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Comparison of the effectiveness of the Montreal Cognitive Assessment 7.2 and the Mini-Mental State Examination in the detection of mild neurocognitive disorder in people over 60 years of age. Preliminary study

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Summary

Aim. Analysis of reliability of the Polish version of the MoCA 7.2 vs. the MMSE in mild NCD detecting, while taking into consideration the sensitivity and specificity of cut-off points for each type of education.

Method. Cross-sectional study was conducted at the Department of Geriatrics, Ludwik Rydygier Collegium Medicum in Bydgoszcz, Nicolaus Copernicus University in Torun. The study was conducted between September 2014 and December 2015. The study involved 131 participants, including 54 people assigned to the group without NCD and 77 to the group with mild NCD. Recruitment for both groups was performed on the basis of specific inclusion and exclusion criteria.

Results. Mean scores of the MoCA 7.2 and the MMSE showed a statistically significant difference between the groups with and without mild NCD. The optimal cut-off point on the MoCA scale for mild NCD was 24/25. The optimal cut-off point on the MMSE scale for mild NCD was 28/29. In the ROC curve analysis, area under the curve (AUC) for the MoCA was significantly greater than the AUC for the MMSE.

Conclusions. The MoCA 7.2 detect mild NCD with greater sensitivity than the MMSE. In the case of this tool, we propose the use of 24/25 cut-off point which has a higher sensitivity than the recommended 25/26 cut-off point. The MoCA 7.2 therefore can be used by primary healthcare and in the geriatric practice as a screening tool in detecting early cognitive impairment.

Key words: neuropsychological assessment, neurocognitive disorders, screening tests

Introduction

The latest edition of the *Diagnostic and Statistical Manual of Mental Disorders*, Fifth Edition (DSM-5), published by the American Psychiatric Association in 2013, revised diagnostic criteria for cognitive impairment in order to reflect the current state of knowledge. New diagnostic criteria in the DSM-5 distinguish major neurocognitive disorder (major NCD) that are determinant of dementia, and mild neurocognitive disorder (mild NCD) considered minor cognitive impairment without dementia, being similar to the commonly used concept of mild cognitive impairment (MCI) [1]. Mild NCD is a minor cognitive disorder in one or multiple domains (attention, executive function, learning, memory, language, motor perception, and social cognition), where occurred deficits do not have a critical impact on the performance of daily living activities.

The time of occurrence of mild NCD is usually considered transitional stage between the physiological aging of the human body and the clinical probability of progression to major NCD. Heterogeneous etiology determines the occurrence of multiple clinical presentations of mild NCD, which can be caused by numerous pathologies of the central nervous system (CNS) [2]. Currently, the DSM-5 identifies ten causes of mild NCD, i.e., (1) Alzheimer's disease; (2) frontotemporal dementia; (3) Lewy body dementia; (4) vascular dementia; (5) traumatic brain injury; (6) medications; (7) HIV infection; (8) prion disease; (9) Parkinson's disease; and (10) Huntington's disease [1].

Epidemiological data indicate that mild NCD (as MCI), depending on the age and the etiology, occurs in 3–22% of the population [3–5], and the annual incidence rate is approximately 1–6% [6]. It is expected that with the steady increase in the proportion of people aged 65 or more in the total population (according to GUS forecast in 2050 up to 32.7%), the incidence of mild NCD in the Polish society will steadily increase [7]. These demographic data show a great challenge facing modern medicine in the field of improving prevention, diagnostic, healthcare, and treatment procedures. In the published Communication from the Commission to the European Parliament and the Council on an European initiative on Alzheimer's disease and other dementias, we learn that it is necessary to identify and promote best practices for early diagnosis of NCD in order to take advantage of the best methods of treatment at the earliest stage of the illness. Through early diagnosis and intervention it may be possible to delay late-stage progression of the illness and thus postpone institutionalization of people with NCD, thereby reducing the high cost of terminal (long-term) care [8].

For the initial diagnosis of patients with suspected NCD – neuropsychological screening scales that assess the overall activity of all higher cortical functions are used. Scales allow an objective assessment of cognitive performance, facilitate the differential diagnosis of patients with mild NCD vs. without NCD and – based on a profile of a dysfunction – allow verification of the progression of deficits [9]. Currently, there is no uniform neuropsychological profile study protocol of patients with mild NCD. There are only general guidelines to help diagnostic tests selection to identify mild NCD. In the present situation, clinicians recommend that diagnosis should be

based on an assessment of the widest possible range of cognitive functions. The use of numerous and diverse neuropsychological research tools with excellent sensitivity at a satisfactory specificity is advised [10].

As a result of the permanent increase in neuropsychological tests, according to the guidelines of evidence-based medicine (EBM), it is suggested that the selection of methods should be preceded by a preliminary analysis of their functionality and reliability. Randomized study, which asses important endpoints, with patients randomly allocated to groups, is considered the best way to compare two diagnostic strategies. Such studies, however, are rare in the literature, so it is advisable to decide on the usefulness of the tests on the basis of their diagnostic accuracy, focusing on sensitivity, specificity, positive predictive value (PPV), negative predictive value (PNV) and repeatability (test – retest, inter-rater) [11].

The Montreal Cognitive Assessment (MoCA) published by Nasreddine et al. [12] in 2005 is a screening tool designed to detect mild NCD. Numerous reports have shown that the MoCA has a significantly higher sensitivity and specificity in identifying mild cognitive deficits compared to the commonly used *brief Mini-Mental State Examination* (MMSE) [13–20]. The MoCA design allows for the assessment of more major cognitive domains (short-term memory, visuospatial, executive and language functions, verbal fluency, attention, naming, abstracting and orientation to time and place) than the MMSE. According to Liew et al. [21], the MoCA can overcome imperfections of the MMSE, in particular by improving the assessment of executive function and minimizing the ceiling effect. The additional advantages of the MoCA are: being free of expense and low cost of application. Currently, there are approx. 35 language versions of the test with different validation status. Gierus et al. [13] developed the Polish version of the MoCA 7.2. and observed that the general results of the Polish version of the MoCA and the Polish version of the MoCA 7.2 show a very high level of covariance, and the mean ranks obtained in a group of patients with different levels of cognitive functioning do not differ significantly from each other. The authors pointed out the need for clinical trials in order to establish appropriately sensitive and specific cut-off points for mild and major NCD as well as positive and negative predictive power of the Polish version of the MoCA 7.2.

The purpose of our study was to analyze the credibility of the Polish version of the MoCA 7.2 vs. the MMSE in detecting mild NCD among people aged over 60 while taking into consideration the sensitivity and specificity of cut-off points with regards to type of education.

Material and methods

Participants

A cross-sectional study was conducted at the Department of Geriatrics, Collegium Medicum in Bydgoszcz, Nicolaus Copernicus University in Torun. The duration of the study: September 2014–December 2015. The total study sample comprised 131 participants. The study distinguished two groups: (1) group without cognitive impairment

(group without NCD) including 54 people; and (2) group with mild neurocognitive disorders (group with mild NCD) including 77 people.

Inclusion criteria for both groups were as follows: (1) age 60 years or over; (2) the admission to the Department of Geriatrics for Comprehensive geriatric assessment. In contrast, the exclusion criteria were considered as follows: (1) diagnosed major NCD; (2) uncorrected hearing loss or total deafness; (3) uncorrected defective eyesight or total blindness; (4) significant dependence in everyday life – a bedridden person; (5) use of drugs which slow down the central nervous system; (6) less than 6 years of formal education.

The study was approved by the Bioethics Committee of the Collegium Medicum in Bydgoszcz, Nicolaus Copernicus University in Torun. All participants gave their written consent for participation in the study.

Diagnostic criteria

All participants within the *Comprehensive geriatric assessment* underwent neuropsychological, quality of life, functional and laboratory testing. On the basis of an overall assessment of the participant, the therapeutic team – consisting of a geriatrician, clinical neuropsychologist and physiotherapist –diagnosed mild NCD or no NCD. The group of experts identified the severity of cognitive impairment without taking the etiology into account. Then, an independent researcher conducted the MoCA 7.2 test without knowing the therapeutic team's diagnosis.

Identification of mild NCD is based on the DSM-5 new diagnostic criteria [1], which include: (A1) the concern of the individual, a knowledgeable informant, or the clinician that there has been a mild decline in cognitive function; (A2) a modest impairment in cognitive performance, preferably documented by standardized neuropsychological testing or, in its absence, another quantified clinical assessment; (B) The cognitive deficits are insufficient to interfere with independence (e.g., instrumental activities of daily living, like more complex tasks such as paying bills or managing medications, are preserved), but greater effort, compensatory strategies, or accommodation may be required to maintain independence; (C) the cognitive deficits do not occur exclusively in the context of a delirium; and (D) the cognitive deficits are not better explained by another mental disorder (e.g., major depressive disorder, schizophrenia).

On the other hand, the inclusion criteria in the group without mild NCD (group without NCD) were as follows: (1) the lack of complaints on cognitive function decline; (2) preserved general cognitive functioning; (3) preserved independence in everyday activities; (4) absence of mental illness.

Neuropsychological tests

The Polish version of the MoCA 7.2 was developed by Gierus et al. [13]. Access to the test was obtained via the official website: http://www.mocatest.org/. The Polish version of the MoCA 7.2 evaluates the following cognitive domains: visuospatial and executive functions (an alternation task adapted from *the trail-making test-B*;

a three-dimensional cube copy, and clock-drawing task); naming (naming 3 animals); attention (repetition of a series of 5 digits forward and 3 digits backward, clapping on the vowel "a" read by the examiner, subtracting seven from 90 in series); language functions (repetition of two sentences); verbal fluency (listing words that start with the letter "s"); abstraction (two-item verbal abstraction task); short-term memory/ delayed recall (recreate 5 previously memorized words); orientation (to answer questions about the time and place). In the Polish version of the MoCA 7.2 recommended cut-off point for distinguishing individuals with mild NCD and those without NCD is 25/26. In addition, the final MoCA 7.2 result is correlated with the years of formal education. Schooling lasting less than 12 years is awarded 1 extra point.

The MMSE is widely used screening tool for the diagnosis of mild and major NCD [22]. Research shows that about 51% of primary healthcare physicians use the MMSE and its variants in clinical practice [23, 24]. The MMSE analyzes the five cognitive domains, i.e., orientation, memory, attention, language, and constructive praxis. The recommended cut-off point to differentiate between people without NCD and those with mild NCD in the MMSE is considered to be 26/27.

The Clock Drawing Test (CDT) is a widely accepted screening tool for cognitive evaluation of visuospatial domain, planning, abstract and conceptual thinking [25]. In clinical practice, the CDT is used by 52% of family doctors [24] and 72% of geriatricians [26]. There are several versions of the test, which differ in the type of tasks and score. Studies showed small differences between the scales, as in all cases they obtained sensitivity of about 87% and diagnostic specificity of about 86% [27]. Zhou et al. [28] noted that the CDT measure narrow area of cognitive disorders – that is why clinicians who wish to explore more cognitive domains and increase the diagnostic accuracy of mild NCD should use the CDT in conjunction with the MMSE (sensitivity of 93.7%, specificity of 92.5%).

The Geriatric Depression Scale (GDS) was developed by Yesavage et al. [29] as a 30-item self-report assessment used to identify depression in the elderly. Polish version of the GDS has been translated and made available to clinical practice by the company Servier Poland. Using the available translation, Bidzan et al. [30] evaluated the specificity and sensitivity of the GDS as 81% and 47%, respectively. The scale allows differentiation of patients with depressive disorder and those with neurocognitive disorders.

Functional tests

The Activities of Daily Living (ADL) [31] and the Instrumental Activities of Daily Living (IADL) [32] are used to verify the performance in terms of people's daily self-care activities. The ADL scale assesses independence in self-care tasks, i.e., bathing, getting dressed, toilet hygiene, functional mobility, self-feeding, and defecation control. The IADL verifies more complex activities of everyday life, which are dependent on higher level of neuropsychological functioning, i.e.,: (1) use of telephone or other form of communication and transportation within the community; (2) managing money and taking medications as prescribed; (3) shopping, housekeeping, preparing meals,

doing laundry. The study used both: the 6-item ADL scale and the 27-item IADL scale. The DSM-5 new clinical diagnostic criteria for mild NCD include the assessment of one's independence, investigated by evaluating self-sufficiency in activities of daily living, we therefore decided to use the ADL and the IADL scales included in the Comprehensive geriatric assessment [1, 33].

Statistical analysis

Demographic characteristic, cognitive scores and functional scores were compared between mild NCD and non-NCD groups using the chi-square test for parametric variables and the Mann-Whitney *U* test for nonparametric data. The diagnostic value of the MoCA 7.2 and the MMSE for screening mild NCD was analyzed using the ROC curve method. A p-value < 0.05 was regarded as statistically significant. The statistical analysis was carried out using Statistica 12.5 software for Windows.

Results

Study group

The study comprised 131 participants, 54 included in the group without NCD, and 77 in the group with mild NCD. The mean age was 74.80 years for the group without NCD and 79.06 years for the group with mild NCD. There were no significant differences in mean age between the groups ($p = 0.001$). In the group without NCD, women constituted 77.78% of participants, while in the group with mild NCD – 70.13%, which also showed no significant gender differences between the two groups. The average number of years of education for a group without NCD was 12.48 years, while for the group with mild NCD – 9.79 years. Analysis of the quality of education (with the assumption that the primary education lasted less than 7 years, vocational or secondary 8–12 years, and higher more than 12 years) showed that 5 people (9.26%) in the group without NCD had primary education; 18 people (33.33%) – secondary or vocational education; while 31 people (57.41%) – higher education. In the group with mild NCD 23 people (29.87%) had primary education, 38 people (49.35%)– secondary or vocational and 16 people (20.78%) had higher education (Table 1).

Table 1. **Characteristics of participants**

	mild NCD (n = 77)	non-NCD (n = 54)	
	Mean (SD)	Mean (SD)	p
Age in years	79.06 (5.54)	74.80 (8.20)	*0.001
Years of education	9.79 (3.44)	12.48 (3.35)	*< 0.001
BMI	33.12 (21.28)	30.17 (22.56)	*0.009
ADL score	5.53 (0.91)	5.89 (0.29)	*0.02

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IADL score	23.01 (4.67)	25.19 (3.13)	*0.002
GDS score	9.09 (4.53)	6.57 (4.60)	*< 0.001
	mild NCD (n = 77)	non-NCD (n = 54)	p (χ^2-test)
Sex: females, % (n)	70.13% (54)	77.78% (43)	0.3302

NCD – neurocognitive disorders; SD – standard deviation; * – statistically significant $p < 0.05$; ADL – Activities of Daily Living; IADL – Instrumental Activities of Daily Living; GDS – Geriatric Depression Scale

Table 2. **Results of cognitive tests**

	mild NCD (n = 77)	Non-NCD (n = 54)	
	Mean (SD)	Mean (SD)	
CDR score	2.82 (1.26)	4.26 (0.83)	*< 0.001
MMSE score	26.67 (2.17)	29.06 (1.22)	*< 0.001
1. Orientation	9.40 (1.41)	9.91 (0.35)	*0.022
2. Memory	2.92 (0.32)	3.04 (0.27)	0.418
3. Attention	3.59 (1.54)	4.59 (0.98)	*< 0.001
4. Delayed Recall	2.12 (0.88)	2.72 (0.60)	*< 0.001
5. Language	2.93 (0.25)	2.98 (0.14)	0.643
6. Executive function	3.85 (0.54)	4 (0.00)	0.304
7. Writting	0.84 (0.37)	0.96 (0.19)	0.235
8. Constructive praxis	0.73 (0.45)	0.81 (0.39)	0.432
MoCA 7.2 score	19.83 (4.08)	25.72 (2.72)	*< 0.001
1. Visuospatial/ executive functions	2.89 (1.07)	4.52 (0.79)	*< 0.001
2. Naming	2.39 (0.73)	2.76 (0.55)	*< 0.001
3. Attention	3.64 (1.36)	5.04 (1.15)	*< 0.001
4. Language	1.356 (1.03)	2.37 (0.73)	*< 0.001
5. Abstraction	1.50 (0.64)	1.80 (0.45)	*0.020
6. Delayed Recall	1.46 (1.69)	2.72 (1.56)	*< 0.001
7. Orientatioin	5.72 (0.60)	5.72 (1.00)	0.451

CDT – Clock Drawing Test; GDS – Geriatric Depression Scale; MMSE – Mini-Mental State Examination; MoCA– Montreal Cognitive Assessment

Reliability of the Polish version of the MoCA 7.2 in detecting mild NCD

The mean MoCA 7.2 and MMSE scores showed significant differences between groups ($p < 0.001$; Table 2). In the ROC curve analysis of the MoCA score in differentiating mild vs. non-NCD, the area under the curve (AUC) was 0.959 ($p < 0.001$; Table 3). Graphic representation of the ROC curve for the MoCA 7.2 and the MMSE are provided in Figure 1. The optimal cut-off score for mild NCD was 24/25 points, with a sensitivity of 89.5% and specificity of 74.1% (Table 4). Then we analyzed each item of the Polish version of the MoCA individually using one-way ANOVA. All items, except "7. Orientation", showed significant differences between two groups (Table 2). There were no significant correlations between the MoCA and the results of functional tests.

Reliability of the Polish version of the MMSE in detecting mild NCD

In the ROC curve analysis of the MMSE score in differentiating mild NCD vs. non-NCD, the area under the curve (AUC) was 0.873 ($p < 0.001$; Table 3). The optimal cut-off score for mild NCD was 28/29, with a sensitivity of 75.0% and specificity of 79.6% (Table 4). We then analyzed each item of the Polish version of the MMSE individually using one-way ANOVA. Only three domains: "1. Orientation", "3. Attention" and "4. Delayed recall", showed significant differences between two groups (Table 2). There were no significant correlations between the MMSE and the results of functional tests.

Table 3. **Receiver operating characteristic curve analysis of the Polish version of the MoCA and the MMSE in detecting mild NCD vs. non-NCD**

	MoCA	MMSE
AUC (SD)	0.959 (0.032)	0.873 (0.037)
p AUC	< 0.001	< 0.001
AUC differences (SD)	0.086 (0.043)	
p AUC differences (SD)	0.043	

AUC – area under the curve; MMSE – Mini-Mental State Examination; MoCA – Montreal Cognitive Assessment

Table 4. **Sensitivity, specificity, ACC, PPV, NPV, LR(+), LR(-), Youden index for all cut-off scores for the MoCA 7.2 and the MMSE**

MoCA 7.2	Sensitivity	Specificity	ACC	PPV	NPV	LR(+)	LR(-)	Youden index
17/18	0.289	1.000	0.585	1.000	0.500		0.711	0.289
18/19	0.289	0.981	0.577	0.957	0.495	15.632	0.724	0.271
19/20	0.382	0.963	0.623	0.935	0.525	10.303	0.642	0.345
20/21	0.526	0.944	0.700	0.930	0.586	9.474	0.502	0.471

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21/22	0.618	0.926	0.746	0.922	0.633	8.349	0.412	0.544
22/23	0.697	0.852	0.762	0.869	0.667	4.707	0.355	0.549
23/24	0.803	0.815	0.808	0.859	0.746	4.334	0.242	0.617
24/25	0.895	0.741	0.831	0.829	0.833	3.451	0.142	0.635
25/26	0.987	0.648	0.846	0.798	0.972	2.805	0.020	0.635
26/27	0.987	0.407	0.746	0.701	0.957	1.665	0.032	0.394
27/28	1.000	0.259	0.692	0.655	1.000	1.350	0.000	0.259
28/29	1.000	0.148	0.646	0.623	1.000	1.174	0.000	0.148
29/30	1.000	0.037	0.600	0.594	1.000	1.038	0.000	0.037
MMSE	Sensitivity	Specificity	ACC	PPV	NPV	LR(+)	LR(-)	Youden index
24/25	0.184	1.000	0.523	1.000	0.466		0.816	0.184
25/26	0.289	0.981	0.577	0.957	0.495	15.632	0.724	0.271
26/27	0.434	0.944	0.646	0.917	0.543	7.816	0.599	0.379
27/28	0.592	0.870	0.708	0.865	0.603	4.568	0.469	0.462
28/29	0.750	0.796	0.769	0.838	0.694	3.682	0.314	0.546
29/30	0.947	0.463	0.746	0.713	0.862	1.764	0.114	0.410

MMSE – Mini-Mental State Examination; MoCA – Montreal Cognitive Assessment; ACC –accuracy; PPV – positive predictive value; NPV – negative predictive value; LR – likelihood ratio

Discussion

The MoCA is designed as a screening tool for detecting mild cognitive impairment (mild NCD). Validation studies on the English version of the MoCA show promising sensitivity (90%) and specificity (87%) in detecting mild NCD caused by Alzheimer's disease compared to commonly used tool – the MMSE (sensitivity of 18%, specificity of 100%) [12]. In addition, the MoCA utility in detecting mild NCD has been confirmed in other etiologies, such as: (1) vascular disease [34]; (2) metastases to the brain [35]; (3) traumatic brain injury [36]; (4) Huntington's disease [37]; (5) Parkinson's disease [38]; (6) mental disorders [39]. It should be emphasized that MoCA only assesses the degree of intensity of cognitive deficits without considering its etiology.

The first translation of the English version of the MoCA into Polish was made by Magierska et al. [13], while Gierus et al. [14] adapted the second version of the MoCA 7.2. into Polish. Review of scientific reports shows the lack of validation studies of both Polish version of the MoCA.

Recommended cut-off point for the Polish version of the MoCA and the MoCA 7.2 – similarly to the original English version – is 25/26 points for mild NCD including 1 additional point for education equal to or shorter than 12 years. In our study, generally recommended cut-off point for mild NCD was characterized by sensitivity of

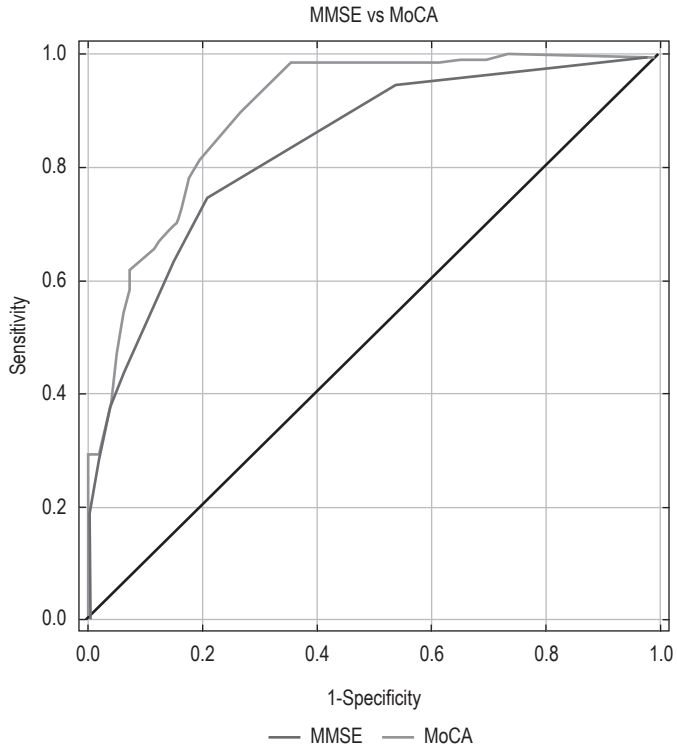

Figure 1. **ROC curve analysis of the MMSE and the MoCA in differentiating mild NCD vs. non-NCD**

98.7% and specificity of 64.8%, where the positive predictive value (PPV) was 0.798 and the negative predictive value (NPV) was 0.972. More unsatisfactory results were obtained by Magierska et al. [13] with sensitivity of 88.1% and a specificity of 40.5%.

The recommended cut-off point for the Polish version of the MMSE in screening for mild NCD is considered 26/27 points. The analysis of own research shows a very low sensitivity (43.4%) and significantly higher specificity (94.4%) at PPV 0.917 and NPV 0.543. Similarly, Magierska et al [13] indicate low diagnostic value of the Polish version of the MMSE in detecting mild NCD with the cut-off point of 25/26 (sensitivity of 28.6%, specificity of 83.7%).

Based on own research results, we concluded that the preferred cut-off point for identifying mild NCD vs. no NCD in the Polish version of the MoCA 7.2 is 24/25. This score shows the highest diagnostic reliability demonstrating a sensitivity of 89.5% and specificity of 74.1% at PPV 0.829 and NPV 0.833. Magierska et al., while using the Polish version of the MoCA [13], also obtained the highest diagnostic value in detecting mild NCD for the cut-off point of 24/25 (sensitivity of 80.9%, specificity of 54%).

Accordingly to our research results – the Polish version of the MMSE most preferably diagnose mild NCD at the cut-off point of 28/29, showing similar sensitivity

(75%) and specificity (79.6%). Magierska et al. [13], on the other hand, recommended the cut-off point of 27/28 as the most sensitive (47.6%) and specific (72.9%) in the diagnostics of mild NCD.

In our study, after analyzing the reliability of diagnostic tests, taking into consideration all the cut-off points, AUC for the MoCA 7.2 and the MMSE was 0.959 ($p < 0.001$) and 0.873 ($p < 0.001$), respectively. Thus, from the statistical point of view, the Polish version of the MoCA 7.2 proved to be a better screening tool for detecting mild NCD than the Polish version of the MMSE.

Analysis of the validation studies of different language versions of the MoCA showed – like our study – a definite diagnostic advantage of the MoCA over the widely used MMSE in screening for mild NCD and insufficient sensitivity and specificity of the recommended cut-off points for mild NCD in both tests. Validation studies of the Japanese version of the MoCA conducted by Fujiwara et al. [19] – similarly to our results – also showed the highest diagnostic value for mild NCD at the cut-off point of 24/25, where the sensitivity and specificity was 90% and 94% (AUC 0.95). The MMSE was characterized by significantly lower diagnostic reliability. Memória et al. [17] also obtained the highest sensitivity (81%) and specificity (77%) (AUC 0.82) in screening for mild NCD using the cut-off point of 24/25 in the Brazilian version of the MoCA. The MMSE showed the best diagnostic reliability (sensitivity of 60%; specificity of 68%; AUC 0.69) at the score of 28/29. Diagnostic accuracy of the MoCA at the cut-off point of 24/25 was additionally confirmed by Liew et al. [21] by showing satisfactory sensitivity of 78%, specificity of 62% and AUC of 0.68.

In contrast, Chu et al. [15], in the validation study of the Chinese version of the MoCA, observed that the score of 22/23 (sensitivity of 78% and specificity of 73%) proved to be the most promising in distinguishing mild NCD with AUC of 0.85. For the Chinese version of the MMSE the score of 27/28 (sensitivity of 67%; specificity of 83%; AUC 0.78) appeared to be the most optimal. Lee et al. [40], in the study of the Korean version of the MoCA for mild NCD, also obtained the optimal cut-off point at the level of 22/23 points characterized by sensitivity of 89% and specificity of 84% (AUC 0.94). The optimal cut-off point for the MMSE was 25/26 (sensitivity of 59%; specificity of 70%; AUC 0.66). Luis et al. [41], in the study of the English version of the MoCA, obtained higher sensitivity (96%) and specificity (95%) with optimal score of 23/24 (AUC 0.97), while in the MMSE with optimal cut-off point of 27/28 they obtained sensitivity and specificity at the level of 58% and 84% (AUC 0.76), respectively. Zhao et al. [42] also determined 23/24 points as the optimal cut-off point in the MoCA for differentiation of mild NCD vs. non-NCD (sensitivity of 77.2%; specificity of 90.1%; AUC 0.882). On the basis of the analysis of own research results and literature review, it can be concluded that lowering the cut-off points from the recommended 26/27 can greatly improve the accuracy of the test in detecting mild NCD.

It is well known that the demographic variables – age, sex, education, regional differences – affect the correctness of the screening diagnostic tests. Clinical studies have demonstrated that the strongest factor influencing the test results and reliability of the MoCA is the level of education [16, 19, 21, 40, 41, 43, 44]. Our study was based

on the analysis of reliability of the polish version of the MoCA 7.2 among geriatric patients covering every level of education. No correlation between each level of education was carried out due to small research groups at different levels of education. The further implementation of the research project is planned for this purpose.

Conclusions

We have demonstrated that the current Polish version of the MoCA 7.2 is superior to the commonly used MMSE in screening for mild NCD. The test can be recommended in primary and geriatric care as screening tool for early NCD. However, further studies are required to find the most optimal cut-off points for mild NCD and major NCD for the Polish population. In addition, there is a need to analyze the MoCA 7.2 for demographic variables and verify their results.

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