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Usefulness of the Polish versions of the Montreal Cognitive Assessment 7.2 and the Mini-Mental State Examination as screening instruments for the detection of mild neurocognitive disorder

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ABSTRACT

Introduction. Screening tests are a key step in the diagnosis of dementia and should therefore be highly sensitive to the detection of mild neurocognitive disorders (NCD). The Mini Mental State Examination (MMSE) is the most commonly used screening method. The Montreal Cognitive Assessment (MoCA) is a newer and less well-known screening tool, which has none of the limitations of the MMSE.

Aim. The aim of this study was to analyse the reliability of the Polish versions of MoCA 7.2 *vs* MMSE in the detection of mild NCD among people aged over 60.

Material and methods. The study was carried out at the Department and Clinic of Geriatrics from September 2014 to March 2017. The study included 281 participants, 91 of whom were assigned to the group without NCD. The other 190 had been diagnosed with mild NCD.

Results. In the analysis of the ROC curve of the MoCA 7.2 results, the AUC was 0.925 ($p < 0.001$). The optimal cut-off point for mild NCD was 23/24 points, with sensitivity and specificity of 83.2% and 79.1%. In the ROC curve of MMSE results, the AUC was 0.847 ($p < 0.001$). The optimal cut-off point for mild NCD was 27/28 points, with sensitivity and specificity of 75.8% and 66.7%. The difference between AUC MoCA 7.2 and MMSE was 0.078 ($p = 0.036$).

Conclusions. MoCA 7.2 detects mild NCD with more sensitivity than MMSE. We recommend using the cut-off point for MoCA of 23/24 points, because this is characterised by a higher sensitivity than the previously recommended cut-off point of 25/26 points. For the MMSE, the recommended cut-off point should be 27/28, which gives greater diagnostic accuracy than the previously recommended 25/26 points.

Key words: mild neurocognitive disorder, Mini Mental State Examination, Montreal Cognitive Assessment, screening tests

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Introduction

Poland as a society is dealing with a progressive ageing of its population. Based on demographic forecasts from the Central Statistical Office, it is expected that the percentage of the total population aged 65 and over will be 20.3% in 2030, and as much as 32.7% by 2050 [1]. It is well-recognised that such significant and progressive changes in the demographic structure will increase the prevalence of dementia [2], which is the third most common cause of mental disorders in old age [3].

One of the methods to deal with this challenge is to improve medical care in the field of diagnostics, treatment

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and rehabilitation of the elderly with suspected cognitive impairment [3]. In the diagnostic area, identification of mild neurocognitive disorders (mild NCD) [2], which are characterised by cognitive impairment with minimal impairment of complex daily activities is recommended [4]. Mild NCD is also considered a dementia prodrome, where the annual risk of conversion into Alzheimer's Disease (AD) is 10–15% [5].

Fluorine-18-Fluorodeoxyglucose Positron Emission Tomography imaging (^{18}F-FDG PET) is considered the best diagnostic tool (88.9% sensitivity; 84.9% specificity) in predicting mild NCD to AD conversion [6]. The use of ^{18}F-FDG PET in differential diagnosis gives the possibility of early identification of the preclinical phase of AD, increasing diagnostic precision and helping to monitor the effectiveness of treatment [7].

On the other hand, screening tests are used for an initial, cursory assessment of the overall level of cognitive activity, which are the basis for the selection of people for whom further diagnostic procedures should be undertaken [8]. The use of cognitive tests is also recommended in the current diagnostic criteria of mild NCD [4, 9]. They should be characterised by high sensitivity and specificity in the detection of discrete cognitive disorders [10]. In addition, the scores used in screening tests should be based on the most up-to-date normative data available characterising a specific population.

Conclusions regarding the results of neuropsychological assessment often come about by comparing test results with normative data. Normative data is useful for taking into account variables that can affect test performance (e.g. demographic factors) to obtain accurate and relevant results. [11].

The Mini Mental State Examination (MMSE) is the most commonly used screening tool in clinical practice today [12]. But increasing attention has been drawn to the insufficient diagnostic sensitivity of MMSE and the pressing need to introduce into routine use other screening methods to assess cognitive functions in the elderly. This is evidenced by the latest meta-analysis of the diagnostic effectiveness of cognitive screening tests for the detection of mild NCD [13]. The MMSE's doubtful diagnostic screening efficacy in identifying mild NCD has contributed to the development of alternative methods.

One of these is the Montreal Cognitive Assessment (MoCA), which according to the authors has none of the restrictions encountered in the MMSE [14]. MoCA, originally developed as a short tool to assess cognitive performance, i.e. to help GPs to detect mild NCD, is increasingly being used in clinical and research settings [15]. Our own analysis of bibliographic databases showed no scientific reports of a validation character of the Polish version equivalent to MoCA 7.2. In addition, the authors of the Polish adaptation of MoCA 7.2, Gierus et al. [16], stressed the need to carry out research on the diagnostic accuracy of the Polish adaptation of MoCA 7.2 in identifying NCD.

The aim of our study was to analyse the reliability of the Polish version of MoCA 7.2 as against the Polish version of MMSE in detecting mild neurocognitive disorders among people over 60 years of age.

We hope that our study may help to expand understanding of the diagnostic reliability of the Polish version of the MoCA 7.2 and MMSE tests, and may contribute to obtaining the latest normative data for the Polish elderly population.

Material and methods

Subjects

Our study was conducted in the Department of Geriatrics at the University Hospital No. 1 A. Jurasza in Bydgoszcz, Poland between September 2014 and March 2017. The total number of participants included was 281. The study identified a group of 91 people without neurocognitive disorders (which we termed the group without NCD), and a group of 190 people with mild neurocognitive disorders (the group with mild NCD).

The study was approved by the Bioethical Committee of the Nicolaus Copernicus University in Toruń at the Collegium Medicum Ludwik Rydygier in Bydgoszcz. All participants were informed about the main assumptions of the study and gave their written consent to participate.

Research procedure

Study participants were admitted according to schedule to the Clinic for Comprehensive Geriatric Assessment (CGA). As part of the CGA's procedure, neuropsychological, quality of life, functional and laboratory tests were carried out. Based on the participant's overall assessment, the therapeutic team, consisting of a geriatrician, nurse, clinical neuropsychologist and physiotherapist, established the diagnosis of either mild NCD or no NCD. A group of experts identified the intensity of cognitive impairment (without NCD vs. mild NCD vs. severe NCD), not including the aetiology.

Subsequently, an independent researcher conducted the MoCA 7.2 test without being aware of the diagnosis of the therapeutic team. The participants were tested using the MoCA 7.2 test in similar conditions: i) at a fixed time (10am-noon); ii) in an examination room; iii) in private; iv) with hearing and vision defects addressed and overcome; and v) with a median interval between MMSE and CDT tests and the MoCA 7.2 of two days.

A detailed analysis of the study participants' medical history was conducted to obtain the following data: sociodemographic parameters (gender, age, education); anthropometric parameters (weight, height); the results of tests carried out as part of the Comprehensive Geriatric Assessment (MMSE, CDT, GDS, ADL, IADL); and the results of a neuropsychological assessment (history, diagnosis without NCD vs mild NCD).

Clinical diagnosis

The inclusion criteria for our study were as follows: i) age 60 or older; ii) scheduled admission to the Clinic for CGA.

The exclusion criteria for our study were as follows: i) major NCD diagnosed according to the Diagnostic and Statistical Manual of Mental Disorders Fifth Edition (DSM-5); ii) uncorrected hearing defects or total deafness; iii) uncorrected

vision defects or complete blindness; iv) significant dependence in everyday life e.g. bedridden; and v) less than six years of formal education.

A diagnosis of mild NCD based on the DSM-5 diagnostic criteria was considered the criterion for inclusion in the group with mild NCD [4].

The inclusion criteria for the group without NCD were: i) no complaints about cognitive decline; ii) maintaining general cognitive functioning; iii) maintaining independence in everyday activities; and iv) no mental illness.

Neuropsychological measures

MoCA is a tool developed in 2005 by Nasreddine et al. [14] for screening diagnosis of mild cognitive impairment (MCI), these days termed mild NCD. The Polish version equivalent to MoCA 7.2 was adopted by Gierus et al. [16]. During the adaptation of the Polish MoCA 7.2 equivalent, in order to minimise cultural differences, changes were made to the Memory subtest, replacing the words truck, banana, violin, desk and green contained in the original version of MoCA 7.2 with the words tap, pineapple, violin, table and white. As in the original English version, 25/26 points was determined to be the recommended cut-off point identifying mild NCD. The final MoCA 7.2 result is correlated with participants' years of formal education. For each year of education fewer than 12 years, one additional point is taken into account [14]. MoCA 7.2 is not used in Polish geriatric practice as part of CGA.

The MMSE was developed in 1975 by Folstein et al. [17] as a screening tool for assessing cognitive status, and is currently most commonly used in the detection of mild and major NCD. MMSE has recently been subject to copyright restrictions [18]. 26/27 points is the recommended identification cut-off point [17]. The MMSE scale is part of the CGA [19].

The Clock Drawing Test (CDT) developed as an auxiliary screening instrument for the purpose of differentiating cognitive patients from patients with cognitive impairment, especially the elderly [20]. In our own study, the Shuman et al. method [21] was used, taking into account a scoring scale of 0–5 points, where 4–5 points was classified as 'normal', and 0–3 points as 'invalid'. The CDT is included in the CGA [19].

The Geriatric Depression Scale 30 (GDS-30) was developed in 1983 by Yesavage et al. [22] as a screening tool for assessing depression in the elderly. The original version of GDS consists of 30 questions to be answered "Yes" or "No", which are scored according to an answer key. In GDS, a score of 0–10 points means no depression, 11–20 points slight depression, while 21–30 points signals major depression. In our own study, all participants completed the GDS questionnaire with the help of another person. The GDS scale is carried out as part of the CGA [19].

Functional measures

Activities of Daily Living (ADL) was developed in 1970 by Katz et al. [23] as a tool to assess the proficiency of basic skills of everyday life. The ADL scale, constructed from six questions, is based on a 7-step scoring procedure, where for each action 0, 0.5 or 1 point is awarded. A score of 5–6 points indicates properly maintained fitness, 3–4 points moderate disability, while ≤ 2 points signals significant malfunction. A low score indicates an inability to function independently and the need for help from other people [24].

Instrumental Activities of Daily Living (IADL) is a tool constructed in 1969 by Lawton et al. [25] to verify the efficiency of complex everyday activities. In our own study, a 27-point scale was used. A score of 27-19 points characterises self-sufficient people, 18-10 points moderately disabled people requiring assistance, and 9-1 points identifies people who are significantly dependent on others. Each tested parameter of instrumental functioning is assessed in terms of the individual's ability to perform it. For each parameter three points can be obtained, meaning they can function without help, two points means they need some help, and one point signals that they are unable to function without help.

The DSM-5 diagnostic criteria for mild NCD include assessment of the subjects' independence by assessing efficiency in basic and complex daily activities, so we decided to use the ADL and the IADL [4]. Both these scales are also included in the CGA [19].

Statistical analysis

Statistical development of the collected research material was initiated by examining the compatibility of the distribution of analysed variables with the normal distribution, using the Shapiro-Wilk test. To compare quantitative variables between groups with non-normal distribution, the Mann-Whitney U test was used. For graphical presentation of the results obtained, box-plot charts were used, where the box indicates a standard error and the whisker a 95% confidence interval. The diagnostic value of MoCA 7.2 and MMSE in the detection of mild NCD was analysed by the ROC curve method. Statistical significance level was set at $p \leq 0.05$. Statistica v. 13 PL software for Windows was used for statistical analysis.

Results

Study sample

This study involved 281 participants; 91 were included in the group without NCD, while 190 were included in the group with mild NCD (Tab. 1).

Characteristics of sociodemographic data show that the median age in the group with mild NCD was 78 years (95% Confidence Interval, CI, range 77.3-79.2), while in the group without NCD it was 74 years (95% CI, range 72.3-75.8). The difference between the two groups turned out to be statistically significant ($p < 0.001$).

The results of tests carried out as part of the CGA showed that statistical differences between the groups ($p < 0.01$) occurred in IADL, CDT and GDS-30. The median IADL score

Table 1. Characteristics of group with mild NCD *vs* group without NCD

	Mild NCD (n = 190)				Without NCD (n = 91)				
	Mean	Median	(-) 95%CI	(+) 95%CI	Mean	Median	(-) 95% CI	(+) 95% CI	p
Weight (kg)	72.8	73	70.9	74.7	71.5	71	68.8	74.2	0.48
Height (cm)	158.7	158	157.4	160.0	161.1	160	159.7	162.6	0.02
BMI (kg/m^2)	28.9	29	28.2	29.6	27.5	27	26.5	28.6	0.01
Age (years)	78.2	78	77.3	79.2	74.1	74	72.3	75.8	< 0.001
ADL (points)	5.7	6	5.7	5.8	5.8	6	5.8	5.9	0.06
IADL (points)	23.7	25	23.1	24.2	25.4	27	24.8	26.1	< 0.001
CDT (points)	3.3	3	3.1	3.5	4.5	5	4.3	4.7	< 0.001
GDS-30 (points)	9.2	8	8.4	10.0	6.7	6	5.6	7.7	< 0.001
Years of education	10.8	11	10.4	11.3	12.9	12	12.1	13.6	< 0.001
Sex	Women (n)	Women (%)	Men (n)	Men (%)	Women (n)	Women (%)	Men (n)	Men (%)	< 0.001
	140	74	50	26	78	86	13	14	

NCD — neurocognitive disorders; CI — Confidence Interval; BMI — Body Mass Index; AD — Activities of Daily Living; IADL — Instrumental Activities of Daily Living; CDT — Clock Drawing Test; GDS-30 — Geriatric Depression Scale-30; P — probability

in the group with mild NCD was 25 points (95% CI, **23?**.1-24.2), and in the group without NCD it was 27 points (95% CI, **24?**.8-26.1). The median CDT score in the group with mild NCD was 3 points (95% CI, 3.1-3.5), while in the group without NCD it was 5 points (95% CI, 5-4.3). The median GDS-30 score in the group with mild NCD was 8 points (95% CI, 8.4-10.0), while in the group without NCD it was 6 points (95% CI, 5.6-7.7).

Analysis of MMSE and MoCA 7.2 cognitive domains

Analysis of each studied cognitive function in MMSE using the Mann-Whitney U test showed that all domains except 'Naming and Repetition' and 'Constructive Praxis' were characterised by a significant difference in results between the two groups.

The median MMSE score in the group with mild NCD was 27 points (95% CI, 26.38-27.06), while in the group without NCD it was 29 points (95% CI, 28.42-29.00). The difference between the two groups was statistically significant ($p < 0.001$) (Tab. 2).

However, analysis of each cognitive function studied in MoCA 7.2 showed that all cognitive domains were characterised by a significant difference in results between the two groups.

The median MoCA 7.2 score in the group with mild NCD was 23 points (95% CI, 21.37-22.28), while in the group without NCD it was 26 points (95% CI, 25.42-26.42). The difference between the two groups was statistically significant ($p < 0.001$) (Tab. 2).

Diagnostic reliability of MMSE and MoCA 7.2

The ROC curve for MMSE in detecting mild NCD was determined based on the results of sensitivity and specificity for eight cut-off points in the range 22/23 to 29/30. The Youden Index method, of which the result was 0.425, determined the optimal cut-off point to be 27/28 points. The optimal cut-off point had 75.8% sensitivity and 66.7% specificity where the positive predictive value (PPV) was 82.5% and the negative predictive value (NPV) was 57.1%. In contrast, the previously recommended threshold of 26/27 points obtained sensitivity and specificity of only 57% and 80% respectively (PPV — 85.5%; NPV — 47.4%) (Tab. 3).

The ROC curve for MoCA 7.2 in detecting mild NCD was determined based on the results of sensitivity and specificity for 13 cut-off points in the range from 17/18 to 29/30. The optimal cut-off point was determined to be 23/24 points, the result was 0.623 and was characterised by 83.2% sensitivity and 79.1% specificity (PPV — 89.3%; NPV — 69.2%), while the recommended cut-off point for mild NCD, 25/26 points, had sensitivity and specificity of 96.3% and 45.1% respectively (PPV — 78.5%; NPV — 85.4%) (Tab. 3).

Analysis of the Receiver Operating Characteristic (ROC) curve for MMSE in detecting mild NCD showed that Area Under the Curve (AUC) was 0.847 ($p < 0.001$). During analysis of the ROC curve, MoCA 7.2's results in the detection of mild NCD AUC was 0.925 ($p < 0.001$). The difference in area under the AUC curves for MMSE and MoCA 7.2 was 0.078 ($p = 0.036$). This means that the AUC for MoCA 7.2 was significantly greater than the AUC for MMSE (Fig. 1).

Discussion

The most common way of linking test results to the disease is to interpret the total result in relation to the cut-off point, so classifying the subject into a particular group [11].

The recommended cut-off point — similar to the original English version — for the Polish version of MoCA and MoCA 7.2 is 25/26 points for mild NCD.

Table 2. Results of cognitive domains of MMSE and MoCA 7.2 tests for group with mild NCD *vs* group without NCD

	Mild NCD (n = 190)				Without NCD (n = 91)				
	Mean	Median	(-) 95% CI	(+) 95% CI	Mean	Median	(-) 95% CI	(+) 95% CI	P
MMSE (points)	26.72	27	26.72	27.06	28.71	29	28.42	29.00	< 0.001
MMSE 1 Orientation	9.58	10	9.58	9.70	9.90	10	9.83	9.97	< 0.001
MMSE 2 Registration	2.99	3	2.99	3.01	3.00	3	-	-	0.049
MMSE 3 Attention and Calculation	3.71	4	3.71	3.92	4.51	5	4.31	4.72	< 0.001
MMSE 4 Recall	1.98	2	1.98	2.12	2.59	3	2.45	2.73	< 0.001
MMSE 5 Naming and Repetition	2.89	3	2.89	2.93	2.93	3	2.88	2.99	0.220
MMSE 6 Executive Function	3.88	4	3.88	3.93	3.99	4	3.97	4.01	0.003
MMSE 7 Writing	0.91	1	0.91	0.95	0.99	1	0.97	1.01	0.020
MMSE 8 Constructive Praxis	0.77	1	0.77	0.83	0.80	1	0.72	0.88	0.550
MoCA 7.2 (points)	21.82	23	21.37	22.28	25.92	26	25.42	26.42	< 0.001
MoCA 1 Visuospatial / Executive	3.49	4	3.33	3.65	4.56	5	4.41	4.71	< 0.001
MoCA 2 Naming	2.58	3	2.50	2.67	2.79	3	2.69	2.89	0.002
MoCA 3 Attention	4.18	4	3.99	4.36	5.00	5	4.76	5.24	< 0.001
MoCA 4 Language	1.68	2	1.53	1.82	2.38	3	2.22	2.55	< 0.001
MoCA 5 Abstraction	1.61	2	1.52	1.69	1.81	2	1.72	1.91	0.004
MoCA 6 Delayed Recall	1.75	2	1.54	1.96	3.02	3	2.77	3.28	< 0.001
MoCA 7 Orientation	5.78	6	5.69	5.88	5.85	6	5.66	6.03	0.009

NCD — neurocognitive disorders; CI MMSE — Confidence Range, Short Mental State Assessment Scale; MoCA — Montreal Cognitive Assessment Scale; P — probability

Table 3. Sensitivity, specificity, ACC, PPV, NPV, LR (+), LR (-), Youden Index for cut-off points for MMSE and MoCA 7.2

	Cut-off points	Sensitivity (%)	Specificity (%)	ACC (%)	PPV (%)	NPV (%)	LR(+)	LR(-)	Youden Index
MMSE	22/23	12.4	98.9	40.6	95.8	35.3	11.129	0.886	0.113
	23/24	19.9	98.9	45.7	97.4	37.4	17.903	0.810	0.188
	24/25	25.3	97.8	48.9	95.9	38.8	11.371	0.764	0.230
	25/26	38.7	94.4	56.9	93.5	42.7	6.968	0.649	0.332
	26/27	57.0	80.0	64.5	85.5	47.4	2.849	0.538	0.370
	27/28	75.8	66.7	72.8	82.5	57.1	2.274	0.363	0.425
	28/29	90.9	34.4	72.5	74.1	64.6	1.386	0.265	0.253
	29/30	100.0	0.00	67.4	67.4	-	1.000	-	0.000
MoCA 7.2	17/18	13.2	98.9	40.9	96.2	35.3	11.974	0.878	0.121
	18/19	20.5	97.8	45.6	95.1	37.1	9.339	0.813	0.183
	19/20	30.0	97.8	52.0	96.6	40.1	13.650	0.716	0.278
	20/21	38.9	94.5	56.9	93.7	42.6	7.088	0.646	0.335
	21/22	48.9	91.2	62.6	92.1	46.1	5.568	0.560	0.402
	22/23	67.9	86.8	74.0	91.5	56.4	5.149	0.370	0.547
	23/24	83.2	79.1	81.9	89.3	69.2	3.983	0.213	0.623
	24/25	92.6	64.8	83.6	84.6	80.8	2.634	0.114	0.575
	25/26	96.3	45.1	79.7	78.5	85.4	1.753	0.082	0.414
	26/27	98.4	26.4	75.1	73.6	88.9	1.337	0.060	0.248
	27/28	98.9	09.9	70.1	69.6	81.8	1.098	0.106	0.088
	28/29	99.5	02.2	68.0	68.0	66.7	1.017	0.239	0.017
	29/30	100.0	0.00	67.6	67.6	-	1.000	-	0.000

MMSE — Mini Mental State Examination; MoCA — Montreal Cognitive Assessment Scale; ACC — accuracy; PPV — Positive Predictive Value; NPV — Negative Predictive Value; LR (+) — Likelihood Ratio Positive; LR (-) — Likelihood Ratio Negative

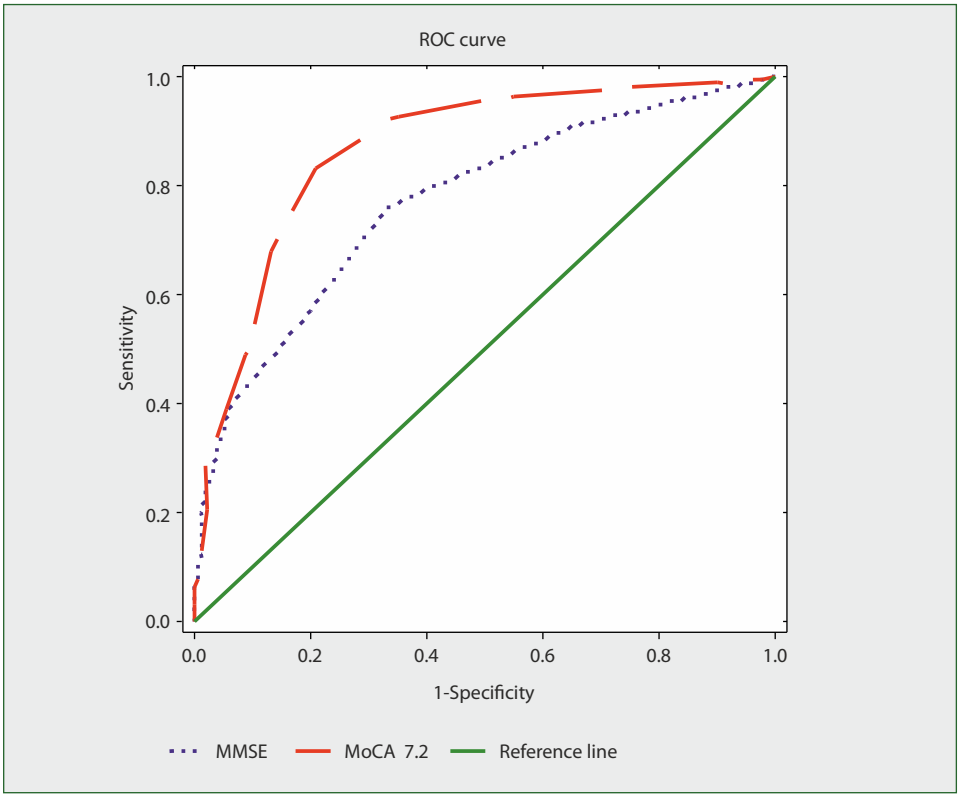

Figure 1. ROC curve analysis for MMSE *vs* MoCA 7.2
ROC — Receiver Operating Characteristic, MMSE — Mini Mental State Examination, MoCA — Montreal Cognitive Assessment Scale

Our own research showed that the commonly recommended cut-off point had 98.7% sensitivity and 64.8% specificity. Magierska et al. obtained less satisfactory results, 88.1% sensitivity and 40.5% specificity [26]. It can be concluded that the recommended cut-off threshold it is not diagnostically sensitive in the detection of mild NCD for the Polish population.

However, in the Polish version of MMSE, the recommended cut-off point for identification of mild NCD is 26/27 points. The analysis of our own research shows very low sensitivity (43.4%) with higher specificity (64.8%). Similarly, Magierska reports the low diagnostic value of the Polish version of MMSE (sensitivity 28.6%; specificity 83.7%).

Based on our own results, it is certain that the most favourable cut-off point identifying mild NCD in MoCA 7.2 is 23/24 points. Scoring above this figure is characterised by the highest diagnostic reliability (sensitivity 83.2%; specificity 79.1%). Magierska recommends a cut-off threshold of 24/25 points (sensitivity 80.9%; specificity 54%).

According to MMSE's own results, the most favourable diagnosis of mild NCD is at the cut-off threshold of 27/28 points (sensitivity 75.8%; specificity 66.7%). Magierska also received the highest diagnostic value of mild NCD for a cut-off point of 27/28 points (sensitivity 47.6%; specificity 72.9%).

In both studies, it was demonstrated that both the adaptation of the Polish MoCA scale and the Polish MoCA 7.2 proved to be better screening tests for detecting mild NCD compared to the Polish version of MMSE from a statistical point of view. The discrepancies between studies may have arisen as a result of differences in the number of research samples and different methodological procedures.

A limitation of the Polish version of the MoCA 7.2 test is that there is little space for drawings in the visual-spatial domain. Vision problems, common among the elderly, often prevent the test from being performed correctly, and there is a risk of the final result being distorted.

Validation studies of MoCA versions from different countries: America [14, 27–29], Japan [30], Brazil [31], Turkey [32], Taiwan [33], China [34], South Korea [35], Romania [36], Spain [37], Malaysia [38], Singapore [39], and Sweden [40] have demonstrated, similarly to our results, the diagnostic advantage of MoCA over the universally used MMSE in identifying mild NCD and sometimes insufficient sensitivity and specificity of the recommended cut-off points for mild NCDs in both tests.

The authors of the MoCA test, Nasreddine et al. [14] determined 25/26 points to be the recommended cut-off point in the detection of MCI, obtaining satisfactory sensitivity (90%) and specificity (87%). Similar diagnostic parameters, for the American version of MoCA, were received by Martinelli et al. [41] (sensitivity 82.2%; specificity 92.3%) and Roalf et al. [28] (sensitivity 84%; specificity 79%) in their studies.

Subsequently, a study by Smith et al. [42] showed promising diagnostic sensitivity (80%) although with less satisfactory specificity (50%). Similar results were published by Damian et al. [27], noting 98% sensitivity and 52% specificity, whereas Luis et al. [43] considered the recommended cut-off point to be ineffective in detecting mild NCD (sensitivity 100%; specificity 32%). A study of the Arabic version of MoCA by Rahman et al. [44] confirmed the high value of the recommended cut-off threshold (sensitivity 85.7%; specificity 92.3%). However, a review of validation studies on Korean [45], Japanese [30], Chinese [34], Brazilian [31], Singaporean [39], Turkish [32] and Spanish [37] versions of MoCA showed that the recommended cut-off threshold of 25/26 points is not characterised by appropriate sensitivity and specificity.

Luis et al. [43], examining the American version of MoCA, noted — exactly as we did in our own study — the highest diagnostic value of mild NCD at the cut-off point of 23/24 points (sensitivity 96%; specificity 95%). These results were confirmed by Damian [27], who recommended an identical optimal cut-off threshold of 23/24 points for the American version of MoCA (sensitivity 87%; specificity 76%).

Analysis of diagnostic performance of foreign language versions of MMSE in detecting mild NCD showed that the recommended cut-off point of 26/27 points — similarly to the research on the Polish version of MMSE — is characterised by unsatisfactory reliability. A meta-analysis by Mitchell et al. [46] conducted on the basis of five studies assessing the reliability of MMSE for mild NCD compared to healthy people (n = 1,857) showed that the recommended cut-off point is characterised by 63.4% sensitivity and 65.4% specificity.

Researchers of multilingual versions of MMSE have observed that increasing the cut-off threshold by one point above the recommended level significantly improves the diagnostic reliability of the MMSE test. The most frequently recommended level is 27/28 points for the identification of mild NCD. [27, 31, 43]

A meta-analysis by Tsoi et al. [47], containing 108 studies evaluating the diagnostic effectiveness of nine cognitive tests in the detection of mild NCD, showed that the MoCA test ranked second in terms of diagnostic relevance, prevailing over MMSE. Of the 35 studies analysing MoCA diagnostic values (n = 2,107 people with mild NCD), only 10 proved the officially recommended cut-off threshold (25/26 points). Other studies indicated other cut-off points, in the range of 20 to 29 points. Researchers observed high heterogeneity of reliability parameters for the recommended cut-off point (sensitivity ranged from 64% to 100%; specificity from 27% to 95%). Using a weighted average for the recommended threshold of 25/26 points for the identification of mild NCD, the authors of the meta-analysis received 83% sensitivity and 75% specificity. In turn, the diagnostic reliability of MMSE was identified based on 58 studies (n = 4,613 people with mild NCD). The researchers observed the most commonly used cut-off value to be 26/27 points (11 studies). Other studies found different limits between 21 and 30. Furthermore, as in the MoCA test, various results were noted for the recommended cut-off point (sensitivity ranged from 13-97%, specificity 31-100%). Ultimately, they showed 71% sensitivity and 74% specificity.

A review of scientific reports assessing the diagnostic reliability of MMSE *vs* MoCA in identifying mild NCD according to the cut-off point indicates a variety of results. The differentiation of MMSE and MoCA diagnostic reliability parameters for specific cut-off thresholds may result from the use of heterogeneous mild NCD diagnostic criteria.

In our own meta-analysis of 20 studies, we observed that frequently the researchers used different versions of Petersen's criteria [48]. The meta-analysis by Tsoi et al. [47] also confirmed the above outcomes. The heterogeneity of the results could have been due to the use of various adaptations and language versions of the tests. In addition, demographic variables i.e. age, gender, level of education, and ethnic differences, could affect the diversity of MoCA performance parameters [32, 33, 49] and MMSE [50, 51] according to cut-off thresholds.

The diagnosis of mild NCD was based on the results of neurocognitive screening tests briefly assessing the efficiency of general cognitive functions, without taking into account the detailed assessment of individual cognitive functions along with determining the individual neurocognitive profile.

In addition, no supplementary neuroimaging diagnostic tests were performed on people with mild NCD that could confirm the diagnosed disease and its aetiology with greater probability. The high cost of neuroimaging studies is the main reason for their lack of use in our own research. These methodological imperfections were not the main assumption of the project. However, expanding the study in the future could increase the value of the study.

In conclusion, the analysis of own research shows that MoCA 7.2 can be used by GPs and in geriatric practice as a screening tool in detecting mild NCD. However, further research is needed to look for the most optimal cut-off threshold for major NCD in the Polish population. In addition, there is a need to analyse MoCA 7.2 in terms of demographic variables and verify the results for these variables.

Conclusions

The MoCA 7.2 test is more effective in diagnosing mild NCD in people aged over 60 than the MMSE test. The optimal cut-off point for detecting mild NCD for the MoCA test is 23/24 points, with 83.2% sensitivity and 79.1% specificity (PPV 89.3%; NPV 69.2%). The optimal cut-off threshold for detecting mild NCD for the MMSE test is 27/28 points, with 75.8% sensitivity and 66.7% specificity (PPV 82.5%; NPV 57.1%).

Therefore, we propose a correction of the cut-off thresholds for the Polish version of the MoCA 7.2 and MMSE tests in identifying mild NCD among people over 60 years of age.

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