The usefulness of the SLUMS test for diagnosis of mild cognitive impairment and dementia

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Summary

Aim. To compare Polish version of The Saint Louis University Mental Status Examination test (SLUMS) to generally used psychometric screening tools for detecting mild cognitive impairment and dementia.

Methods. The total number of 58 nursing home residents were divided into 3 groups: 1) people showing no symptoms of dementia, 2) people with mild cognitive impairment and 3) people with suspected dementia. The Saint Louis University Mental Status Examination (SLUMS), Mini Mental State Examination (MMSE), Short Test of Mental State (STMS) and Test Your Memory (TYM) were administered for comparison.

Results. Mean age was 81.7 ± 8.62. Regarding the education, 37.9% of the sample was educated at the primary school level, 31% completed high school and 22.4 % had higher education. The SLUMS internal consistency was 0.7031. The mean of total SLUMS score was 23.3 in no demented residents, 19.3 among those identified as having cognitive impairments and 13.1 residents with suspected dementia. The statistical analysis illustrated that SLUMS differentiate the dementia residents from those considered as having cognitive impairment (p = 0.01), as well as from non demented participants (p = 0.0001). Moreover, it seems to be useful for detecting mild cognitive impairment in non demented participants (p = 0.017), while MMSE does not offer such a possibility (p = 0.51).

Conclusions. The SLUMS is not just another screening tool that can complement the range of existing cognitive tests in Polish clinical practice, but according to statistical analysis it demonstrates superior capabilities in the screening diagnosis compared to the most famous scale used in Poland – MMSE.

Introduction

Mild cognitive impairment (MCI) is a term used to describe a heterogeneous group of symptoms associated with cognitive impairment and often refers to the transition period between normal functioning and dementia [1]. Despite the fact that in Europe the term MCI is classified in the ICD-10, International Statistical Clas-

sification of Diseases and Related Health Problems, it has been primarily used in research worldwide. Since the 5th edition of the Diagnostic and Statistical Manual of Mental Disorder has been extended to include mild neurocognitive disorders, there is an urgent need to verify the guidelines of the diagnosis of MCI in clinical practice [2, 3]. According to the 2011 guidelines of the American Alzheimer's Association set forth at a meeting of the Annual Wellness Visit, an early diagnosis of cognitive impairment, its treatment and monitoring of symptoms should be provided by primary healthcare [4]. The idea of a holistic approach to the elderly patient can bring many advantages – an early diagnosis, access to appropriate pharmacological treatment and a promotion of interdisciplinary treatment strategies, including non-pharmacological treatment that takes into account the patient's psychological and social aspects of functioning [5].

Despite a significant (3–27%) prevalence of MCI in people aged 60 years and older, it is often misdiagnosed [6]. In some patients, MCI is correctly diagnosed four years after the onset of symptoms [7]. In addition, 81% of patients with dementia remain undiagnosed [8].

The crux of the problem is associated with the fact that there is a high risk of conversion of MCI into dementia, which, in turn, is associated with a twofold higher risk of mortality in this group of patients [9]. Estimated data emphasize that the risk of conversion of MCI into dementia in a single year is 10–15% and 40% within two years of the onset of cognitive impairment [10].

It seems that in Europe, including Poland, the key challenge is to raise awareness of MCI and promote its early detection by general practitioners during routine patient visits. Currently, only a small number of general practitioners recognize the need to detect cognitive deficits at an early stage, and many of them feel insufficiently prepared to diagnose them [8].

The first step in the early diagnosis of MCI and dementia, is the use of screening tools that have good psychometric properties, which take 10–15 minutes to complete [11]. There is evidence to suggest that the simultaneous use of several tools increases the predictive value of a clinical examination [12]. However, according to Gugała et al. [13], the lack of Polish normative data for many neuropsychological tools is a significant limitation in psychometric analysis.

Aim

The aim of this study was to assess the psychometric properties of the Saint Louis University Mental Status Examination (SLUMS) compared to commonly used MCI and dementia screening tools. There is a need to propagate fundamental sensitive tests among Polish clinicians. The SLUMS is a diagnostic tool created by researchers from the Saint Louis University to detect MCI [14, 15]. An English, Arabic and Portuguese version of the test are available [16, 17].

Material and method

The study was carried out with the approval of the Bioethics Committee of the Wroclaw Medical University in a welfare home in Wroclaw, maintaining respondent anonymity. Fifty eight people aged 64 years or older, who gave their written consent to participate in the research, were enrolled in the study. The exclusion criteria included obtaining less than 15 points in the Mini Mental State Examination (MMSE) [18], which made communication with the subject impossible, the presence of a serious mental illness in medical records (such as psychotic or mood disorders) and addiction to alcohol. All the individuals who were qualified for the study had good motor skills, as well as proper auditory and visual functions. The prevalence and severity of dementia were assessed using criteria from the Diagnostic and Statistical Manual of Mental Disorders, 4th edition (DSM-IV) and using the Clinical Dementia Rating (CDR) [19]. MCI was diagnosed in those people, who did not meet the criteria for a diagnosis of dementia, but did meet the criteria proposed by experts from the Mayo Clinic Group in 2004. These included complaints of memory impairment reported by the person undergoing the test and a result of 0.5 in the CDR scale [11]. Cognitive functioning was assessed using psychometric screening tools, such as a) Mini Mental State Examination (MMSE) [18], b) Short Test of Mental Status (STMS) [20], c) Test Your Memory (TYM) [21] and d) the Saint Louis University Mental Status Examination (SLUMS) tests [14, 15, 22].

In the first stage of the study, the results of the psychometric screening tests were compared and classified into three groups based on the result of the CDR scale: 1. no symptoms of dementia ("lack of dementia"), 2. probable MCI symptoms ("cognitive impairment") and 3. the presence of symptoms that indicate a likelihood of dementia ("suspected dementia"). Next, the severity of cognitive impairment in the individual screening tests was analyzed depending on the generally accepted cut-off points in the subject group. The scores were divided into three MMSE and SLUMS corresponding categories, interpreted as:

– "lack of dementia", (MMSE > 27 points, SLUMS > 27 points for those with secondary and higher education and a SLUMS score > 25 points for those with vocational or primary education);

– "cognitive impairment" (MMSE 24–26 points., SLUMS 21–26 points for those with secondary and higher education and a SLUMS score between 20–24 points for those with vocational or primary education);

– "suspicion of dementia" (MMSE < 24 points, SLUMS < 20 points for those with secondary and higher education and a SLUMS score < 19 points for those with vocational or primary education);

and into two categories based on the STMS and TYM tests, as follows:
– "lack of dementia", (STMS ≥ 30 points, TYM ≥ 39 points),
– "suspicion of dementia" (STMS < 30 points, TYM < 39 points).

The final stage of the analysis was the evaluation of the psychometric properties of the Saint Louis University Mental Status Examination (SLUMS) screening tool, which was used in Poland for the first time. A division into three groups according to the CDR result was used for reference.

Tools

Mini-Mental State Examination, MMSE

MMSE is the most frequently used screening tool to assess the cognitive function in Polish clinical practice. Its scale consists of 30 tasks allowing a quantitative assessment of various domains of the human cognitive function: time and place orientation, registration, attention and calculation, recall, naming, repetition, comprehension, reading, writing and praxis. The MMSE scale was revised due to the age and education of the respondents, and the following algorithm was created: MMSE (k) = MMSE – [0.47 x (years of education – 12) + 0.131 x (70 – age)] [23].

Short Test of Mental Status, STMS

Currently, this test is increasingly being used as a screening scale for assessing the cognitive function in the elderly. Similarly to the MMSE, STMS allows the assessment of a variety of cognitive domains, such as orientation in time and place, attention, immediate recall of 4 words and delayed recall after 3 minutes, calculation, constructive praxis, abstract and conceptual thinking and memory of previously acquired knowledge [20].

Test Your Memory, TYM

TYM is a screening tool created in 2008, allowing the assessment of cognitive function. The test was developed by Dr Jerry Brown from the Addenbrooke Hospital in Cambridge, United Kingdom [24]. In Poland, it was tested by two independent academic centres in Lodz and Wroclaw [21, 25]. The TYM differs from standard tests in that it is filled out by the patient. It analyzes 10 fields: orientation, the ability to copy a sentence, semantic knowledge, calculation, verbal fluency, abstract thinking, naming, visuospatial abilities, recall of a copied sentence and the assessment of one's independence.

The Saint Louis University Mental Status Examination (SLUMS)

The SLUMS test was created by a team from the Saint Louis University in the place of other screening tools previously used to diagnose MCI limited by poor sensitivity. SLUMS is made up of 11 tasks, which can give up to 30 points [14, 15]. The first three tasks of the test allow the clinicist to assess the allopsychic orientation of the patient.

The patient is then asked to memorize five words. Next, the patient is asked to perform a simple mental math task, which evaluates the subject's arithmetic skills, abstract thinking, as well as his/her ability to concentrate. Categorical fluency is assessed in the task where the subject is asked to name as many names of animals as possible in 1 minute. The researcher then asks the subject to recall the words he/ she had memorized earlier. This allows the assessment of delayed memory. Subsequently, the patient is asked to recall a sequence of numbers in reverse order, draw a clock (setting the hands at ten to eleven) and recognize geometric figures. The last task evaluates the subject's logical memory, whereby the researcher reads the subject a story, and he/she has to answer 4 questions connected to it. The test lasts for a maximum of 10 minutes. Compared to the MMSE, SLUMS includes more fields, such as: remembering after deferment, categorical fluency, memorizing a sequence of numbers, memorizing facts, drawing a clock, which also assess the executive abilities of the subject.

The authors of the SLUMS test agreed for it to be assessed in Poland. The English version of the test was translated into Polish in accordance with the recommendations by the adaptation of tests and questionnaires, using back translation. The final test version does not differ significantly from the original one apart from the use of different words, such as "names used", "the name of the city" and "the last job" in the last task, which assesses the ability of the respondent to memorize facts. These changes were approved by competent judges in order to adapt the names to the Polish socio-cultural conditions.

Statistical analysis

Normality of the data was analyzed using the D'Agostino-Pearson test. Quantitative variables were compared between groups using the Mann-Whitney U test. The relationship between qualitative variables with two or more categories and quantitative variables was assessed using the Kruskal-Wallis test. A Bonferroni corrected post-hoc analysis was carried out using multiple repetitions. The relationship between the two qualitative variables was evaluated using the χ^2 test or the Fisher test (in the case of small sample sizes).

The discriminatory power of the tests was analysed using the ROC curve. The maximal cut-off points were determined using the Youndes index. The difference in the areas under the ROC curves was assessed using the DeLong method. The reliability of the test was verified using Cronbach's alpha coefficient. An analysis of the relationships between the different test results was carried out using Spearman's correlation coefficient.

The analysis was performed using the MedCalc R statistical package for Windows.

Results

Descriptive statistics

Thirty-three women (56.9%) and 25 men (43.1%) took part in the study. The average age of the subjects was 81.7 ± 8.62 years. The majority of participants had primary education – 37.9%. 31% of the participants had secondary education, 22.4% had higher education and 8.6% had vocational education.

Due to the fact that the results were analysed on the basis of the CDR scale, the subjects were divided into three groups: 1. lack of symptoms of dementia – 39.7% (n = 23), 2. probable MCI – 27.6% (n = 16), 3. probable dementia – 32.8% (n = 19).

The average results in individual screening tests in the study group were as follow: 25.4 ($\pm$ 4.29) points in the MMSE test, 24.1 ($\pm$ 5.42) points in the STMS test, TYM 35.4 ($\pm$ 8.61) points in the TYM test and 19.2 ($\pm$ 5.97) points in the SLUMS test.

Table 1 contains descriptive characteristics of the overall results as well as of the subtests of the psychometric screening tools, with subjects divided into three groups, 1. "lack of dementia", 2. "cognitive impairment", 3. "suspicion of dementia". Statistically significant differences between the groups are also indicated.

Table 1. **A comparison of the results of the psychometric tests in the studied group**

Scale	Lack of dementia (n = 23) [1]			Cognitive impairment (n = 16) [2]			Suspicion of dementia (n = 19) [3]				
	Mean	SD	Median	Mean	SD	Med.	Mean.	SD	Med.	p-value	Post-hoc*
MMSE											
Total score	28.39	2.27	28.00	26.19	1.94	26.00	21.11	4.19	21.00	0.0001	[1] vs. [3] p = 0.0001 [2] vs. [3] p = 0.021
Orientation	9.61	0.58	10.00	9.38	0.62	9.00	6.74	2.40	7.00	0.0001	[1] vs.[3] p = 0.0001 [2] vs. [3] p = 0.004
Registration	2.96	0.21	3.00	2.94	0.25	3.00	2.79	0.54	3.00	0.38	
Attention and calculation	4.09	1.44	5.00	2.31	1.58	3.00	1.68	1.60	1.00	0.0001	[1] vs. [2] p = 0.005 [1] vs. [3] p = 0.0001
Recall	2.09	0.67	2.00	1.38	1.15	1.50	0.79	0.98	1.00	0.0001	[1] vs. [3] p = 0.0001
Naming	2.00	0.00	2.00	2.00	0.00	2.00	1.95	0.23	2.00	0.36	
Repetition	0.91	0.29	1.00	0.69	0.48	1.00	0.68	0.48	1.00	0.13	
Comprehension	2.70	0.47	3.00	2.69	0.60	3.00	2.58	0.69	3.00	0.89	
Reading	0.96	0.21	1.00	1.00	0.00	1.00	0.90	0.32	1.00	0.37	
Writing	0.96	0.21	1.00	0.94	0.25	1.00	0.90	0.32	1.00	0.73	
Praxis	0.74	0.45	1.00	0.31	0.48	0.00	0.37	0.50	0.00	0.013	[1] vs. [2] p = 0.028
STMS											

Total score	28.44	3.24	28.00	23.44	4.47	23.00	19.32	3.87	19.00	0.0001	[1] vs. [2] p = 0.013 [1] vs. [3] p = 0.0001
Orientation	7.74	0.45	8.00	7.44	0.51	7.00	5.84	1.83	6.00	0.0001	[1] vs. [3] p = 0.0001 [2] vs. [3] p = 0.034
Attention	4.70	0.76	5.00	4.56	0.73	5.00	3.95	1.13	4.00	0.012	[1] vs. [3] p = 0.017
Learning	3.61	0.58	4.00	3.38	0.50	3.00	2.63	1.07	3.00	0.001	[1] vs. [3] p = 0.001
Arithmetic	3.35	0.83	4.00	2.13	1.31	2.00	1.90	1.49	2.00	0.001	[1] vs. [2] p = 0.012 [1] vs. [3] p = 0.003
Abstract thinking	2.17	1.11	3.00	0.94	1.24	0.00	1.47	1.26	1.00	0.011	[1] vs.[2] p = 0.009
Knowledge	3.22	1.04	4.00	2.00	1.10	2.00	1.58	1.12	1.00	0.0001	[1] vs. [2] p = 0.011 [1] vs. [3] p = 0.0001
Praxis	3.00	0.80	3.00	2.25	1.39	2.00	1.47	1.39	1.00	0.002	[1] vs. [3] p = 0.001
Delayed recall	0.65	0.98	0.00	0.75	1.13	0.00	0.47	0.77	0.00	0.81	
TYM											
Total score	42.78	3.18	44.00	34.63	7.07	34.50	27.21	6.29	27.00	0.0001	[1] vs. [2] p = 0.002 [1] vs. [3] p = 0.0001
Orientation	9.96	0.21	10.00	9.94	0.25	10.00	7.79	2.32	8.00	0.0001	[1] vs. [3] p = 0.0001 [2] vs. [3] p = 0.0001
Semantic knowledge	2.17	0.49	2.00	1.56	0.63	2.00	1.63	0.68	2.00	0.003	[1] vs. [2] p = 0.024 [1] vs. [3] p = 0.006
Rewriting	2.22	0.52	2.00	1.94	0.57	2.00	1.37	0.90	2.00	0.002	[1] vs. [3] p = 0.002
Arithmetic	3.74	0.45	4.00	2.56	1.59	3.00	2.90	1.33	3.00	0.017	[1] vs. [2] p = 0.033
Fluency	3.30	1.11	4.00	3.00	0.97	3.00	1.84	1.42	2.00	0.002	[1] vs. [3] p = 0.001
Abstraction	3.17	1.15	4.00	1.44	1.55	1.00	2.42	1.22	2.00	0.002	[1] vs. [2] p = 0.001
Naming	4.44	1.44	5.00	3.69	2.21	5.00	2.47	2.41	2.00	0.028	[1] vs. [3] p = 0.024
Connecting points	2.44	0.90	3.00	2.25	1.18	3.00	1.53	1.26	1.00	0.035	[1] vs. [3] p = 0.039
Clock	3.48	1.04	4.00	2.63	1.59	3.50	1.58	1.64	1.00	0.001	[1] vs. [3] p = 0.001
Delayed recall	3.00	1.71	3.00	1.69	2.02	0.50	0.84	1.57	0.00	0.003	[1] vs. [3] p = 0.002
Independence	4.87	0.46	5.00	3.94	1.44	5.00	2.84	1.30	3.00	0.0001	[1] vs. [3] p = 0.0001 [2] vs. [3] p = 0.049
SLUMS											
Total score	24.30	2.98	24.00	19.25	4.43	20.00	13.05	3.54	13.00	0.0001	[1] vs. [2] p = 0.017 [1] vs. [3] p = 0.0001 [2] vs. [3] p = 0.01

Orientation	2.78	0.42	3.00	2.63	0.50	3.00	1.84	0.90	2.00	0.0001	[1] vs.[3] p = 0.0001 [2] vs.[3] p = 0.019
Counting and attention	2.39	1.20	3.00	2.06	1.18	3.00	1.16	1.21	1.00	0.008	[1] vs. [3] p = 0.007
Fluency	2.48	0.67	3.00	1.88	0.81	2.00	1.37	0.76	1.00	0.0001	[1] vs. [3] p = 0.0001
Memory/words	2.65	1.19	3.00	1.50	1.32	1.50	0.68	1.00	0.00	0.0001	[1] vs. [2] p = 0.043 [1] vs. [3] p = 0.0001
Numbers	1.00	0.74	1.00	0.81	0.75	1.00	0.53	0.77	0.00	0.11	
Clock	3.61	0.78	4.00	2.94	1.77	4.00	1.37	1.61	1.00	0.0001	[1] vs. [3] p = 0.0001 [2] vs. [3] p = 0.015
Figures	2.00	0.00	2.00	1.94	0.25	2.00	1.90	0.32	2.00	0.31	
Memory/history	7.39	1.12	8.00	5.50	2.00	5.00	4.21	2.39	4.00	0.0001	[1] vs. [2] p = 0.014 [1] vs. [3] p = 0.0001

*The table contains p values of the comparison of results between groups, where the significance level was $p < 0.05$.

In the SLUMS test, the subjects without symptoms of dementia scored 24.3 points, those with cognitive impairment scored 19.25 points and those with suspected dementia – 13.05 points. The post-hoc analysis showed statistically significant differences between the groups. SLUMS differentiated between a "lack of dementia" and "cognitive impairment" at $p = 0.017$; "lack of dementia" and "suspicion of dementia" at $p = 0.0001$; "cognitive impairment" and "suspicion of dementia" at $p = 0.01$. Post-hoc analyses in the remaining screening tools showed statistically significant differences between the "lack of dementia" and "suspicion of dementia" groups ($p = 0.0001$) and the "cognitive impairment" and "suspicion of dementia" ($p = 0.021$) when using the MMSE scale; "lack of dementia" and "cognitive impairment" ($p = 0.013$) as well as "lack of dementia" and "suspicion of dementia" ($p = 0.0001$) in the STMS scale and between the "lack of dementia" and "suspicion of dementia" ($p = 0.0001$) in the TYM scale.

The assessment of the degree of cognitive impairment and dementia – a comparison of two psychometric screening tools.

The results show a discrepancy between the different tests when assuming commonly used cut off points in each assessment scale. According to the MMSE test, 25.9% (n = 15) subjects were suspected of having dementia. The SLUMS test classified 48.3% (n = 28) of the subjects into the same group. 50% (n = 29) of the subjects were considered not to have dementia or cognitive impairment symptoms based on the MMSE results, while only 13.8% (n = 8) of them where classified into this group when using the SLUMS criteria. In the case of tests with two categories, 39.7% (n = 23) of the subjects were suspected of having dementia using the TYM test, while 82.8% (n = 48) of the subjects were classified in the same group using the STMS test.
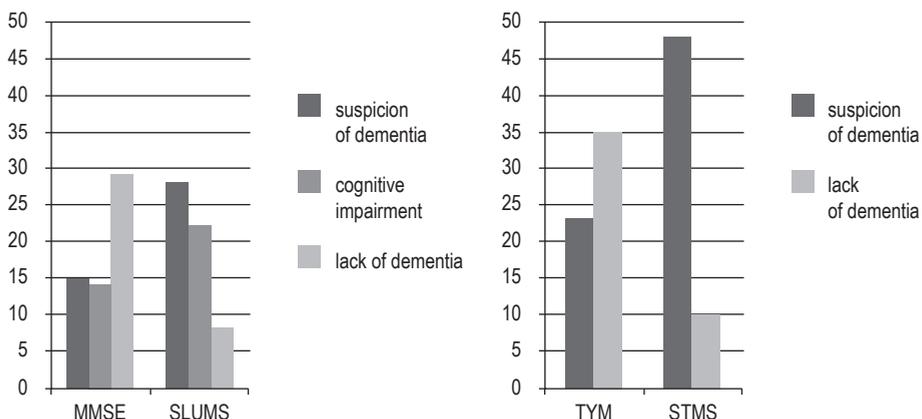
Figure 1. **Classification of the subjects in individual tests based on their scores**

Table 2. **A comparison of the distribution of the MMSE and SLUMS by diagnostic category**

MMSE	SLUMS			
	Lack of dementia	Cognitive impairment	Suspicion of dementia	
Lack of dementia	6 20.7% RT 75.0% CT 10.3% GT	16 55.2% RT 72.7% CT 27.6% GT	7 24.1% RT 25.0% CT 12.1% GT	29 (50.0%)
Cognitive impairment	2 14.3% RT 25.0% CT 3.4% GT	6 42.9% RT 27.3% CT 10.3% GT	6 42.9% RT 21.4% CT 10.3% GT	14 (24.1%)
Suspicion of dementia	0 0.0% RT 0.0% CT 0.0% GT	0 0.0% RT 0.0% CT 0.0% GT	15 100.0% RT 53.6% CT 25.9% GT	15 (25.9%)
	8 (13.8%)	22 (37.9%)	28 (48.3%)	58

The comparison of the distribution by diagnostic category based on the MMSE and SLUMS scores demonstrated that the SLUMS test classified significantly more subjects in the "suspected dementia" group (p = 0.001) (Table 2). Seven subjects classified in the "suspected dementia" group and 16 classified in the "cognitive impairment" group using SLUMS were found to have no dementia or cognitive impairment symptoms using the MMSE test.

The analysis of the psychometric properties of the SLUMS test

The reliability of the test was assessed using the internal consistency of the scale. The Cronbach's alpha coefficient greater than 0.7 according to the Nunnally's criterion [26] suggests that the scale is reliable. This result was 0.7031 for the SLUMS test, which suggests a high level of its accuracy. After removing some subtests from the analysis (the Figure subtest), the results indicated a higher Cronbach's alpha coefficient – 0.7157.

The diagnostic accuracy of the SLUMS test, assessed using the coefficient of correlation with other tests, showed it to have a very strong relationship with the STMS ($r = 0.816$; $p < 0.0001$), TYM ($r = 0.883$; $p < 0.0001$) and MMSE ($r = 0.66$; $p < 0.0001$) test.

When taking the education (table 3) and age (table 4) of the subjects into account, a comparison of the results obtained in the individual SLUMS subtests indicated that they are relatively independent of socio-demographic factors. The statistical analysis showed a difference in the ability to memorize a series of numbers between people over 75 years old ($p = 0.025$) and younger individuals. Another significant difference between subjects with primary and vocational education and the remaining individuals was found in the calculation and attention subtest ($p = 0.002$).

Table 3. **SLUMS test results taking age into account**

	< 75 years of age (n = 11)			> 75 years of age (n = 47)			
SLUMS	Mean	SD	Med.	Mean	SD	Med.	P-value
Overall result	21.27	5.22	21.00	18.75	6.08	20.00	0.22
Orientation	2.73	0.47	3.00	2.36	0.79	3.00	0.17
Calculation and attention	1.91	1.38	3.00	1.89	1.29	3.00	0.95
Verbal Fluency	2.00	0.77	2.00	1.94	0.89	2.00	0.88
Memory	2.18	1.66	3.00	1.57	1.36	1.00	0.24
Memory/numbers	1.27	0.79	1.00	0.68	0.73	1.00	0.025
Clock	3.09	1.64	4.00	2.60	1.69	4.00	0.32
Figures	1.91	0.30	2.00	1.96	0.20	2.00	0.52
Memory/history	6.18	2.27	6.00	5.75	2.31	6.00	0.56

Table 4. **SLUMS test results taking education into account**

	Higher education (n = 13)			Secondary education (n = 18)			Vocational and primary education (n = 27)			
SLUMS	Mean	SD	Med.	Mean	SD	Med.	Mean	SD	Med.	P-value
Overall result	18.77	8.19	17.00	21.28	5.69	22.50	18.07	4.66	19.00	0.15
Orientation	2.23	0.93	3.00	2.50	0.86	3.00	2.48	0.58	3.00	0.61
Calculation and attention	1.92	1.26	3.00	2.72	0.83	3.00	1.33	1.30	1.00	0.002

Verbal Fluency	1.85	1.14	2.00	2.33	0.77	2.50	1.74	0.71	2.00	0.062
Memory	1.62	1.50	1.00	2.00	1.61	2.00	1.52	1.28	1.00	0.59
Memory/numbers	100	0.82	1.00	1.00	0.69	1.00	0.56	0.75	0.00	0.069
Clock	2.39	1.89	4.00	3.11	1.28	4.00	2.56	1.80	4.00	0.57
Figures	1.92	0.28	2.00	1.94	0.24	2.00	1.96	0.19	2.00	0.57
Memory/history	5.85	2.38	6.00	5.67	2.59	6.00	5.93	2.11	6.00	0.99

* Statistically significant difference for people with vocational and primary education

Figure 2a shows the ROC curve, which demonstrates the sensitivity and specificity of each screening tool in differentiating between individuals classified as having no dementia symptoms and those suspected of having MCI and dementia. The area under the curve (AUC) is 0.919. Figure 2b shows the ROC curve that displays the differentiation between individuals classified as having no dementia and MCI and those suspected of having dementia, where the AUC is 0.944.

The analyses confirm the statistically significant discrimination ability of the SLUMS test in the screening of dementia, MCI and a lack of dementia symptoms. The cut-off point to diagnose dementia was set at ≤ 17 points with a sensitivity of 94.74% and a specificity of 87.18%. The score of ≤ 20 points is the optimal cut-off point for the diagnosis of cognitive impairment in the studied group, while maintaining a sensitivity of 82.86% and a specificity of 86.96%.

Table 5. **Diagnostic properties of psychometric tests**

	Scale with cut-off point	AUC	Sensitivity	Specificity
Suspicion of cognitive impairment	MMSE ≤ 27	0.869	91.43	69.57
	STMS ≤ 24	0.888	77.14	95.65
	TYM ≤ 36	0.934	80.00	95.65
	SLUMS ≤ 20	0.919	82.86	86.96
Suspicion of dementia	MMSE ≤ 23	0.898	73.68	97.44
	STMS ≤ 19	0.879	63.16	92.31
	TYM ≤ 31	0.899	73.68	89.74
	SLUMS ≤ 17	0.944	94.74	87.18

AUC – area under the curve

The statistical analysis showed no significant differences between the ROC curves for each of the screening tools (table 5).

Discussion

The SLUMS test has been found to be reliable in screening for mild cognitive impairment [14, 15].

This test is ranked among those available screening tools recommended by the American Alzheimer's Association that provide operationalized diagnosis of mild cog-
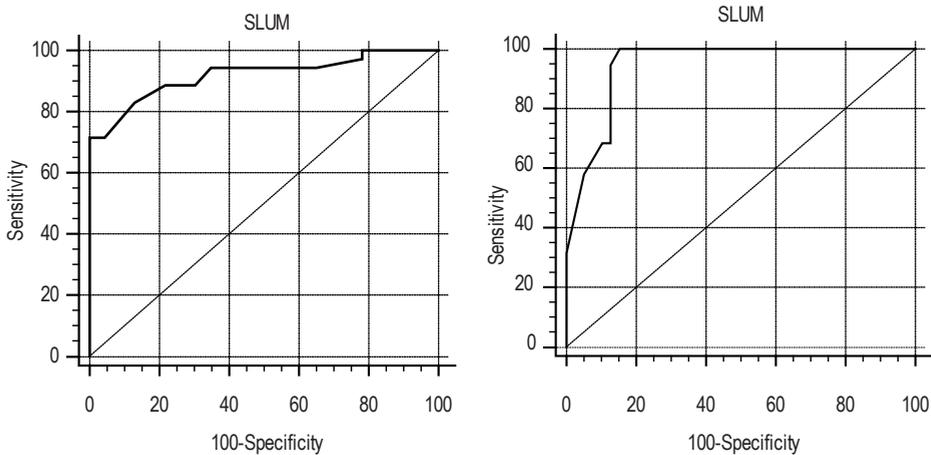
Figure 2a **and 2b. The ROC curve in SLUMS test that differentiate between (a)
a "lack of dementia" and "MCI and dementia" as well as (b)
a "lack of dementia and MCI" and "dementia"**

nitive impairment [4]. Nevertheless, experts stress that there are insufficient empirical
reports relating to the use of the SLUMS test in clinical and research studies. The data
obtained in this study, which focused on the possibility of using a Polish version of
the test for the diagnosis of MCI and dementia, confirms its psychometric properties.
The Cronbach's alpha reliability coefficient approached an acceptable value. Addition-
ally, this value increased on removing 'Figures' from the analysis. This subtest may
be omitted in the Polish version of the SLUMS test, due to a lack of differences in the
responses of the subjects with varying cognitive function (no differences in responses
between subjects with suspected dementia and those with an absence of symptoms).
Similar results were obtained by researchers from Saint Louis, who emphasized a low
discriminatory power of this subtest [15].

   The statistically significant strong positive correlations between the results of the
SLUMS and STMS ($r = 0.816$), TYM ($r = 0.883$) and MMSE ($r = 0.66$) tests indicate
that the Polish version of the test is accurate and has a convergent validity. The results
of previous studies evaluating the sensitivity of the above mentioned tests indicate that
the STMS and TYM are superior to the commonly used MMSE [20–22, 27]. These
findings, together with a strong correlation of the SLUMS and TYM and STMS tests
suggest that it is a better psychometric test than the MMSE.

   Additionally, the presence of statistically significant differences between tests in
detecting cognitive impairment and dementia suggests SLUMS to be a better screening
tool in the elderly at risk of cognitive impairment than the commonly used MMSE test.
When assuming commonly applied cut-off points, the comparison of the distribution of
subjects in the MMSE and SLUMS diagnostic categories confirmed that the SLUMS
classified subjects in the "suspected dementia" group more frequently than the MMSE.

Seven subjects from the "suspected dementia" group and 16 from the "cognitive impairment" group were found to have no dementia or cognitive impairment symptoms using the standard MMSE test.

When comparing SLUMS to STMS and TYM, it can be noted that the distribution of subjects in the group without dementia and cognitive impairment in SLUMS is similar to that found in the STMS group. The subjects can be divided into two groups based on the STMS results: those suspected of dementia and those without any symptoms. According to the norms used in the STMS test, subjects with cognitive impairment may also be classified in the group suspected of dementia. The distribution of subjects in diagnostic groups is different when taking into account the TYM results. The number of subjects classified in the "suspected dementia" group is similar when comparing the SLUMS and TYM test results. Contrary to the results that take into account the STMS norms, subjects with cognitive impairment were classified in the "lack of dementia" group in the TYM test. Such a finding is similar to earlier studies of the Polish TYM version, where it was found that the test was limited in differentiating between subjects with mild cognitive impairment and healthy subjects [21]. The qualitative analysis of the distribution of subjects in the diagnostic categories using different tests suggests that the SLUMS has a high discriminatory power for differentiating subjects with MCI. It can also be used as a supplement to tools that only diagnose subjects into two groups: those with and without dementia.

The comparison of the results of the psychometric tests carried out on the three study groups clearly shows that the SLUMS test outweighs the remaining tests in diagnosing MCI. In the study group, only the SLUMS result differed statistically between the three diagnostic groups (suspected dementia, cognitive impairment and a lack of symptoms). This is in accordance with previous reports, where subjects had worse scores in the SLUMS test than the MMSE [28, 29]. Therefore, the results confirmed the assumptions of the authors that the SLUMS test is more sensitive in detecting MCI and dementia compared to other screening tests. Carrying out a clinical examination that includes a SLUMS test reduces the risk of failing to diagnose cognitive impairment in a patient, which is often the case when using the MMSE as a screening tool [30, 31].

This study analyzed the ROC curve as well as the sensitivity and specificity of the SLUMS test. Despite the fact that there is no statistically significant difference in the areas under the ROC curve between individual tests, the SLUMS test showed a strong discriminatory power in differentiating dementia (sensitivity: 94.74%, specificity: 87.18%) from cognitive impairment (sensitivity: 82.86%, specificity: 86.96%). This study was limited both due to the size of the study group and its nature (residents of a welfare home). Therefore, the cut-off points ($\leq$ 17 points in the case of dementia; $\leq$ 20 points in the case of cognitive impairment) used in this study should not be used as diagnostic standards in the Polish population. The results seem to be understated given the cut-off points established by the authors. This is the main limitation of the present study. At the same time, owing to the discriminatory ability of the SLUMS

test in detecting MCI, there is a need for its validation in Poland on a large group of respondents from different social backgrounds.

Conclusions

The presented study confirms the psychometric properties of the SLUMS test in the screening of cognitive impairment and dementia. Reliability coefficients reached acceptable values. Statistically significant, positive and strong correlation coefficients between the results of standard currently used screening tests of and the Polish version of the SLUMS test suggest its high accuracy and convergent validity. Moreover, the SLUMS test is characterized by a high discriminatory power in the diagnosis of MCI in the studied group of patients. Limitations of the SLUMS test, like most cognitive tools, include the necessity of patient good fine motor skills and proper auditory and visual functions. Secondly, the original test sheet does not include an instruction for the subject, which may lead clinicists to carry out the tests in a non-uniform manner.

Seemingly, after the including an instruction for clinicians in Polish language in the test, the SLUMS test may be an effective alternative to the commonly used MMSE and an effective tool in the diagnosis of MCI.

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