Psychiatr. Pol. 2016; 50(5): 1039–1052
PL ISSN 0033-2674 (PRINT), ISSN 2391-5854 (ONLINE)
www.psychiatriapolska.pl
DOI: https://doi.org/10.12740/PP/45368

Is the Montreal Cognitive Assessment (MoCA) test better suited than the Mini-Mental State Examination (MMSE) in mild cognitive impairment (MCI) detection among people aged over 60? Meta-analysis

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Summary

Introduction. Screening tests play a crucial role in dementia diagnostics, thus they should be very sensitive for mild cognitive impairment (MCI) assessment. Nowadays, the Mini-Mental State Examination (MMSE) is the most commonly used scale in cognitive function evaluation, albeit it is claimed to be imprecise for MCI detection. The Montreal Cognitive Assessment (MoCA), was created as an alternative method for MMSE.

Aim. MoCA vs. MMSE credibility assessment in detecting MCI, while taking into consideration the sensitivity and specificity by cut-off points.

Material and methods. A systematic literature search was carried out by the authors using EBSCO host Web, Wiley Online Library, Springer Link, Science Direct and Medline databases. The following medical subject headings were used in the search: mild cognitive impairment, mini-mental state examination, Montreal cognitive assessment, diagnostics value. Papers which met inclusion and exclusion criteria were chosen to be included in this review. At the end, for the evaluation of MoCA 20, and MMSE 13 studies were qualified. Research credibility was established by computing weighted arithmetic mean, where weight is defined as population for which the result of sensitivity and specificity for the cut-off point was achieved. The cut-offs are shown as ROC curve and accuracy of diagnosis for MoCA and MMSE was calculated as the area under the curve (AUC).

Results. ROC curve analysis for MoCA demonstrated that MCI best detection can be achieved with a cut-off point of 24/25 (n = 9350, the sensitivity of 80.48% and specificity of 81.19%). AUC was 0.846 (95% CI 0.823–0.868). For MMSE, it turned out that more impor-

The study was not sponsored.

tant cut-off was of 27/28 (n = 882, 66.34% sensitivity and specificity of 72.94%). AUC was 0.736 (95% CI 0.718–0.767).

Conclusions. MoCA test better meets the criteria for screening tests for the detection of MCI among patients over 60 years of age than MMSE.

Key words: mild cognitive impairment, Montreal Cognitive Assessment, Mini-Mental State Examination

Introduction

Human ageing is associated with various cognitive changes. Mild cognitive impairment (MCI) is defined mostly as cognitive impairment with normal global cognitive functioning without dementia. Many researchers consider MCI as a transitional stage between the natural aging and dementia. Early identification and intervention for MCI may help to slow down the development of dementia [1, 2].

The contemporary diagnostics of people suspected of having dementia uses neuropsychological screening scales to assess the overall activity of the higher cortical functions. Screening is a key step in the diagnosis of dementia, which is why methods used in them should have a high sensitivity for the detection of MCI [3].

The Mini-Mental State Examination (MMSE) was published 40 years ago, in 1975 as a practical method for cognitive function assessment [4]. Currently it is the most commonly used screening method in the assessment of the severity of dementia in both: clinical and research field. According to Milne et al., 79% of the healthcare professionals use at least one test, 51% of them – the MMSE and its variants [5]. Iracleous et al. obtained similar results [6]. Research of Davey et al. shows that 91% of interviewees use MMSE during their medical practice [7]. Despite the fact that American Academy of Neurology in its guidance suggested MMSE as an important tool in detecting early cognitive disorders, many researchers doubts the accuracy of this scale [8]. The scientific debate draws attention to: the insufficient sensitivity of the different tests which assess individual domains only and the lack of correlation between the final result and age, education, gender or ethnic differences [9–12]. Questions concerning the use of MMSE as a screening tool for MCI contributed to the creation of alternative methods. One of them is the Montreal Cognitive Assessment Scale (MoCA), which, according to the authors, has no MMSE limitations [13]. A study evaluating the type of the most commonly used (by primary medical care professionals) screening scale to detect dementia has shown that only 5% of them use MoCA [6]. Table 1 shows comparison of cognitive domains tested in MMSE and MoCA conducted by Magierska et al. [14].

Detailed analysis of bibliographic databases showed lack of meta-analysis of the diagnostic efficacy studies differentiating those two scales in detecting MCI. The aim of our paper is to conduct a study that compares the accuracy of MMSE vs. MoCA in differentiating healthy subjects from those with MCI according to the cut-off point.

Table 1. **Comparison of MMSE and MoCA in terms of the studied areas of cognition and scoring**

Cognitive function		MMSE (No. of points/trials)	MoCA (No. of points/trials)
Orientation		10 tasks (10 points)	6 tasks (6 points)
Memory	Learning	Learning of 3 words (3points/1 trial allowed)	learning of 5 words (no points/2 trials allowed)
	Delayed recall	3 words (3 points)	5 words (5points)
	Cued recall (optional)	not present	5 words (no points)
	Recognition (optional	not present	5 words (no points)
Naming		2 items (2 points)	3 pictures (3 points)
Visuospatial functions		copy of pentagons (1 point)	copy of cube (1 point) clock drawing (3 points)
Comprehension		3-stage command (3)	not present
Vigilance		not present	tapping with hand at letter A (1 point)
Language		repetition of sentence (1 point)	Repetition of 2 sentences (2 points)
Reading		Sentence (1 point)	not present
Abstract thinking		not present	similarities (2 points)
Writing		patient's sentence (1 point)	not present
Alternating Trial Making		not present	1 trial (1 points)

Source: Magierska J, Magierski R, Fendler W, Kłoszewska I, Sobów TM. Clinical application of the Polish adaptation of the Montreal Cognitive Assessment (MoCA) test in screening for cognitive impairment. Neurol. Neurochirurg. Pol. 2012; 46(2): 130–139

Materials and methods

Search methodology

A systematic literature search was carried out by the authors using Medline, Wiley Online Library, Science Direct, Springer, EBSCO HOST and Google Scholar databases. The following medical subject headings were used in the search: mild cognitive impairment, Mini Mental State Examination, Montreal Cognitive Assessment, diagnostics value. All articles with any aforementioned key words combination were verified. The initial identification was carried out according to the preliminary criteria, which included articles: 1) written in Polish and English; 2) taking into account the different language versions of MoCA and MMSE; 3) assessing the diagnostic reliability of MoCA vs. MMSE in detecting MCI (which predispose to Alzheimer's disease (AD). The search process was carried out from December 2014 to February 2015.

Search results

The systematic search yielded a total of 70 articles. 19 duplicates of full-text articles and abstracts were verified and removed. Articles regarded as important (n = 51) were downloaded and analyzed with the application of the inclusion and exclusion criteria. Figure 1 presents the scheme of the search.

Specific inclusion criteria

1) Separated group of Healthy Controls (HC) and MCI group;
2) Statistical analysis of both groups' demographic data;
3) Statistical evaluation of the diagnostic reliability of MoCA scale and MMSE for the MCI group vs. the control group;
4) Taking into account the sensitivity, specificity of cut-off points for MoCA and MMSE for MCI group vs. HC.

Specific exclusion criteria

1) Dissertations, abstracts and poster presentations;
2) Research in the form of a case study;
3) The examined population under 60 years of age;
4) Absence of socio-demographic profile of the HC and MCI group;
5) Studies lacking the diagnostic criteria for MCI;
6) Studies lacking the percentages of people with MCI and HC;
7) Studies showing the statistical parameters of MoCA (and/if MMSE) only for particular cognitive domains without taking into account the value of the global cognitive functioning.

Statistical analysis

The analysis was performed using the STATISCICA 10.0 software. Statistical power was established by computing weighted arithmetic mean, where weight was defined as population size in each study for which the result of sensitivity and specificity for the cut-off point in HC vs. MCI group was obtained. Cut-off points are presented as ROC curve and accuracy of diagnosis for MoCA and MMSE was calculated as the area under the curve (AUC). P-value < 0.05 was considered statistically significant.

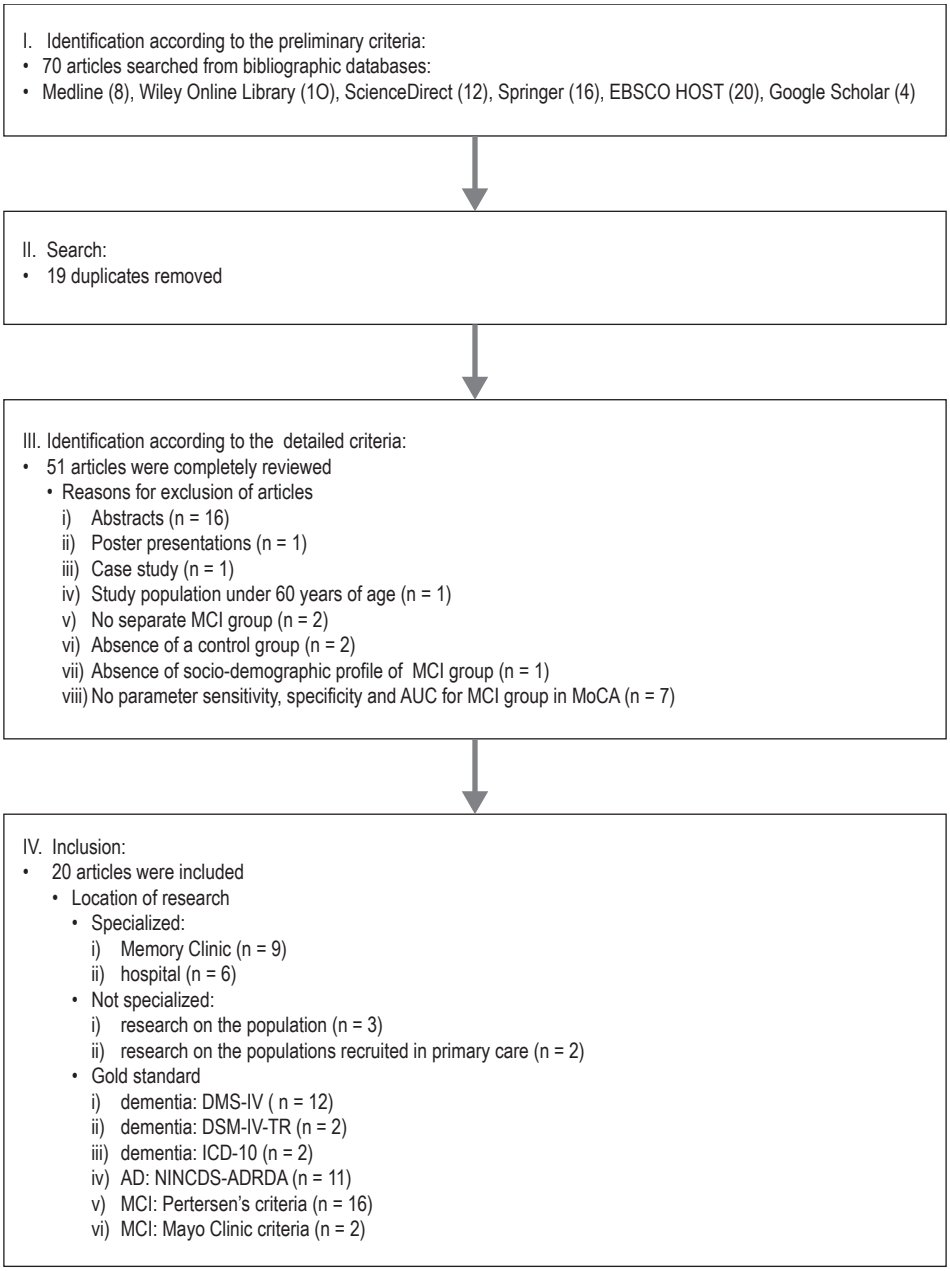

Figure 1. **Scheme of research qualifications for meta-analysis**

Results

51 articles were fully analyzed. During detailed review, 31 studies were excluded (Figure 1). Finally, 20 studies met the inclusion and exclusion criteria for MoCA, including 13 for MMSE.

Socio-demographic profile

Table 2 shows the socio-demographic profile of HC and MCI groups from included studies. The total sample size in the group of Healthy Controls is 8,928, including 4,862 (54.5%) women. The mean age and years of education is 69.56 (SD = 2.7) and 7.95 (SD = 2.00) respectively. MCI group sample size is 3,024, including 1,665 women (55.1%), the mean age and years of education is 73.58 (SD = 3.45) and 5.65 (SD = 2.24) respectively.

Table 2. **Socio-demographic profile of HC vs. MCI for qualified research and the weighted arithmetic mean of demographic parameters**

	Control Group (CG)				MCI Group			
	HC (n)	Age (SD)	Women n (%)	Years of Education (SD)	MCI (n)	Age (SD)	Women n (%)	Years of Education (SD)
2015, Chu [15]	115	72.2 (6.1)	87 (75.7)	7.0 (4.7)	87	77.2 (6.3)	55 (63.2)	4.6 (5.2)
2014, Gil [16]	84	68 (10.4)	58 (69.4)	14 (4.7)	26	65 (13.4)	17 (65.9)	13 (5.1)
2014, Martinelli [17]	39	71.8 (6.9)	29 (74.7)	7 (1.8)	45	76.6 (7.1)	27 (60)	6 (1.9)
2014, Kaya [18]	246	68 (10.3)	148 (60.2)		114	74.2 (8.8)	49 (43)	
2013, Memoria [19]	28	72.5 (5.3)	21 (75)	13.7 (2.6)	30	74.7 (5.7)	23 (77)	9.7 (5)
2013, Hu [20]	146	67.2 (5.3)	81 (55.5)	9.3 (2.6)	84	60.7 (5)	48 (57.1)	9.8 (3)
2013, Roalf [21]	140	71.2 (9.2)	94 (67.1)	15.9 (3.0)	126	72.3 (8.1)	62 (49.2)	14.9 (4.2)
2013, Ng [22]	103	56.4 (8.3)	62 (60)	12.1 (3.2)	49	62.4 (9.4)	22 (44.9)	10.9 (4.3)
2012, Yu [23]	865	70.4 (7.1)	489 (56.5)	10.5 (5.3)	115	71.5 (7.3)	68 (59.1)	8.4 (5.5)
2012, Magierska [14]	37	71.4 (5.2)	25.9 (70)	14.3 (3.1)	42	74.2 (6.4)	33.6 (8)	13.4 (4.9)
2011, Zhaoa [24]	150	69.9 (5.2)	62 (41)		150	70.7 (4.3)	71 (47.3)	
2011, Damian [25]	89	77.7 (9.5)	58 (65)	15.2 (2.7)	46	79.4 (7.8)	13 (28)	15.5 (2.6)
2011, Lu [26]	6,283	72 (0.8)	3273 (52.1)	6.7 (1.1)	1,687	75.1 (0.9)	950 (56.3)	3.5 (1)
2010, Fujiwara [27]	36	76.4 (3.3)	26 (72)	12.3 (2.3)	30	77.3 (6.3)	23 (76.9)	11.5 (3.1)
2010, Guo [28]	186	67.6 (6.9)	99 (53)	12.2 (3.2)	121	68.4 (7.2)	63 (52)	11.8 (3.5)
2009, Luis [29]	74	78.9 (3.7)	38 (51.3)	14.2 (2.5)	24	78.9 (5.3)	9 (23)	14.4 (4.1)
2009, Rahman [30]	90	65.7 (5.5)	68 (55.7)	10.8 (5.4)	94	68.5 (3.7)	54 (44.3)	8.2 (5.5)
2008, Lee [31]	115	69.1 (6.1)	81 (70.4)	8 (3.5)	37	71.3 (5.9)	23 (62.2)	8.3 (3.8)
2007, Smith [32]	12	64 (10.8)	8 (67)	12 (2.5)	23	77.5 (7.8)	13 (57)	11.3 (2.5)

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2005, Nasreddine [13]	90	72.8 (7.0)	54 (60)	13.3 (3.4)	94	75.19 (6.27)	41 (44)	12.3 (4.3)
Total	8,928	69.6 (2.7)	4,862 (54.5)	7.95 (2)	3,024	73.58 (3.45)	1,665 (55.1)	5.65 (2.24)

Diagnostic profile

Analysis of the studies shows that the average scores for MMSE in the HC group is 26.68 (SD = 1.09), and for MoCA it is 23.66 (SD = 1.58) respectively. MCI group scored 22.69 (SD = 1.70) in MMSE and 16.56 (SD = 2.13) in MoCA.

Researchers frequently used the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) to make the diagnosis of dementia. These criteria were used in 12 studies [13–18, 20, 23, 26–28, 31]. Two studies made use of newer, revised version of the DSM-IV, i.e., the Diagnostic and Statistical Manual of Mental Disorders, 4th Edition, Text Revision (DSM-IV-RT) [21, 22]. The criteria according to the International Statistical Classification of Diseases and Related Health Problems, 10th Revision (ICD-10) were used in two studies [14, 32]. To define AD, 10 studies used the National Institute of Neurological and Communicative Disorders and Stroke-Alzheimer's Disease and Related Disorders Association (NINCDS-ADRDA) definition [13, 15, 17–19, 22, 26–29]. Petersen et al.'s criterion was the most popular in diagnosis of MCI. Specifying: 4 studies used the criteria of Petersen et al. from 1999 [24, 27, 29]; 2 studies used the criteria of Petersen et al. from 1999 adapted by Busse et al. in 2006 [16, 20]; 10 studies included the criteria of Petersen et al. from 2001 [13–15, 18, 21–23, 30–32]. The analysis showed that in 2 cases researchers used criteria proposed by the Mayo Clinic Group in 2004 [19, 28]. In the following two studies MCI was defined as Clinical Dementia Rating (CDR) = 0.5 without functional deficits [25, 26]. Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) were used in 2 cases for MCI diagnosis [24, 28].

Table 3 shows the diagnostic profile of analyzed data.

Studies qualified to systematic review evaluate different language versions of MoCA and MMSE tests. The original, English-language version of the two scales was used most frequently – in 8 studies [13, 17, 21, 22, 25, 28, 29, 32]. Other publications used non-English versions of the tests. Chinese version of the scales was used in 4 studies [16, 20, 24, 26], and the following language versions were used once: Polish [14], Spanish [16], Turkish [18], Brazilian [19], Beijing [23], Japanese [27], Korean [31].

Among 20 included studies, 15 were carried out in specialist centers with high prevention i.e., 9 in Memory Clinics [13, 15, 16, 21, 22, 24, 27, 28, 32] and 6 in specialist hospitals [14, 17–20, 31]. In the remaining 5 studies research material was collected in less specialized facilities. Specifying, 3 research projects were carried out in social assistance centers [23, 26, 29], and 2 more in primary healthcare center [25, 31].

Table 3. **Average scores of MoCA and MMSE for healthy controls and MCI groups obtained in the individual studies and the weighted arithmetic mean of the analyzed test scores for both groups**

	Control Group		MCI Group	
	MMS mean (SD)	MoCA mean (SD)	MMSE mean (SD)	MoCA mean (SD)
2015, Chu [15]	28.5 (1.5)	24.4 (3.2)	25.4 (3.4)	18.7 (4.6)
2014, Gil [16]	28.6	25.2	27.3	20.7
2014, Martinelli [17]	29.1 (1.2)	26.9 (1.8)	26.9 (2.0)	22.1 (2.5)
2014, Kaya [18]	28.2 (1.8)	23.3 (3.1)	25.6 (2.1)	18.9 (3.3)
2013, Memoria [19]	28.9 (1.3)	26.3 (2.9)	27.3 (2.1)	22.1 (3.2)
2013, Hu [20]	28.5 (1.1)	27.7 (1.3)	27.3 (1.2)	24.5 (1.9)
2013, Roalf [21]	29.3 (0.9)	26.8 (2.6)	26 (3.5)	20.9 (4.5)
2013, Ng [22]	29.2 (0.9)	28.6 (1.5)	28.1 (2.1)	27 (3.0)
2012, Yu [23]	26.6 (3.8)	22.3 (5.4)	23.3 (5.4)	17.8 (6.3)
2012, Magierska [14]	28.9 (1.0)	25.1 (2.8)	27.7 (1.7)	25.1 (2.8)
2011, Zhaoa [24]	27.1 (2)	24 (2.6)	26.6 (1.9)	23.3 (1.9)
2011, Damian [25]	28.5 (1.6)	25.3 (2.8)	25.3 (3.3)	19.0 (4.4)
2011, Lu [26]	26.3 (0.6)	23.8 (0.9)	20.4 (1.1)	14.1 (1.3)
2010, Guo [28]	28.4 (1.5)		27.1 (1.8)	
2009, Luis [29]	28.6 (1.6)	25.9 (1.8)	26.8 (2.3)	20.5 (2.4)
2008, Lee [31]	25.5 (3.8)	25 (2.6)	24 (2.9)	18.5 (3.7)
2007, Smith [32]	28.4 (1.5)	25 (3.1)	27.6 (1.6)	22.5 (3.5)
Total	26.7 (1.1)	23.7 (1.6)	22.7 (1.7)	16.6 (2.1)

Sensitivity and specificity of MoCA and MMSE in MCI detection

Evaluation of sensitivity and specificity of MoCA test in differentiating people with MCI vs. HC is based on 20 trials. With the help of the recommended cut-off point of 25/26 we obtained sensitivity and specificity of 89.97% and 56.73% respectively (n = 2,549). According to the ROC curve analysis (Figure 2), we observed that the best detection of MCI can be achieved with a cut-off point of 24/25 (n = 9,350, the sensitivity of 80.48% and specificity of 81.19%). AUC was 0.846 (95% CI: 0.823–0.868). Table 4 shows the parameters of sensitivity and specificity for different cut-off points described in these studies, and the weighted arithmetic mean of these results.

Analysis of sensitivity and specificity of MMSE in detecting MCI vs. HC included 13 studies. For a standard cut-off point of 26/27, sensitivity of 56.4% and specificity of 67.38% (n = 1,732) was obtained. Based on the ROC curve (Figure 3) the more

important cut-off point in the differentiation of MCI vs. control group proved to be cut-off point of 27/28 (n = 882, sensitivity of 66.34% and specificity of 72.94%) (Table 4). AUC was 0.736 (95% CI: 0.718–0.767). The odds ratio is in favor of MoCA, OR = 1.146 (95% CI: 1.116–1.176).

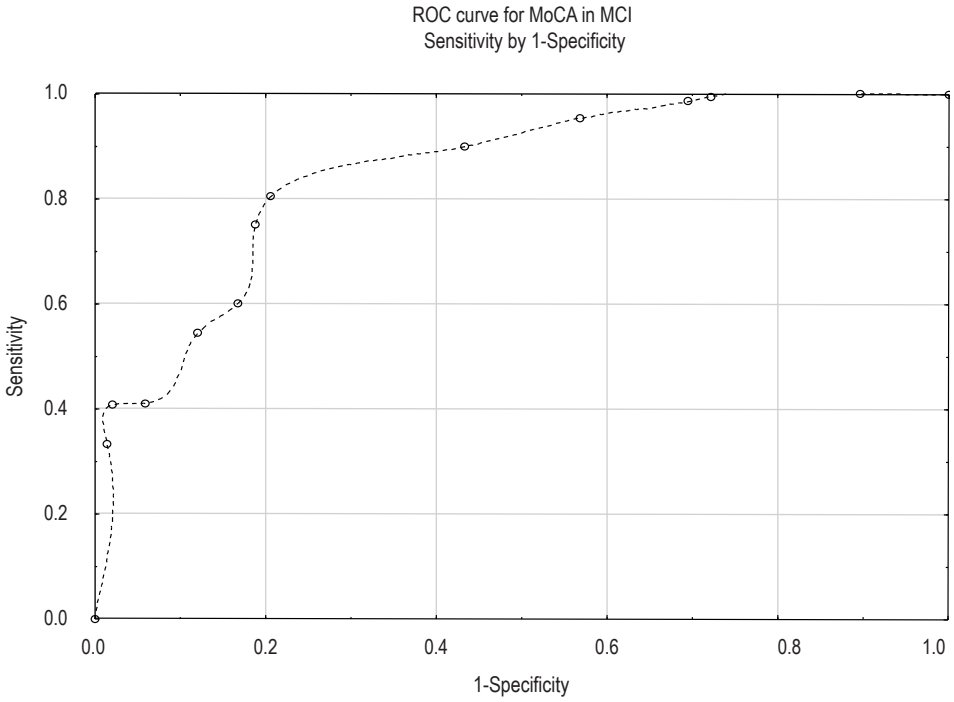

Figure 2. **ROC curve based on the weighted arithmetic means of MoCA results for individual cut-off points in detecting MCI vs. HC**

Table 4. **The value of the sensitivity and specificity parameter with regard to cut-off points for the MMSE and MoCA in detecting MCI vs. HC. Weighted arithmetic mean of sensitivity and specificity for cut-off points**

MoCA					MMSE				
Cut-off point	Studies	Subjects	Sensitivity	Specificity	Cut-off point	Studies	Subjects	Sensitivity	Specificity
18/19	2	218	41.1%	97.9%					
19/20	4	641	33.4%	98.6%					
20/21	6	1,301	40.9%	94.2%					
21/22	6	1,921	54.5%	79.4%					
22/23	7	1,258	60.1%	88.0%					

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23/24	10	1,956	75.2%	83.3%	23/24	1	230	21.0%	95.0%
24/25	8	9,350	80.5%	81.19%	24/25	4	598	19.2%	96.6%
25/26	13	2,549	90.0%	56.7%	25/26	5	541	30.1%	90.8%
26/27	9	1,306	95.4%	43.2%	26/27	4	1,732	56.4%	67.4%
27/28	5	789	98.6%	30.5%	27/28	6	882	66.3%	72.9%
28/29	4	489	99.5%	27.8%	28/29	3	611	82.0%	59.4%
29/30	4	489	100.0%	10.3%	29/30	3	441	51.6%	22.5%

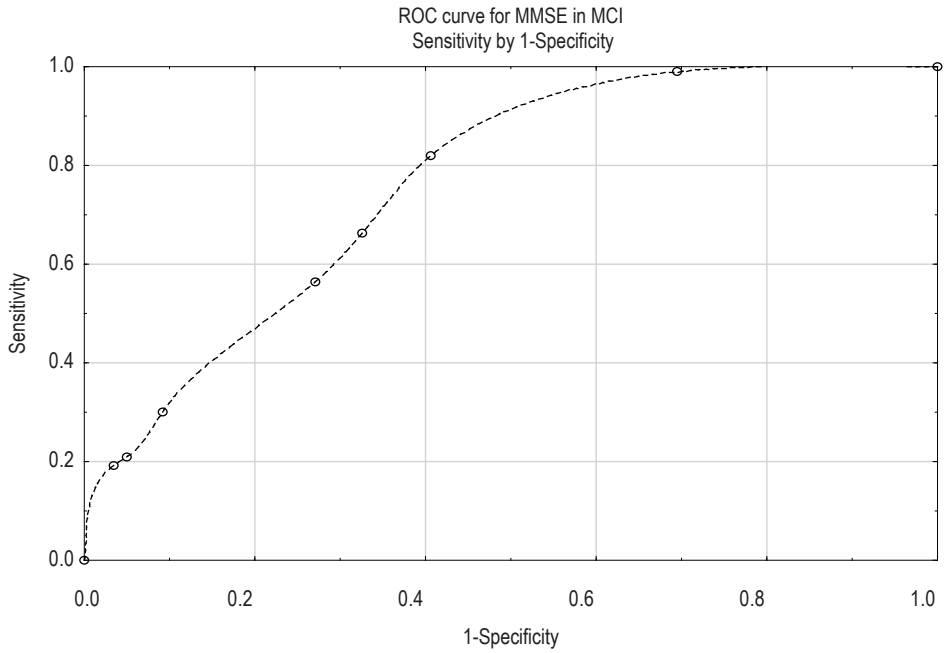

Figure 3. **ROC curve based on the weighted arithmetic means of MMSE results for individual cut-off points in detecting MCI**

Discussion

This is the first, up to date, meta-analysis which takes into account the statistical reliability of the screening assessment scales MoCA vs. MMSE for MCI diagnostics. The analysis provides a detailed overview of the studies that met the search inclusion and exclusion criteria. The review evaluate the reliability of 20 published studies analyzing MoCA and MMSE in distinguishing MCI among the healthy population aged over 60. Whole sample of MCI group consisted of 3,024, and a group of healthy controls consisted of 4,862 people.

To analyze the sensitivity and specificity of MoCA for all the cut-offs, it was observed that only 5 studies had data for eight or more cut-off points. The remaining 16 studies included only data for the most reliable – according to the authors – cut-off points. In most cases sensitivity and specificity were documented for the recommended parameter 25/26 (n = 13 studies), for 23/24 (n = 10) and 24/25 (n = 9). Finally, the ROC analysis showed that the most diagnostically reliable cut-off point in differentiating MCI vs. HC is 24/25 (sensitivity of 80.48% and specificity of 81.19%). In contrast, evaluation of the MMSE reliability parameters based on cut-off points showed that 13 out of 20 studies provide information regarding the sensitivity and specificity. Only 2 studies reported results for 5 or more cut-off points. The remaining 11 studies took into account the most promising parameters based on the cut-off points. Most often sensitivity and specificity for scoring: 27/28 (n = 6 studies); 25/26 (n = 5); and recommended 26/27 (n = 4) was presented. On the basis on ROC analysis, score 27/28 proved to be most promising (sensitivity of 66.34% and a specificity of 72.94%) in differentiating MCI vs. HC. The lack of data for different cut-off points for MoCA MMSE reduced the possibility of increasing the survey weight for other cut-off points than selected by the author as the best. Analyzing the diagnostic reliability of the test based on multiple cut-offs – where AUC was 0.736 for MMSE (95% CI: 0.718–0.767) and for MoCA 0.846 (95% CI: 0.823–0.868) – one can make an assumption that MoCA is better in detecting MCI than MMSE. A similar conclusion was made by Mitchell et al. [8] in a meta-analysis evaluating the accuracy of MMSE in detecting MCI. The author concluded that MMSE is characterized by low detection of early cognitive deficits. Many researchers have found significant correlation between the final result of the screening assay and years of education.

Conclusions

MoCA meets the criteria for screening tests for the detection of MCI in patients over 60 years of age better than MMSE. For MoCA best cut-off point is 24/25 (sensitivity of 80.48% and specificity of 81.19%), while for MMSE best cut-off point is 27/28 (sensitivity of 66.34% and specificity of 72.94%). Researchers evaluating credibility of screening tests for MCI detection should include in their studies the parameters of sensitivity and specificity for multiple cut-offs.

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Note: meta-analysis included studies [13–32].

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