

Reliability and Validity of the Modified Mini Cog: A Measure for Screening Cognitive Functions in Literates and Non-literates

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ABSTRACT

Background: The original Mini Cog was modified to make it applicable to non-literates as well. However the reliability and validity of the modified mini cog (MMC) has not been examined. Therefore, we aimed to investigate the intra- and inter-rater reliability, criterion validity, sensitivity and specificity of the MMC.

Methods: In this methodological and repeated measures design, elderly individuals (>60 years) with no neurological diagnosis or adults (>18 years) with neurological diagnosis were recruited from a tertiary hospital and the local community using purposive and snowball sampling. One of the raters administered the MMC twice (one week apart). Another rater administered the MMC and the Rowland Universal Dementia Assessment Scale (RUDAS) once during the first assessment session.

Results: The ICC for consistency of a rater across the tests and absolute agreement between two raters ranged from 0.97-0.99. The MMC scores of two raters were not significantly different. The MMC was able to differentiate between elderly participants with no neurological diagnosis and adult participants with neurological diagnosis. A significant correlation (Coefficients: 0.52-0.68) was found between the MMC and RUDAS. The sensitivity and specificity of the MMC were 86% and 70% respectively. The cutoff score of the MMC was found ≤ 3 .

Conclusions: We demonstrated an excellent intra- and inter-rater reliability, and adequate criterion validity, sensitivity and specificity of the MMC. The MMC was also able to discriminate various groups having varied level of cognitive dysfunction. However, further studies are warranted to get more insight into the value of this instrument.

Keywords: Modified mini cog; reliability; sensitivity; specificity; validity.

INTRODUCTION

It is recognized that the aging of the population leads to an increase in the incidence of cognitive impairments¹ a clinical manifestation that precedes dementia.² Furthermore, cognitive impairments are common in a variety of neurological disorders such as stroke, traumatic brain injury, Alzheimer's disease, Parkinson's disease and psychiatric conditions including schizophrenia.³ Early detection of cognitive impairments is crucial for determining whether an individual is at risk of developing dementia, access to appropriate treatments, and delaying cognitive deterioration.⁴

The Mini Cog is a very short and simple cognitive screening tool that comprises a memory test and a clock-drawing task (CDT).⁵ The CDT is highly influenced by education and hence may not be valid for non-literate individuals. Therefore, Adhikari and colleagues developed a Modified Mini Cog (MMC) test for use with non-literate and literate individuals.⁶ The MMC replaced the CDT in the mini cog with two alternate distractor tasks of everyday life; a Serial Subtraction Task (SST) or a Multistep Performance Task (MPT) and, thereby, improved its validity in non-literate individuals. A preliminary validation of the MMC was also established by demonstrating a good association with the dementia severity rating scale.⁶

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One of the important characteristics of an ideal cognitive tool is having sound psychometric properties, including reliability and validity. The current study investigated intra-rater as well as inter-rater reliability, criterion validity, sensitivity and specificity of the MMC. Additionally, a cutoff score of the MMC was also determined.

METHODS

In this methodological and repeated measures design, individuals were recruited if they met the following criteria: 1) Elderly individuals (>60 years of age) with no neurological diagnosis or adults (>18 years of age) with a neurological diagnosis (stroke, traumatic brain injury, Parkinson's disease, intracranial tumors, Alzheimer's disease or combination of them) that could lead to cognitive decline or higher function deficits, 2) Ability to understand the questions asked (in their own native language) and respond to the interviewer. Those participants who answered "No" to the question; "Have you ever been diagnosed with any neurological conditions?" were enrolled under elderly individuals with no neurological conditions. This probing question was asked to the participant directly or to the participants' close relatives in case participants could not answer or participants were non literates. Those individuals who were unconscious or medically and surgically unstable at the time of assessment, or had medical comorbidities that could influence administration of the assessment tools were excluded from the study. Those who could read, write and understand were considered literates and those who could not were considered non-literates. Participants were recruited from a tertiary level teaching hospital located at the sub-urban region (where people could have easy access from urban as well as rural regions of the country) and from the local community using purposive and snowball sampling techniques.

The assessment tools used in this study are as follows:

The Modified Mini Cog (MMC) test: The MMC was administered based on the provided instructions, and scored using the scoring guidelines.⁶ The strength of the association between the MMC (either with the SST or MPT) and the dementia severity scale tested by Adhikari and colleagues ranged from 0.7 to 0.9.⁶ Therefore, the first distractor was administered following three-word registration. The 2nd distractor was considered at times when participants were unable to perform the 1st distractor by any reason. The highest score obtained out of two was considered for analysis.

Rowland Universal Dementia Assessment Scale (RUDAS) - Nepali version: The Rowland Universal Dementia Assessment Scale (RUDAS)⁷ is a short cognitive screening instrument designed to minimize the effects of cultural learning and language diversity on the assessment of baseline cognitive performance. It consists of six items; memory, visuo-spatial orientation, praxis, visuo-constructional drawing, memory recall, and language. The total maximum score is 30 points. Any score of 22 or less should be considered as possible cognitive impairment. The inter-rater and test-retest reliability of the RUDAS was found to be excellent (0.98 to 0.99). The original RUDAS has been cross-culturally adopted for the Nepali language,⁸ which has been used in this study. The Nepali RUDAS (N-RUDAS) has acceptable internal consistency (Cronbach's alpha = 0.7), a sensitivity of 81.5% and specificity of 76.06%.

Ethical approval was received from an Institutional Review Committee, Kathmandu University School of Medical Sciences (IRC-KUSMS: 122/18, 53/20, 55/20), Dhulikhel, Nepal. Written informed consent was obtained from each participant prior to data collection. Two physiotherapy interns trained for the administration of the MMC and the RUDAS assessed each participant independently. Details on the procedure are presented in **Figure 1**.

To achieve a moderate positive correlation (effect size: 0.4) with 85% power, and alpha level at 0.05, we required total 80 participants. By considering 10% drop out rate, we enrolled 88 participants; 44 participants (22 literates and 22 non-literates) in each group (with and without neurological diagnosis). However, only 80 participants; 37 with no neurological diagnosis (19 literates, 18 non-literates) and 43 with Neurological diagnosis (23 literates and 20 non-literates) completed the study.

The mean and standard deviation or number and percentages were calculated to summarize the MMC score and characteristics of the participants. Data were examined for normality using the Kolmogorov-Smirnov test. The difference between raters for the MMC score was compared using the Mann Whitney U test and the difference between test and retest scores of rater 1 was compared using the Wilcoxon signed-rank test.

To establish reliability, the intra-class correlation coefficients (ICC) were examined. The ICC_{2,1} and ICC_{3,1} were calculated for inter-rater and intra-rater reliability respectively. The standard error of measurement (SE) was calculated using the formula; $SE = SD \cdot \sqrt{1 - ICC}$.⁹ The

following classification was used for the interpretation of the ICC values: poor reliability ICC < 0.50, moderate reliability ICC

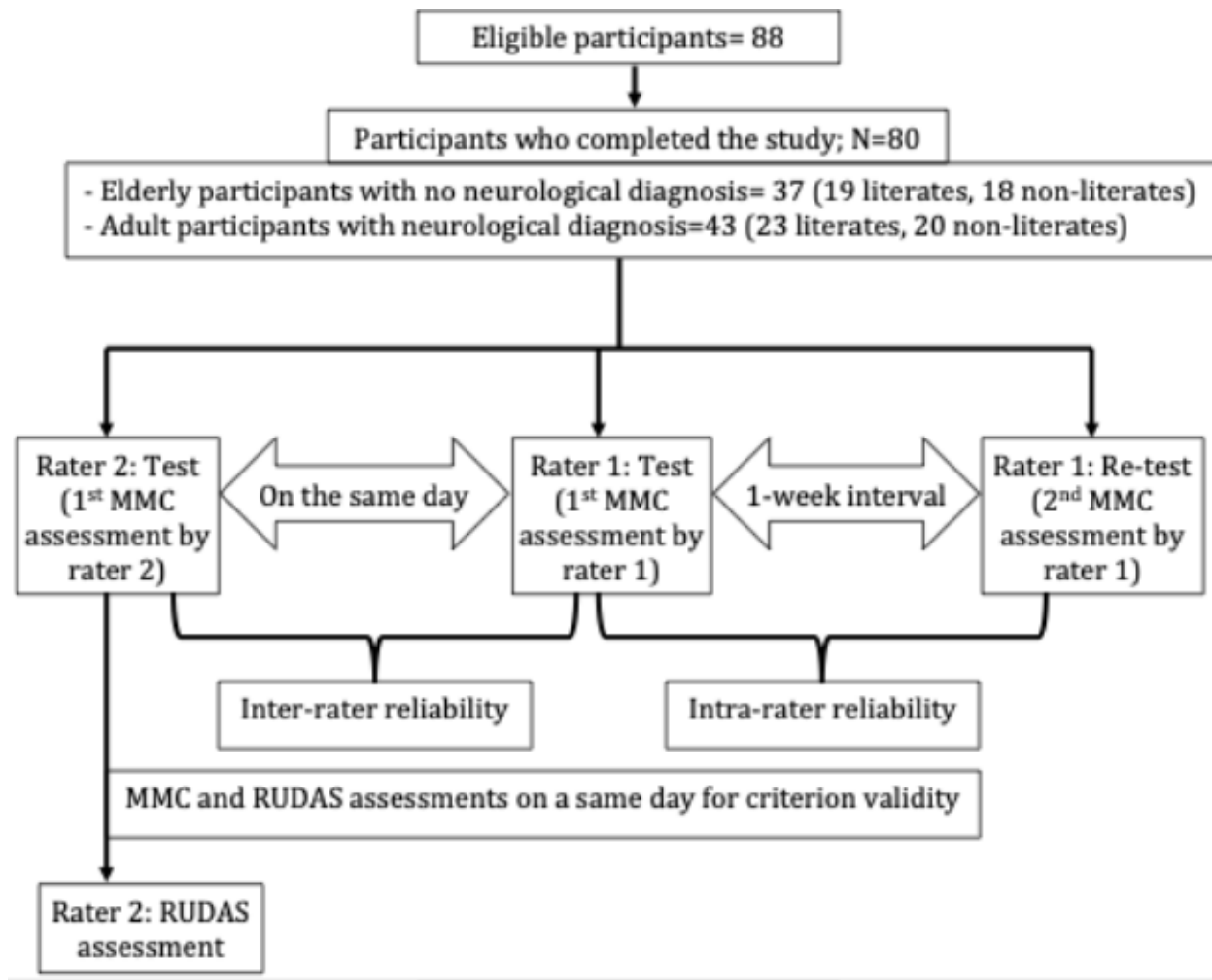


Figure 1. Process flow chart. MMC: Modified Mini Cog, RUDAS: Rowland Universal Dementia Assessment scale - Nepali version. As shown in the figure: Test of Rater 1 and Test of Rater 2 were used to assess inter-rater reliability. Test of Rater 1 and Retest of Rater 1 were used to assess intra-rater reliability. MMC test of Rater 2 and RUDAS test of Rater 2 were used to assess criterion validity.

between 0.50 and 0.75, good reliability between >0.75 and 0.90, and excellent reliability ICC > 0.90.¹⁰

Pearson product-moment correlation coefficient (Pearson’s *r*) was calculated to establish the criterion validity of the MMC with RUDAS. Receiver Operating Characteristic curve analysis was performed to test the sensitivity and specificity and to obtain an optimal cutoff value.

Multiple linear regressions were conducted to examine the relationships among demographic characteristics and the total MMC scores.

Two-tailed significance levels were set at *p* < 0.05. All statistical analyses were performed using the SPSS version 29.0 (IBM Corp, Armonk, NY).

RESULTS

Table 1. Characteristics of the participants.

Characteristics	Full sample	Sub-samples			
		Based on the diagnosis		Based on the literacy	
		Elderly participants with no neurological diagnosis	Adult participants with neurological diagnosis	Literates	Non-literates
Number of participants	80	37	43	42	38
Age (year); mean \pm SD	58.6 \pm 16.3	67.1 \pm 5.5	51.4 \pm 18.8	53.7 \pm 20.1	64.1 \pm 7.6
Sex; frequency (%)					
Male	52 (65)	21 (56.8)	31 (72.1)	36 (85.7)	16 (42.1)
Female	28 (35)	16 (43.2)	12 (27.9)	6 (14.3)	22 (57.9)
Education; frequency (%)					
Non-literates	38 (47.5)	18 (47.4)	20 (52.6)		
Literates	42 (52.5)	19 (45.2)	23 (54.8)		
Pre-primary	7 (16.7)	3 (15.8)	4 (17.4)	-	-
Primary	9 (21.4)	5 (26.3)	4 (17.4)		
Secondary	21 (50.0)	11 (57.9)	10 (43.5)		
University or higher education	5 (11.9)	0	5 (21.7)		
Occupation; frequency (%)					
Farmer/house- wife/ husband	39 (48.8)	20 (54.1)	19 (44.2)	9 (21.4)	30 (78.9)
Driver or labor	7 (8.8)	1 (2.7)	6 (14.0)	6 (14.3)	1 (2.6)
Teacher/officer/student	11 (13.8)	3 (8.1)	8 (18.6)	11 (26.2)	0
Business	12 (15.0)	8 (21.6)	4 (9.3)	10 (23.8)	2 (5.3)
Others	11 (13.8)	5 (13.5)	6 (14.0)	6 (14.3)	5 (13.2)
Neurological diagnosis; frequency (%)					
No neurological diagnosis	37 (46.2)			19 (45.2)	18 (47.4)
With neurological diagnosis	43 (53.8)			23 (54.8)	20 (52.6)
Stroke or TIA	19 (44.2)			10 (43.5)	9 (45.0)
Traumatic brain injury	16 (37.2)	-	-	8 (34.8)	8 (40.0)
Brain tumor	2 (4.7)			1 (4.3)	1 (5.0)
Brain tumor	1 (2.3)			0	1 (5.0)
Parkinson's disease	5 (11.6)			4 (17.4)	1 (5.0)
Other or multiple diagnosis					

Note: TIA: Transient Ischemic Attack; SD: Standard Deviation.

A total of 80 participants were completed the study. The mean age of the sample was 58.6 years \pm 16.3, which was lower than the mean age in the subsample of elderly participants with no neurological diagnosis but higher than the mean age of adult participants with neurological diagnosis, literate as well as non-literate subsamples. More than half of the participants in the sample (65%) were male. Whereas, the majority of non-literate participants (58%) were females. Approximately half of the participants in the sample (n=38, 47.5%) were non-literate - this was true even in the subsample of elderly participants with no neurological diagnosis (n=18, 48.6%), and adult participants with neurological diagnosis (n=20, 46.5%) as well. About 79% of participants in the non-literate subsample were farmers, housewives, or househusbands by occupation, which was higher than the percentage of these occupations

in all other subsamples. The subsample of adult participants with neurological diagnosis included participants with stroke, traumatic brain injury, brain tumor, Parkinson's disease and a combination of two or more these conditions. Approximately, half of them ($n = 19$, 44%) were patients with stroke and over one third ($n = 16$, 37%) were patients with traumatic brain injury.

The ICC for consistency of the raters across the tests and absolute agreement between the two raters ranged from 0.97 to 0.99. The reliability is excellent in the sample of total participants as well as in various subsamples as shown in **Tables 2 and 3**. The small standard errors of measurement indicated minimal random or systematic error. The MMC scores of rater 1 and rater 2 were not significantly different ($U = 3137$, $p = 0.82$). The MMC scores of rater 1 at test and retest were also not significantly different ($Z = -0.3$, $p = 0.76$). These findings further strengthen the excellent intra- and inter-rater reliability demonstrated by the ICC values.

Table 2. Intra-class Correlation Coefficient in examining consistency between test and retest.

Samples	MMC score (Mean \pm SD)		ICC _{3,1}	SE	95% CI	Intra-rater Reliability
	Test	Retest				
Full sample (N = 80)	3.36 \pm 1.33	3.38 \pm 1.32	0.98	0.19	0.969-0.987	Excellent
Sub-sample: Elderly participants with no neurological diagnosis (n = 37)	3.67 \pm 1.14	3.78 \pm 1.06	0.99	0.11	0.989-0.997	Excellent
Sub-sample: Adult participants with neurological diagnosis (n = 43)	3.02 \pm 1.41	3.02 \pm 1.44	0.97	0.24	0.944-0.984	Excellent
Sub-sample: Literates (n = 42)	3.71 \pm 1.22	3.74 \pm 1.19	0.97	0.21	0.944-0.984	Excellent
Sub-sample: Non-literates (n = 38)	2.97 \pm 1.37	2.97 \pm 1.37	0.98	0.19	0.972-0.992	Excellent

Note: ICC: Intra-class Correlation Coefficient; MMC: Modified Mini Cog; SE: SD: Standard error; Deviation; N: total number of participants; n: number of participants in the sub-samples; CI: Confidence Interval

Table 3. Intra-class Correlation Coefficient in examining absolute agreement between two raters.

Samples	MMC score (Mean \pm SD)		ICC _{2,1}	SE	95% CI	Inter-rater Reliability
	Rater 1	Rater 2				
Full sample (N = 80)	3.36 \pm 1.33	3.44 \pm 1.24	0.98	0.19	0.970-0.988	Excellent
Sub-sample: Elderly participants with no neurological diagnosis (n = 37)	3.67 \pm 1.14	3.78 \pm 1.06	0.99	0.11	0.989-0.997	Excellent
Sub-sample: Adult participants with neurological diagnosis (n = 43)	3.02 \pm 1.41	3.14 \pm 1.32	0.97	0.24	0.946-0.984	Excellent
Sub-sample: Literates (n = 42)	3.71 \pm 1.22	3.79 \pm 1.16	0.98	0.17	0.976-0.993	Excellent
Sub-sample: Non-literates (n = 38)	2.97 \pm 1.37	3.05 \pm 1.23	0.97	0.24	0.946-0.985	Excellent

Note: ICC: Intra-class Correlation Coefficient; MMC: Modified Mini Cog; SE: SD: Standard error; Deviation; N: total number of participants; n: number of participants in the sub-samples; CI: Confidence Interval

The validation of the MMC test was described comparing the mean scores of different groups. The MMC was able to differentiate between elderly participants with no neurological diagnosis and adult participants with neurological diagnosis (test of rater 1: $U=546.0$, $p=0.01$; retest of rater 1: $U=547.5$, $p=0.01$; test of rater 2: $U=562.0$, $p=0.02$) and also between literate and non-literate individuals (test of rater 1: $U=546.0$, $p=0.01$; retest of rater 1: $U=533.0$, $p=0.008$; test of rater 2: $U=529.0$, $p=0.007$). Thus, the MMC was able to differentiate between various levels of cognitive functions.

A significant correlation was found between the MMC and RUDAS in the sample of total participants ($r = 0.67$, $p < 0.001$), in the subsamples of elderly participants with no neurological diagnosis ($r = 0.52$, $p = 0.001$) and in adult participants with neurological diagnosis ($r = 0.68$, $p < 0.001$). The higher the score in the MMC, the higher is the score in the RUDAS and vice versa. The positive moderate correlation suggests a good criterion validity of the MMC.

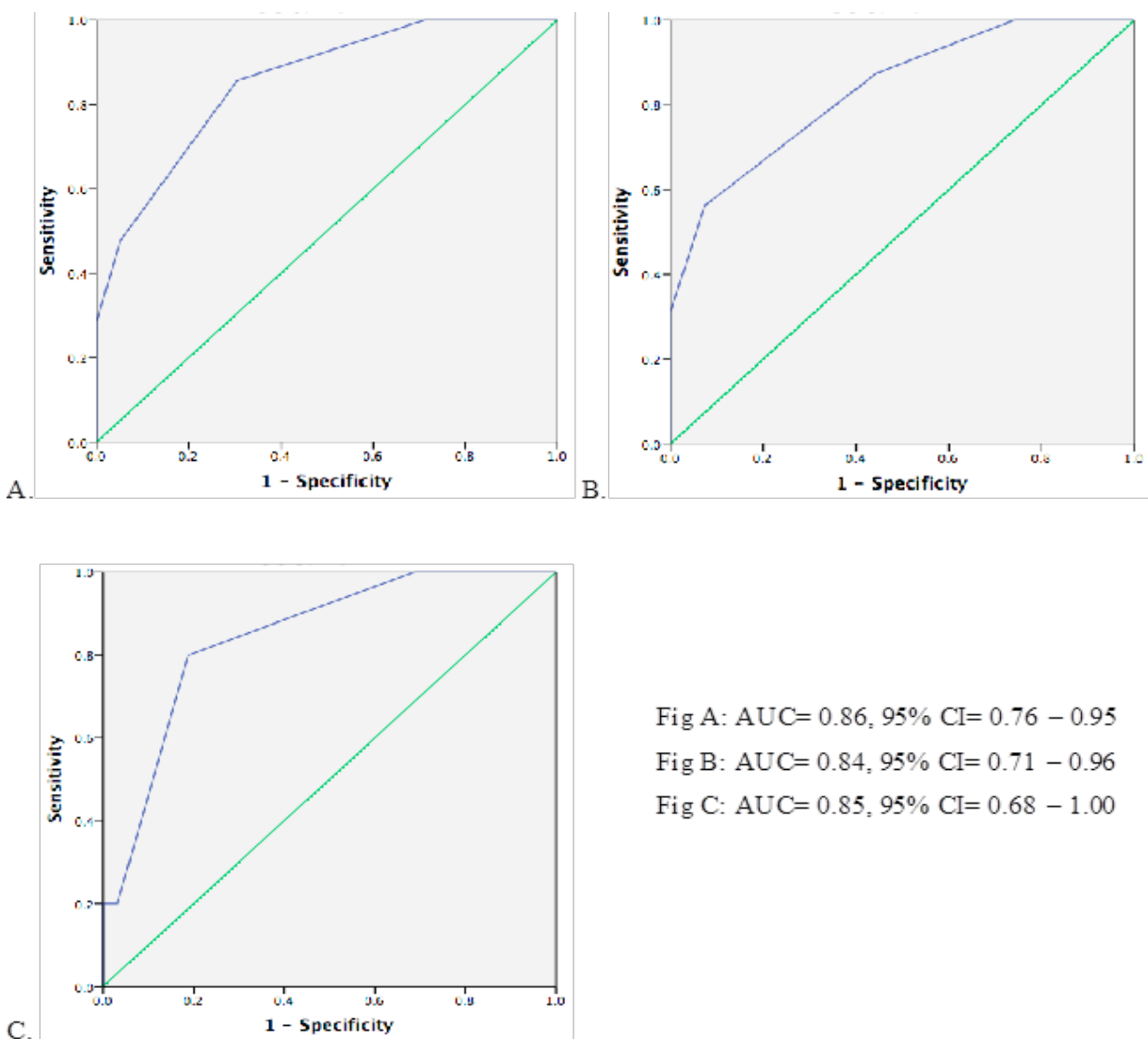


Figure 2: Receiver Operating Characteristic (ROC) curve; A: In a sample of total participants (N = 80); B: In sub-sample of adult participants with neurological diagnosis (n = 43); C: In sub-sample of elderly participants with no neurological diagnosis (n = 37); AUC: Area under the curve

The Area Under the Curve (AUC) ranged from 0.84 to 0.86 ($p < 0.001$) (Figure 2). These AUC values suggested good predictive validity of the MMC. The higher AUC values indicated that the model well distinguished between positive and negative outcomes. The cutoff score of the MMC was

found to be ≤ 3 in the sample and subsamples as well. The sensitivity and specificity of the MMC were found 86% and 70% in the total sample, 88% and 57% in subsample of adult participants with neurological diagnosis and 80% and 81% in the subsample of elderly participants with no neurological diagnosis respectively.

Table 4. Multiple linear regressions examining influence of various demographic characteristics on the modified min cog score. (N = 80)

Predictors	Beta Coefficient	95% CI	P-value
A) When outcome variable: MMC score of rater 1, exposure variables: Age, Sex, Literacy, and Education			
Age	-0.008	-0.03 to 0.01	0.39
Sex	0.23	-0.44 to 0.91	0.49
Literacy	-0.11	-1.40 to 1.17	0.86
Education	0.34	-0.11 to 0.78	0.14
B) When outcome variable: MMC score of rater 2, exposure variables: Age, Sex, Literacy, and Education			
Age	-0.01	-0.03 to 0.007	0.26
Sex	0.15	-0.47 to 0.77	0.63
Literacy	-0.17	-1.35 to 1.01	0.77
Education	0.34	-0.07 to 0.75	0.12

Note: MMC: Modified Mini Cog, CI: Confidence Interval, N: total number of participants

Additionally, we were interested in better understanding how different factors - age, sex, literacy and education - contributed to the total MMC scores of both raters. As shown on Table 4, neither age, sex, literacy, nor education demonstrated statistically significant associations with the total MMC score. These findings indicated that the MMC scores were not significantly influenced by those demographic characteristics and thus the MMC tool can be suitable for testing cognitive functions of individuals with a wide range of age, education as well as for both sexes, literate and non-literate individuals.

DISCUSSION

The objectives of the current study were to determine intra-rater as well as inter-rater reliability, criterion validity, sensitivity and specificity of the MMC. The results demonstrated an excellent (0.97 to 0.99) intra-rater as well as inter-rater reliability, which indicated an excellent consistency of raters across the tests and an absolute agreement between the two raters. Statistically significant positive correlations (0.5 to 0.7) were found between the MMC and RUDAS, which indicated an adequate criterion validity of the MMC. The MMC was also able to discriminate various groups having different levels of cognitive functions, thereby establishing the validity of the MMC. We determined a cutoff score of (≤ 3) the tool. The sensitivity and specificity of the tool was found to be adequate (sensitivity + specificity = > 1.5). Additionally, this study demonstrated that the MMC test is not significantly influenced by age, sex, literacy and education level and thus we argue that the

MMC is a suitable tool for testing cognitive functions in heterogeneous populations.

This is the first study to examine the reliability and validity of the MMC. Therefore, there is a lack of previous literature to make a direct comparison of the findings of the present study. So, the discussion below is mainly focused in comparing our findings with the psychometric properties of the original and various cross-culturally adapted Mini Cog versions.

The excellent inter- and intra-rater reliability achieved in this study is consistent with the reliability demonstrated in the original Mini Cog study (0.9). These values are much larger than the minimal expected ICC value (0.7).¹¹ Other cross-culturally adapted versions of the Mini Cog such as Thai^{12, 13} and Persian¹⁴ versions have also shown good reliability similar to the present study. Consistent with our study, the Mini Cog was found to be reliable tool in screening cognitive functions in

various cohorts such as elderly individuals,¹⁴ individuals with mild cognitive impairments¹⁵ and population with dementia.¹⁶ This evidence indicates that the MMC could be a reliable tool in screening cognitive functions in the elderly population, and in people with cognitive impairments due to various causes such as dementia, stroke, traumatic brain injury, and Parkinson's diseases.

In our earlier work published recently,⁶ we had demonstrated the preliminary validation of the MMC by comparing it with the Dementia Severity Rating Scale (DSRS). The correlation coefficient of the MMC found in the study while comparing with the DSRC (0.7 to 0.9) is consistent with the correlation we found in the present study while comparing with the RUDAS (0.67). There are only two studies to date which demonstrated the criterion validity of the MMC. Thus, the correlations established in these studies confirms the criterion validity of the MMC. On the other hand, the correlation coefficient obtained in this study (0.68) is almost double the coefficient obtained in the Persian version of the Mini Cog (0.39). This could be because the original Mini Cog is significantly influenced by the education whereas the MMC has been derived in such a way that it is least influenced by education.⁶ Additionally, the mean scores of the MMC have been compared across various groups in the present study and the MMC was able to differentiate between various levels of cognitive functions. This result also supports the validity of the MMC. We also demonstrated good sensitivity and specificity of the MMC, which is comparable to the findings of the original¹⁶ and different adapted versions of the Mini Cog test.^{12, 13} The sensitivity, specificity, and cut-off score determined in the present study are comparable with the findings of an article in which data from two Spanish studies were analyzed.¹⁷ The cut-off score we determined would be valuable in evaluation of the cognitive functions in the clinical practice. However, it should be used in conjunction with the clinical signs and symptoms of the patients.

Consistent with the previous preliminary validation study,⁶ this work demonstrated that the MMC is least influenced by age, sex, literacy and education level. This finding proved that; a) there was a need to modify the original Mini Cog to make it applicable to non-literate individuals and b) the MMC has been appropriately modified and it is now applicable to both literate and non-literate individuals.

This study could demonstrate the validation of the MMC in a sample of heterogenous individuals, which is one of the significant strengths of the study. We also calculated

a cut-off score, which could be very useful to use the tool as an outcome measure in the research. The MMC could also be valuable for the clinical practitioners for quick screening of cognitive functions in a heterogenous population. However, the sample sizes in the sub-groups were relatively small. Unfortunately, we could not use any screening tool to test the literacy of the participants. Those who could read, write and understand were considered literates and those who could not were considered non-literates. Further studies are definitely required, on a larger cohort of participants of different origins, cultures and backgrounds.

CONCLUSIONS

We demonstrated the reliability and validity of the MMC. This could be a valuable tool to screen cognitive functions in literate as well as non-literate and elderly individuals with no neurological diagnosis as well as adults with neurological diagnosis. Moreover, it can be used in research as well as routine practice to screen cognitive deficits. However, further studies are warranted to get more insight into the value of this instrument.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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