International Journal of Gerontology 18 (2024) 24–28
https://doi.org/10.6890/IJGE.202401_18(1).0005

International Journal of Gerontology

journal homepage: http://www.sgecm.org.tw/ijge/

Original Article

The Role of Subtests of the Mini-Mental State Examination-Second Edition in Predicting Activities of Daily Living in People with Dementia

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ARTICLE INFO

Accepted 26 June 2023

Keywords:
dementia,
activities of daily living,
processing speed

SUMMARY

Objective: The aim of this study was to investigate the relationship between specific subtests of the Mini-Mental State Examination-Second Edition (MMSE-2) and activities of daily living (ADL) functions in people with dementia.
Methods: A cross-sectional design study was conducted to collect data from two teaching hospitals in northern Taiwan between March 2019 and March 2020. One hundred and twenty-five people with dementia were recruited and assessed with the MMSE-2, Barthel Index (BI), Self-Perceived Difficulty Scale, Ability Scale, and Lawton Instrumental Activities of Daily Living Scale (Lawton IADL) once.
Results: The subtests of registration, language, MMSE-2: Standard Version total score, story memory, processing speed, and MMSE-2: Expanded Version (MMSE-2: EV) total score of the MMSE-2 were significantly correlated with the BI, Self-Perceived Difficulty Scale, and Ability Scale (r = .31–.35, p < .001). In addition, the subtests of orientation, MMSE-2: Brief Version total score, and visual-constructional ability were significantly correlated with the Ability Scale (r = .32–.33, p < .001). All, except for registration subtest, were significantly correlated with the Lawton IADL (r = .29–.57, p < .001). The registration and language subtests were two important predictors of the BI, while the processing speed subtest was the only predictor for the Self-Perceived Difficulty Scale and Ability Scale. The MMSE-2: EV total score was an important predictor of the Lawton IADL.
Conclusions: The overall findings from our study demonstrates that the relationship between the MMSE-2 and ADL functions is not simply general, but that specific aspects of the MMSE-2 do in fact correlate more significantly and strongly with certain ADL functions. The findings of this study could help with the early detection of people with dementia and may provide useful information for early interventions to maintain patients' independence.

1. Introduction

With the rapid growth of the aging population which has resulted in an increase in the prevalence of dementia.[1] Dementia which is associated with cognitive decline, could have an impact on individual's ability to perform activities of daily living (ADL), leading to dependence on others.[1,2] This dependence can cause distress for individuals with dementia and their caregivers, and it is associated with poor quality of life, increased health care cost, and increased risk of mortality in people with dementia.[1]

There are two types of ADL, including basic ADL (BADL) and instrumental ADL (IADL),[1,3] which require different levels of cognitive processing. BADL refers to personal activities such as feeding, bathing, and dressing. Assessing BADL is usually done through interviews, but this method has limitations, as individuals with dementia may not accurately rate themselves, and proxies may over-or underestimate ADL impairment.[4] Therefore, direct measures requiring people with dementia to perform specific BADL tasks have been reported to have better validity.[4,13]

IADL includes complex activities like using transportation, managing money, and shopping. Studies have shown that performing IADL requires complex cognitive function processing than BADL and therefore is more prone to deterioration triggered by cognitive decline.[1,5,6] Briefly, BADL and IADL are both essential for people with dementia to determine whether they could live independently at home or in the community.

The Mini-Mental State Examination (MMSE) is the most widely used measure for detecting early cognitive function status in people with dementia,[7] but it has limitations, including vulnerability to practice effects. To address these limitations, the MMSE-Second Edition (MMSE-2) was developed, which consists of three versions: a brief version (MMSE-2: BV), standard version (MMSE-2: SV), and expanded version (MMSE-2: EV).[8] Depending on the user's purpose, each version could be administered separately and thus, the administration time could be reduced which preserves the strength of the MMSE. Furthermore, the subtests of the MMSE-2 could be used to represent a specific cognitive ability.[8] The various subtests of

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the MMSE-2 could provide useful information for identifying which individual aspect of cognition begins to decline and help track the progress of dementia.

Previous studies shown that MMSE scores were highly associated with ADL measure scores.[9–11] Han et al. reported that the "naming" of MMSE was most related to "grooming" and "bathing" and "orientation to time was associated with "responsibility for own medication" in people with Alzheimer's disease.[9] However, the relationship between specific subtests of the MMSE-2 and ADL measures has not yet been examined in people with dementia. Therefore, the aim of this study was to investigate the relationship between specific subtests of the MMSE-2 and ADL functions (including BADL and IADL) in people with dementia. This information could be used to design early interventions to assist people with dementia in becoming independent in ADL.

2. Methods

2.1. Study design and participants

This was a cross-sectional design study conducted in northern Taiwan. The data was collected from the Department of Psychiatry or the Department of Neurology of two hospitals between March 2019 and March 2020. Our research team first examined the records of the patients to select potential participants. On the day of their clinical appointment, the potential participants were approached by two trained raters to explain the research purposes and were invited to take part in the study. The inclusion criteria for people with dementia eligible to participate in this study were: (1) diagnosis of probable dementia and dementia according to the Diagnostic and Statistical Manual of Mental Disorder, fifth edition, (2) age $\geq$ 65 years, and (3) willingness to participate in the study. People with mental retardation, history of severe brain injury, or having significant physical disabilities were excluded.

Appropriate sample size for the present study was determined by using a sample size calculator (https://sample-size.net/correlation-sample-size/) with a validity criterion of 0.8 and a significance level of 0.05 (two-tailed).[12] A correlational study in the UK estimated the correlation coefficient between cognitive and ADL functions was 0.2. Therefore, the required sample size was determined to be at least 29.

The study procedures followed the study guidelines and were approved by the Research Ethics Committee of the hospitals. Informed consent was obtained from both the participants and their caregivers.

2.2. Procedure

The MMSE-2, Barthel Index (BI, assessing actual performance), Barthel Index-Based Supplementary Scales (BI-SS) which consist of the Self-Perceived Difficulty Scale and Ability Scale (assessing self-perceived difficulty and ability, respectively), and Lawton Instrumental Activities of Daily Living Scale (Lawton IADL, assessing IADL) were administered to our participants by two trained raters via face-to-face interviews, except for the Ability Scale. The Ability Scale was assessed by observing the participants perform specific ADL tasks with several assessments tools.[13] Each participant only had to be assessed once and all data collection procedures were constantly monitored through correspondence. The participants' demographic details and information on co-morbidities were collected from medical records.

2.3. Measures

2.3.1. MMSE-2

The MMSE-2 was used to assess the participants' cognitive mental status. The MMSE-2: BV (score range: 0–16) is composed of three subtests: registration, orientation, and recall. The MMSE-2: SV (score range: 0–30) is comprised of six subtests: three subtests derived from the MMSE-2: BV plus the subtests of the attention and calculation, language, and visual-constructional ability. The MMSE-2: EV (score range: 0–90) is composed of eight subtests in which six subtests were extracted from the MMSE-2: SV as well as the subtests of story memory and processing speed.[8] A higher total score indicates better cognitive mental status. The MMSE-2 has been reported to overall have good internal consistency (alpha = 0.62–0.79),[14] and good to excellent test-retest reliability (intraclass correlation coefficient, ICC = 0.56–0.93) in people with dementia.[15]

2.3.2. BI

The BI was used to assess the participants' BADL function. The BI includes 10 items: feeding, grooming, bathing, dressing, bowel care, bladder care, toilet use, ambulation, transfer, and stair climbing. Total possible scores of the BI range from 0 to 20, with higher scores indicating more independence in ADL.[16] The BI has been reported to have good reliability (ICC = 0.96)[17] and validity.[16–18]

2.3.3. BI-SS

The BI-SS consists of two scales, including the Self-Perceived Difficulty Scale and Ability Scale. The Self-Perceived Difficulty Scale was used to assess the participants' self-perceived difficulty in performing BADL. The 10 items of the Self-Perceived Difficulty Scale, which were adapted from the original BI, consists of three response categories ranging from 0 (with much difficulty), 1 (with some difficulty), and 2 (without any difficulty), with a total possible score of 20. The higher the score the lower the patient's self-perceived difficulty in performing BADL.[13] The validity and reliability of the Self-Perceived Difficulty Scale has been reported to be satisfactory (rho = 0.78 and ICC = 0.78, respectively).[13,19]

The Ability Scale was used to assess the participants' ability to perform BADL. The Ability Scale adopted eight items from the BI: feeding, grooming, dressing, bathing, toilet use, transfer, mobility, and stairs.[4] The Ability Scale is assessed by observing patients perform specific ADL tasks with several assessment tools provided by the assessor. The items of the Ability Scale are organized into three or four response categories (0 to 2 points or 0 to 3 points) and total possible scores range from 0 to 18, with higher scores indicating higher level of ability to perform BADL. The validity and test-retest reliability of the Ability Scale has been reported to be excellent (rho = 0.90 and ICC = 0.97, respectively).[13,19]

2.3.4. Lawton IADL

The Lawton IADL was used to assess the participants' ability to perform 8 IADL tasks: using the telephone, using transport, managing money, shopping, taking drugs, cooking food, housekeeping, and doing laundry.[20] The Lawton IADL is scored as 1 (independent) or 0 (dependent), with a maximum score of 8, the higher the score the higher the independence. The reliability and validity of the Lawton IADL have been reported to be excellent (Cronbach's alpha = 0.843 and ICC = 0.92, respective).[20,21]

2.4. Statistical analysis

Demographic characteristics of the participants were summa-

rized with descriptive statistics. Pearson's correlation coefficient (r) was first used to examine the association between the MMSE-2, BI, BI-SS, and Lawton IADL. An *r* value > 0.75 indicated high correlation, values of 0.50 to 0.75 represented moderate correlations, values of 0.25 to 0.50 indicated small correlations, and values of ≤ 0.25 indicated weak correlation.[22] Given the numerous correlations performed, the significance level was adjusted using a Bonferroni correction[22] (.05 divided by the 44 correlation analyses conducted) and a significance level of $p < .001$ was set.

According to the literatures, the presence of a significant correlation between variables is the prerequisite for the application of regression analysis.[23,24] Thus, only variables that showed a significant correlation were included in the next stage of the analysis. In the next stage of the analysis, a multiple regression analysis was used to investigate the relationship between the included variables (as independent variables) and the BI, BI-SS, and Lawton IADL as dependent variable. A stepwise regression approach was used to identify the most important predictors of the ADL functions. Since ADL function tends to decline with age, we adjusted for age and each regression model was checked for collinearity. The VIF of all the variables in the regression model was less than 10;[25,26] therefore, the collinearity could be ignored. Data was analyzed using IBM SPSS 17.0.

3. Results

A total of 125 people with dementia participated in the study. The participants had a mean age of 80.26 ± 7.32 years, 64% were female, and 50.40% had an educational level below elementary school (Table 1). The mean score of the MMSE-2: SV was 14.07 ± 6.44, indicating that on average, our participants had moderate cognitive impairment. The mean score of the BI was 17.14 ± 4.59, indicating that on average, our participants had moderate independence in ADL.

Results of the correlation analysis are shown in Table 2. The subtests of registration, language, MMSE-2: SV total score, story memory, processing speed, and MMSE-2: EV total score of the MMSE-2 were significantly correlated with the BI, Self-Perceived Difficulty Scale, and Ability Scale ($r = .31–.35$, $p < .001$). In addition, the subtests of orientation, MMSE-2: BV total score, and visual-constructional ability were significantly correlated with the Ability Scale ($r = .32–.33$, $p < .001$). All, except for registration subtest, were significantly correlated with the Lawton IADL ($r = .29–.57$, $p < .001$).

Table 3 shows the results of the final stepwise regression analysis adjusted by age. The registration and language subtests of the MMSE-2 were two important predictors of the BI, together contributing 13% of the variance. The processing speed subtest was only predictor for the Self-Perceived Difficulty Scale and Ability Scale, accounting for 11% and 15% of the variance, respectively. The MMSE-2: EV total score was an important predictor of the Lawton IADL, explaining 34% of the variance.

4. Discussion

The purpose of this study was to examine the relationship between specific subtests of the MMSE-2, BI, BI-SS, and Lawton IADL, and whether the specific cognitive functions could predict ADL function in people with dementia. The MMSE-2: EV total score appeared to significantly correlate with all ADL functions (including BADL and IADL), and this is not surprising given that the MMSE-2: EV total

Table 1
Characteristics of the participants (n = 125).

Characteristic	
Age (years), mean ± SD	80.26 ± 7.32
Gender, n (%)	
Male	45 (36.00)
Female	80 (64.00)
Education, n (%)	
Below elementary school	63 (50.40)
Junior to senior high school	43 (34.40)
College and above	19 (15.20)
MMSE-2, mean ± SD	
MMSE-2: BV (0–16)	6.63 ± 3.80
MMSE-2: SV (0–30)	14.07 ± 6.44
MMSE-2: EV (0–90)	20.50 ± 11.40
BI, mean ± SD (0–20)	17.14 ± 4.59
Self-Perceived Difficulty Scale, mean ± SD (0–20)	17.16 ± 4.84
Ability Scale, mean ± SD (0–18)	14.26 ± 4.60
Lawton IADL, mean ± SD (0–8)	2.73 ± 1.92

BI, Barthel Index; Lawton IADL, Lawton Instrumental Activities of Daily Living Scale; MMSE-2, Mini-Mental State Examination-Second Edition; MMSE-2: BV, Mini-Mental State Examination-Second Edition: Brief Version; MMSE-2: SV, Mini-Mental State Examination-Second Edition: Standard Version; MMSE-2: EV, Mini-Mental State Examination-Second Edition: Expanded Version; SD, standard deviation.

Table 2
Correlations between the MMSE-2, BI, BI-SS, and Lawton IADL (n = 125).

Versions and subtests	BI	Self-Perceived Difficulty Scale	Ability Scale	Lawton IADL
MMSE-2				
Registration	.34*	.31*	.32*	.22
Orientation	.22	.23	.32*	.47*
Recall	-.08	-.06	-.01	.29*
Brief Version total score	.25	.25	.33*	.46*
Attention and calculation	.20	.19	.19	.34*
Language	.30*	.33*	.32*	.38*
Visual-constructional ability	.26	.24	.33*	.43*
Standard Version total score	.31*	.32*	.37*	.51*
Story memory	.28*	.30*	.34*	.55*
Processing speed	.34*	.35*	.40*.	.55*
Expanded Version total score	.31*	.33*	.37*	.57*

* Significant difference after Bonferroni correction at $p < .05/44$ ($p < .001$).
BI, Barthel Index; Lawton IADL, Lawton Instrumental Activities of Daily Living Scale; MMSE-2, Mini-Mental State Examination-Second Edition.

Table 3
Stepwise regression results on measurements of interest in patients with dementia adjusted for age (n = 125).

Regression model	Predictors	*B*	*Beta*	95% CI	*t*-value	*p*-value	R^2
BI	Registration	1.02	0.26	0.30, 1.74	2.82	0.006*	0.13
	Language	0.46	0.19	0.03, 0.89	2.10	0.038**	
Self-Perceived Difficulty Scale	Processing speed	0.18	0.35	0.09, 0.26	4.09	0.000*	0.11
Ability Scale	Processing speed	0.19	0.39	0.11, 0.27	4.64	0.000*	0.15
Lawton IADL	Expanded Version total score	0.10	0.57	0.07, 0.12	7.66	0.000*	0.34

* $p < .01$. ** $p < .05$.
BI, Barthel Index; CI, confidence intervals; Lawton IADL, Lawton Instrumental Activities of Daily Living Scale; MMSE-2, Mini-Mental State Examination-Second Edition.

score is an aggregation of all MMSE-2 subtests, encompassing many complex cognitive functions that are needed to perform daily activities. In addition, the MMSE: 2-EV total score was found to have clinical utility in predicting the Lawton IADL. Based on our findings, the MMSE-2 is not only valuable for screening cognitive functions but also a useful tool for predicting IADL functions in people with dementia.

Although our study findings showed that the MMSE-2-EV total score was significantly positively correlated with the BI, BI-SS, and Lawton IADL, the results revealed that each specific MMSE-2 subtest also plays a role in the association with ADL functions. Both the BI and Self-Perceived Difficulty Scale were substantially associated with important cognitive functions, and specifically in registration, language, story memory, and processing speed. These findings indicate that people with dementia with better ability in the abovementioned cognitive functions, can better engage in performing BADL tasks. The results might imply that interventions for people with dementia focusing on these cognitive functions may be more beneficial for improving BADL.

It should be noted that, the Ability Scale was also significantly and positively associated with orientation and visual-constructional ability. The Ability Scale was observational-based; people with dementia were required to carry out the ADL tasks using several assessments tools that were prepared by the assessor. Those assessment tools might not be the usual tools that participants use in their daily lives and thus they might feel uncomfortable and require more cognitive efforts to implement these ADL tasks.[13] A challenge was observed when participants were asked to get dressed, suggesting that a decline in visuospatial ability might have affected their ability to locate objects in space.

Surprisingly, the registration subtest was the only MMSE-2 subtest that did not significantly correlate with the Lawton IADL. One possible reason might be that the registration subtest was simply a repetition of three items stored in short-term memory, and may not be related to any of the complex functional daily skills measured by the Lawton IADL.[6] Based on our results, performing ADL tasks, particularly IADL tasks which are more complex than BADL tasks, required almost all aspects of cognitive function. The findings support our hypothesis that cognitive functions are important to ADL functions and particularly for more complex ADL functions captured by the Lawton IADL.

Both registration and language subtests of the MMSE-2 were predictors of the BI. The BI assessed whether the participants actually perform BADL in daily life. When performing BADL, it might have required using the registration as it involves immediate memory.[9] For example, the toilet use that might require person immediate memory to remember whether or not he/she has wiped after using the toile. Furthermore, language is essential for being able to communicate with others about their needs for assistant in performing BADL.[6,9] If someone is unable to communicate their needs for assistant to a caregiver or family member, it could result in frustration and inadequate care. Overall, registration and language are crucial for performing BADL, and it is necessary to identify and address the deficits in registration and language which could certainly be a helpful step in promoting independence in BADL for people with dementia.

One of the most significant findings was that the processing speed subtest was an important predictor for the Self-Perceived Difficulty Scale and Ability Scale. The processing speed subtest, which was similar to the Symbol Digit Modalities Test, requires an individual to substitute digits for abstract symbols using a reference key.[27] Previous studies had shown that individuals with slower processing speed may take longer to complete tasks and may have difficulty keep up with the pace of daily activities.[28] We observed that when assessing Ability Scale, participants who have difficulty responding quickly to a task were showing a sense of frustration and displayed a difficulty in performing ADL, supporting the link between processing speed and BADL functions. Our findings highlight the importance of assessing and addressing processing speed deficits in people with dementia. By improving their processing speed, individuals with dementia may be better able to maintain their ability to perform ADL tasks and increase their independence.

Regarding IADL, the MMSE-2: EV total score was an important predictor of the Lawton IADL. This was not surprising, as mentioned previously, given that performing complex tasks like IADL requires many aggregated cognitive functions. It has been reported that people with dementia with poor attention and calculation, are likely to have difficulty in many, if not most, of their everyday daily tasks, such as shopping.[6,29] Although the registration subtest did not significant correlate with Lawton IADL, the regression analysis results show that it required all aspects of cognitive functions (demonstrated by MMSE-2: EV total score) to predict IADL functions. Our current findings suggest that there is utility to in predicting IADL functions in people with dementia using the MMSE-2: EV.

Three limitations require attention in the present study. First, our participants were a convenience sample recruited from two hospitals in northern Taiwan; this might have affected the generalizability of our study results. Second, we did not collect information regarding participants' disease subtype, degree, and place of residence during our study. Future studies are needed to cross-validate our findings in specific subtype groups. Third, the self-report by the participants might have overestimated or underestimated their actual performance, and thus may have affected the results of the BI and Lawton IADL. This limitation might be due to the inherent challenges of an interview study design. However, in the current study, we used the BI and Ability Scale to assess the participants which allowed us to obtain information regarding the discrepancy between actual performance of ADL in real-life circumstances and their ability to execute an ADL task using standardized assessment tools. It is strength that our participants were assessed with both the BI and Ability Scale since it provided comprehensive information (including different aspects of ADL functions) on ADL functions.

5. Conclusion

This was the first study to examine the relationship between performance on the MMSE-2 and ADL in people with dementia. The overall findings from our study demonstrates that the relationship between the MMSE-2 and ADL functions is not simply general, but that specific aspects of the MMSE-2, such as language, story memory, processing speed, orientation, and visual-constructional ability, do in fact correlate more significantly and strongly with certain ADL functions. In addition, the registration and language subtests were two important predictors of the BI, while the processing speed subtest was the only predictor for the Self-Perceived Difficulty Scale and Ability Scale. The findings obtained in this study could help with the early detection of people with dementia and may provide useful information for early interventions to maintain patients' independence.

Acknowledgements

We would like to thank the participants for their work during data collection.

Funding

This study was supported Puzi Hospital, Ministry of Health and Welfare.

Ethics approval and consent to participate

This study was approved by the Institutional Review Board of Cardinal Tien Hospital (CTH-107-3-5-016) and Taipei City Hospital (TCHIRB-108-01014). All participants provided written informed consent before enrolment.

Conflicts of interest

The authors declare that they have no conflict of interest.

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