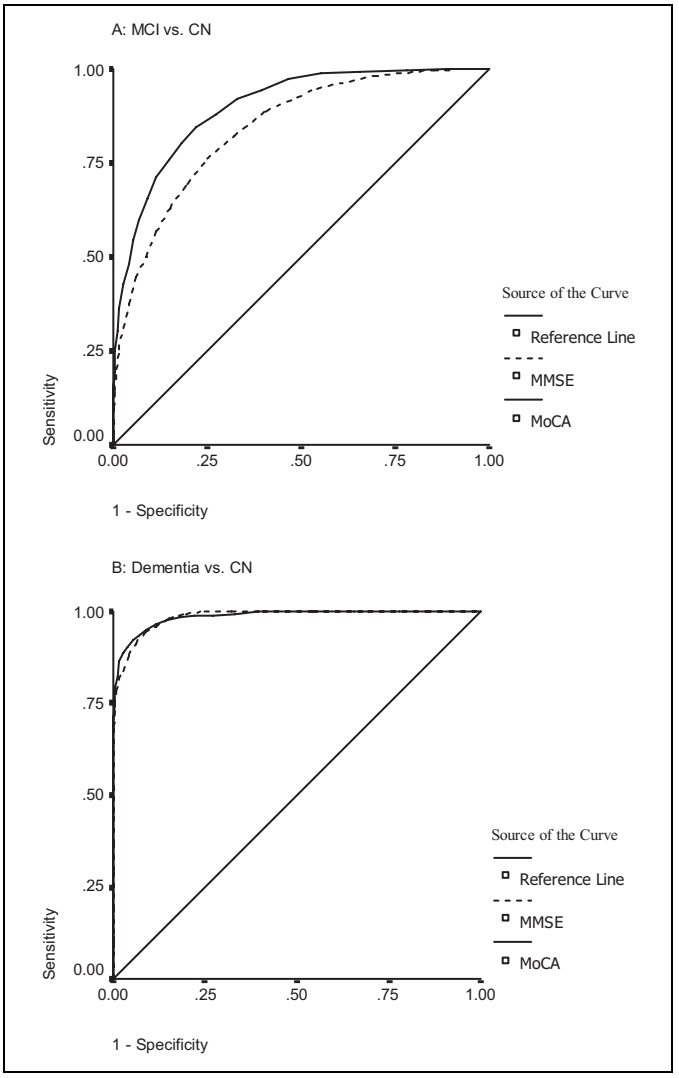

Figure 1. Receiver–operating characteristic curves of MoCA and MMSE for differentiating between MCI and CN (A) and dementia and CN (B). A, The AUC was larger for the MoCA than MMSE in differentiating MCI from CN (0.899, 95% CI 0.891-0.907 vs 0.842, 95% CI 0.831-0.852; $P < .01$). B, There was no significant AUC difference between the MoCA and MMSE in differentiating dementia from CN (0.986, 95% CI 0.982-0.990 vs 0.985, 95% CI 0.981-0.989, $P > .05$). AUC indicates area under the curve; CN, cognitively normal people; MCI, mild cognitive impairment; MMSE, Mini-Mental State Examination; MoCA, Montreal Cognitive Assessment.

of elderly Chinese on several subtests. Reasons may include that the trail making and cube copying test are unfamiliar to elderly Chinese, and the 2 sentences for repeating, which were translated from English with minor revision, are too unwieldy or complicated for Chinese syntax. Moreover, estimated mean years of education was much less in CN of this study (6.7) than mean years of education of the original study (13.3), which could also affect scores on MoCA and its subtests.

Given the low average and broad range in both education level and MoCA score, it is easy to understand why the recommended cutoff[5] of 25/26 was not applicable to elderly Chinese (high sensitivity of 98.4% for cognitive impairment, but low

specificity of 52.2% for identifying CN). We therefore developed optimal MoCA cutoff points based on education level (13/14 for individuals with no formal education, 19/20 for individuals with 1 to 6 years of education, and 24/25 for individuals with 7 or more years of education). In other studies, 22/23 was used for the MoCA Korean version[6] and 24/25 for the MoCA in community dwellers of the Southeastern United States.[8] Their adjusted cutoff points were also lower than the original. These changes were necessary to serve culturally diverse populations with different education levels. Notably, we applied the MoCA to individuals with less education and established an ideal cutoff point for them because they represent a considerable proportion of the population in China, whereas other studies usually excluded illiterates. The MoCA still had lower sensitivity for detecting cognitive impairments in participants with less education than the sensitivity in participants with more education with their individual optimal cutoff points, confirming that poor education limited its applicability. Like most studies, this study provided no cutoff point separating MCI from dementia, although their MoCA scores differed significantly. This was because the distinction between MCI and dementia should be determined on the basis of functional impairment due to cognitive decline and not a certain MoCA score.

With optimal cutoff points, the MoCA effectively detected 83.8% of all cognitive impairments, 80.5% of MCI, and 96.9% of dementia in the entire sample. Its sensitivity for dementia was as high as that previously reported (93%-100%),[5-11] while its sensitivity for MCI was lower than that for amnestic MCI in most of the previous studies (89%-96%),[5-9] with a specificity of 82.5% for identifying CN, which was also lower than others. Performance of the MoCA in screening for MCI may be weakened by the considerable overlap in the MoCA scores between CN and MCI in this study, which was also attributed to the broad range and low average in MoCA score of CN. Furthermore, concept of MCI in this study included all the individuals whose cognitive level was between cognitively normal and dementia but not only those with amnestic MCI, which may also affect its performance. The MoCA showed acceptable PLRs and good NLRs for MCI, good PLRs and excellent NLRs for dementia, and fulfilled the screening tool requirement that a negative result reliably predicts normal cognitive function.

One limitation of this study is that the unequal size of the CN, MCI, and dementia groups derived from the community population may compromise the statistical ability of between-group comparisons. This shortcoming might be ignored inasmuch as we actually got positive results in most comparisons. Moreover, to minimize its effects, LR values were used to evaluate validity of the MoCA because they do not depend on disease prevalence and can be compared between different populations or settings.[21-23]

In summary, population-based MoCA norms considering significant demographic factors were established for elderly Chinese. Optimal cutoff points were also developed inasmuch as the recommended cutoff point was not applicable to elderly Chinese. With adjusted cutoffs, the MoCA proved to be a valid instrument to screen for MCI and dementia in Chinese older community population.

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Authors' Note

Jianping Jia supervised this study and is the guarantor. Jihui Lu and Dan Li conceived the idea and designed the methods. All authors participated in data collection. Jianping Jia, Jihui Lu, and Dan Li interpreted the data and carried out the statistical analysis. Jihui Lu prepared the manuscript and Jianping Jia revised the manuscript. All authors assisted with the preparation of manuscript. Xiang-Fei Jia helped with the data computerization and analysis. Jihui Lu and Dan Li contributed equally.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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