Brief Report

Conversion Between the Mini-Mental State Examination and the Montreal Cognitive Assessment for Patients With Different Forms of Dementia

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\textbf{Keywords:} Mini-Mental Status Examination (MMSE), Montreal Cognitive Assessment (MoCA), dementia, Alzheimer’s disease, frontotemporal dementia, Parkinson dementia, Lewy body dementia, conversion

\textbf{Abstract}

Objectives: The Mini-Mental Status Examination (MMSE) and the Montreal Cognitive Assessment (MoCA) are 2 frequently used brief cognitive screening tasks. Here, we provide a conversion method from MMSE to MoCA for patients with Alzheimer’s dementia, frontotemporal dementia, and Parkinson dementia/Lewy body dementia, as well as for patients with dementia and with or without previous stroke. This conversion is needed as everyday clinical practice varies in their use of the 2 scales, which makes comparisons between studies, meta-analysis, and patient cohorts difficult.

Design: Observational cohort study.

Setting and Participants: A total of 387 patients with recently diagnosed dementia in memory clinics from the Swedish registry for cognitive/dementia disorders (SveDem) from 2007 to 2018.

Methods: Overall, 387 patients of the Swedish registry for cognitive/dementia disorders with both MMSE and MoCA scores were evaluated. An equipercentile equating method was used to convert MMSE to MoCA scores in the different patient populations. Furthermore, receiver operating curves were used to examine whether MMSE or MoCA scores can distinguish between patients with different dementia types.

Results: MMSE scores were converted to MoCA scores for all dementia types and depicted in a conversion table. Results show that the equipercentile equating method and log-linear smoothing allow the creation of a conversion table in which for each test score of the MMSE, the equivalent score of the MoCA for each investigated group can be looked up (and vice-versa).

Conclusions and Implications: This study reports a reliable and easy conversion for transforming MMSE to MoCA scores (and vice-versa) in patients with Alzheimer’s dementia, frontotemporal dementia, Parkinson dementia or Lewy body dementia, as well as patients with dementia with and without previous stroke.

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The Mini-Mental State Examination (MMSE\textsuperscript{1}) is one of the most widely used cognitive screening tests to determine the severity of dementia in clinical settings. Developed in 1975, the MMSE is a brief test to examine orientation, immediate and short-term memory, attention, calculation, language, and praxis. Yet, disadvantages of the MMSE include difficulties in identifying mild cognitive impairment,\textsuperscript{2} and it is restricted by copyright since 2001, which makes it less feasible for daily clinical use.\textsuperscript{3} Disadvantages include the narrow scope of the test and interpretation complexity such that age, education, and cultural background affect scores.\textsuperscript{2} Furthermore, the MMSE is less efficient in assessing executive impairments.\textsuperscript{4}

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The Montreal Cognitive Assessment (MoCA) is a brief cognitive screening tool that consists of a number of separate tasks including tests on short-term memory; visuospatial abilities; executive functioning; attention, concentration, and working memory; language; and orientation to time and place. It has been shown to be more sensitive to detect mild cognitive impairment and Alzheimer’s dementia (AD) in a variety of settings and conditions than the MMSE.11

Many dementia best practice guidelines refer to both, MMSE and MoCA scores as standardized tools for cognitive testing during clinical practice.12 Unfortunately, clinical trials and clinicians in everyday clinical practice vary in their use of the 2 scales, which makes comparisons between studies, meta-analysis, and patient cohorts in general difficult, as the direct comparison of MMSE and MoCA scores is complicated. Several previously published studies have attempted to develop MoCA to MMSE conversion algorithms and conversion tables.13–15 yet, to the authors’ best knowledge, the present study is the first that provides a conversion from MoCA to MMSE scores for patients with different forms of dementia [AD, vascular dementia (VAD); Parkinson’s disease dementia and Lewy body dementia (PDD/LBD)] as well as for patients with dementia without previous stroke vs patients with dementia with the previous stroke in a large Swedish cohort. Next to providing a conversion table from MMSE to MoCA scores, the study examines whether MMSE and MoCA scores can distinguish between different forms of dementia.

Methods

We analyzed MMSE and MoCA data of patients with dementia in patients that had both test scores registered in SveDem, the Swedish national quality registry of dementia disorders from 2007 to 2018. Dementia disorders in the SveDem database are clinically diagnosed according to the International Statistical Classification of Diseases and Related Health Problems, Tenth Revision classification.17 In addition, the McKeith criteria12 are used for D LB, and the Movement Disorder Society Task Force criteria19 for PDD. In total, 434 patients of SveDem provided data on both tests, MMSE and MoCA, and were therefore integrated into our analysis. Furthermore, 387 of the overall sample was diagnosed with having AD, VAD, or PDD/LDB (n = 286 with AD, n = 73 with VAD, and n = 28 with either PDD or D LB; n = 59 had a previous stroke).

Statistical Analyses

Statistical Analyses were performed in SPSS (statistics 25; IBM Corp, Armonk, NY) and in R statistical software (https://www.r-project.org). Demographic information was displayed as means and standard deviations for continuous variables and count in percent for categorical variables. Initially, patient sociodemographic variables and scores on the neuropsychological tests were computed for each group (AD vs VAD vs PDD/LBD, as well as overall dementia without stroke vs patients with stroke). Correlations between the 2 screening instruments and age effects were investigated using the Spearman rank correlation coefficient, as variables were not normally distributed, whereas for sex effects nonparametric Mann-Whitney U tests were used.

The subsample of the SveDem data set, including only patients in which both MMSE and MoCA were performed, was randomly divided into training (50%) and validation sample (50%) to avoid overfitting. We also divided the data set on our subgroups (AD, VAD, PDD/LDB, dementia, and previous stroke) in a training and a validation sample, whenever possible. We derived our conversion models in the training samples, and the performance of these models was then evaluated in the validation samples.

To convert MMSE to MoCA scores and vice-versa, the equipercentile equating method with log-linear smoothing was used (R package: ‘SNSequate’20), which matches test scores based on their respective percentile ranks after smoothing the corresponding distribution. The overall sample, as well as the AD subgroup sample, was randomly divided into training and validation samples in a 1:1 ratio to cross-validate our results. The 2 groups did not differ regarding their demographics. Because of a small sample size, we could not divide the VAD, PDD/LDB, and dementia with stroke subgroup into training and validation data. Therefore, the analyses of these subgroups remain exploratory.

The ability to differentiate patients with different forms of dementia (AD, VAD, PDD/LBD, dementia, and previous stroke) was evaluated using the area under receiver operating characteristics (ROC) curves.

Results

Patient Characteristics

An overview of the demographic and clinical characteristics for the overall sample and for each subgroup is displayed in Table 1. Furthermore, the patient characteristics of included patients with dementia in comparison with all patients with dementia registered in the SveDem database are displayed in Supplementary Table 1. Our analyses revealed that MMSE and MoCA scores were highly and significantly correlated for the overall patient group (r = 0.58, P < .001), as well as for all subgroups: AD (r = 0.59, P < .001), VAD (r = 0.57, P < .001), PDD/LDB (r = 0.47, P = .011), and patients with previous stroke (r = 0.60, P < .001).

In addition, we investigated the effects of age at diagnosis and sex on total scores of MMSE and MoCA for the overall sample and for each subgroup. It should be noted that neither the MMSE nor the MoCA include age or sex adjustments. Spearman rank correlation coefficient revealed that patient age at diagnosis showed no significant correlations between either the MMSE or the MOCA in the overall analysis (MMSE: r = 0.02, P = .755; MoCA: r = −0.04, P = .491), and also there were no significant age-test correlations found in all subgroups: AD (MMSE: r = 0.05, P = .447; MoCA: r = −0.01, P = .900), VAD (MMSE: r = −0.19, P = .107; MoCA: r = −0.08, P = .506), PDD/LDB (MMSE: r = 0.05, P = .820; MoCA: r = −0.22, P = .249), and patients with previous stroke (MMSE: r = 0.02, P = .998; MoCA: r = −0.04, P = .787).

We tested for sex effects on test scores with the Mann Whitney U test, showing that the overall distribution of MMSE (Z = −0.59, P = .554) and of MoCA values (Z = −0.77, P = .441) is the same across male and female patients. There were also no significant differences in the MMSE and MoCA distributions for male and female individuals in all subgroups: AD (MMSE: Z = −1.29, P = .194; MoCA: Z = −1.37, P = .169), VAD (MMSE: Z = 1.13, P = .259; MoCA: Z = −1.72, P = .085), PDD/LDB (MMSE: Z = 0.48, P = .494; MoCA: Z = −0.86, P = .387), and patients with previous stroke (MMSE: Z = 0.76, P = .445; MoCA: Z = 0.30, P = .760).

Conversions of MMSE and MoCA Using Equipercentile Equating Method

We generated 2 conversion tables, Tables 2 and 3, using the equipercentile equating method and log-linear smoothing for the overall samples, as well for the subgroups, in which for each test score of the MMSE, the equivalent score of the MoCA for each of our investigated groups can be looked up (Table 2) and vice-versa (Table 3). One advantage of this method is that equivalent scores are always within an interval of possible achievable scores, even though irregular score distributions are possible.21 Therefore, to ensure a normal distribution of the test scores, log-linear smoothing of each
measure's raw scores was applied leading to higher accuracy. Training and validation samples show similar results, therefore supporting our analysis.

**Table 1**

| Demographic and Clinical Characteristics | Overall | AD | VAD | DLB/PDD | P Value* Patients with Previous Stroke (All Dementia Types) |
|-----------------------------------------|---------|----|-----|---------|-------------------------------------------------------------|
| Age at diagnosis (y, mean, SD)           | 79.0 (8.1) | 78.9 (8.1) | 80.6 (7.7) | 76.0 (8.0) | .017 79.9 (7.4) |
| Sex, female:male, n, %                  | 212:175 54.7%:55.3% | 171:115 59.7%:40.3% | 31:42 42.4%:57.6% | 10:18 35.7%:64.3% | .003 27:32 45.8%:54.2% |
| Cognition                               |         |    |     |         |                                                             |
| MMSE (mean, SD)                          | 22.4 (4.2) | 22.3 (4.2) | 23.0 (3.8) | 21.3 (4.7) | .14 21.4 (4.6) |
| MoCA (mean SD)                           | 17.1 (4.4) | 17.1 (4.4) | 17.6 (4.1) | 16.8 (5.3) | .67 16.5 (5.0) |
| Previous stroke, yes:no, n, %           | 59:328 15.2%:84.4% | 30:256 10.5%:89.5% | 28:45 38.4%:61.6% | 1:27 3.6%:96.4% | <.001 16.5 (5.0) |

SD, standard deviation. Values are mean and SD for continuous variables and count in percent for categorical variables. *P values are reported for the AD, VAD, and DLB/PDD comparison.

**Table 2**

| Conversion Table of the MMSE to MoCA Conversion for the Overall Sample, and the AD, VAD, PDD/DLB, and Dementia and Stroke Subgroups |
|---|---|---|---|---|---|
| MMSE | Overall Sample | AD | VAD | PDD/DLB | Dementia and Stroke |
| 0   | 1   | 1  | 3  | 3.5  | 2 |
| 1   | 1   | 1  | 3  | 3.5  | 2 |
| 2   | 1   | 1  | 3  | 3.5  | 2 |
| 3   | 1   | 1  | 3  | 3.5  | 2 |
| 4   | 1   | 1  | 3  | 3.5  | 2 |
| 5   | 2   | 2  | 3  | 3.5  | 2 |
| 6   | 3   | 3  | 3  | 3.5  | 2 |
| 7   | 4   | 4  | 7  | 8   | 7 |
| 8   | 4   | 4  | 7  | 8.5  | 7 |
| 9   | 5   | 4  | 7  | 8.5  | 8 |
| 10  | 5   | 5  | 7  | 8.5  | 8 |
| 11  | 6   | 6  | 7  | 8.5  | 8 |
| 12  | 7   | 7  | 8  | 8.5  | 8 |
| 13  | 8   | 7  | 9  | 9    | 9 |
| 14  | 8   | 7  | 9  | 9    | 9 |
| 15  | 9   | 8  | 9  | 10   | 10 |
| 16  | 9   | 9  | 10 | 9.5  | 10 |
| 17  | 10  | 10 | 11 | 10   | 11 |
| 18  | 11  | 12 | 11 | 10.5 | 11 |
| 19  | 12  | 13 | 12 | 11   | 11 |
| 20  | 13  | 14 | 13 | 12   | 13 |
| 21  | 15  | 15 | 14 | 16   | 14 |
| 22  | 16  | 16 | 16 | 16   | 16 |
| 23  | 18  | 18 | 18 | 19   | 18 |
| 24  | 19  | 19 | 19 | 21   | 19 |
| 25  | 20  | 20 | 20 | 23   | 20 |
| 26  | 21  | 21 | 21 | 23   | 22 |
| 27  | 22  | 22 | 22 | 24   | 23 |
| 28  | 23  | 23 | 23 | 24   | 24 |
| 29  | 24  | 24 | 24 | 25   | 25 |
| 30  | 26  | 26 | 26 | 25.5 | 26 |

Conversion table of the MMSE to MoCA conversions using the equipercentile equating method.

**Table 3**

| Conversion Table of the MoCA to MMSE Conversion for the Overall Sample, and the AD, VAD, PDD/DLB, and Dementia and Stroke Subgroups |
|---|---|---|---|---|---|
| MMSE | Overall Sample | AD | VAD | PDD/DLB | Dementia and Stroke |
| 0   | MoCA | 2   | 3  | 3   | 2 |
| 1   | 2   | 2  | 3  | 3   | 2 |
| 2   | 2   | 2  | 3  | 3   | 2 |
| 3   | 5   | 5  | 3  | 3   | 2 |
| 4   | 6   | 6  | 3  | 3   | 2 |
| 5   | 8   | 9  | 3  | 3   | 2 |
| 6   | 10  | 10 | 3  | 3   | 2 |
| 7   | 11  | 11 | 3  | 3   | 2 |
| 8   | 12  | 14 | 12 | 7   | 7 |
| 9   | 14  | 15 | 13 | 13.5| 12 |
| 10  | 16  | 16 | 15 | 17  | 15 |
| 11  | 17  | 17 | 17 | 18.8| 17 |
| 12  | 18  | 18 | 18 | 19.5| 18 |
| 13  | 19  | 19 | 19 | 20.6| 19 |
| 14  | 20  | 19 | 20 | 20.7| 20 |
| 15  | 20  | 20 | 21 | 20.9| 21 |
| 16  | 21  | 21 | 21 | 21  | 21 |
| 17  | 22  | 22 | 22 | 21.2| 22 |
| 18  | 22  | 22 | 22 | 22  | 22 |
| 19  | 23  | 23 | 23 | 23  | 23 |
| 20  | 24  | 24 | 24 | 23.3| 24 |
| 21  | 25  | 25 | 25 | 24  | 25 |
| 22  | 25  | 25 | 25 | 24  | 25 |
| 23  | 27  | 27 | 27 | 25  | 26 |
| 24  | 28  | 29 | 28 | 26.5| 27 |
| 25  | 29  | 29 | 28 | 29.5| 28 |
| 26  | 29  | 29 | 29 | 29.5| 28 |
| 27  | 30  | 30 | 29 | 29.5| 29 |
| 28  | 30  | 30 | 29 | 29.5| 29 |
| 29  | 30  | 30 | 29 | 29.5| 29 |
| 30  | 30  | 30 | 29 | 29.5| 29 |

Conversion table of the MoCA to MMSE conversions using the equipercentile equating method.

**Discussion**

The purpose of this present report was to facilitate the conversion from MMSE to MoCA scores using a simple and reliable conversion method in patients with different forms of dementia and dementia with and without previous stroke. With the help of our provided conversion table, MMSE scores can be easily translated into MoCA scores and, therefore, the present report provides a tool to compare...
data between longitudinal studies or different clinical settings when only one of these cognitive tests are used.

The equipercentile equating method has been widely used in previous studies as this method enables a direct comparison of MMSE and MoCA scores. Yet, in the present study, we could not evaluate the entire range of MoCA scores (0–30 points) as patients in our data only scored from 3 to 28 points.

To our knowledge, this is the first study on the conversion of MMSE and MoCA in patients with different forms of dementia (AD, VAD, PDD/DLB) and patients with dementia and previous stroke. The present brief communication adds to the literature of MMSE and MoCA conversions using equipercentile equating methods conducted in several healthy and clinical populations. As the cognitive profile of patients with AD, VAD, and PDD/DLB differ, we could expect different patterns in our conversions due to the fact that MMSE primarily assesses memory and language abilities, whereas the MoCA assesses a broader range of cognitive domains, including executive and visuospatial functioning. The conversion of MMSE and MOCA was conducted in Swedish patients with dementia, and future studies are needed to test our finding in other populations. Some limitations must be considered: first, the present study did not have a healthy control group for further validation of our MMSE and MoCA scores. Second, as the population was based on the SveDem database, there may be some degree of selection bias and limited generalizability in our results. However, as our sample depicts a comparable sample from the overall SveDem data, we are convinced that our results are generalizable (Supplementary Tables 1 and 2). Third, we did not have information on patient education. Finally, the PDD/DLB sample used is quite small, and therefore, results cannot be generalized.

Conclusions and Implications

The present report provided a conversion from MMSE to MoCA scores in a large Swedish sample for the first time for different forms of dementia. These findings can help to fully use existing research data and can serve as a reference for clinicians to continue clinical care using the MoCA in patients who were previously provided with MMSE screenings.

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**Supplementary Table 1**  
Characteristics of Included Patients With Dementia in Comparison With All Patients With Dementia Registered in SveDem

| Patient Characteristics | Patients with Dementia Included in This Study | All Patients with Dementia in SveDem | P Value |
|-------------------------|------------------------------------------------|--------------------------------------|---------|
| n                       | 387                                            | 80,004                               | .180    |
| Age at dementia diagnosis, median (IQR) | 80.0 (74.0, 85.0) | 81.0 (75.0, 85.0) | .180 |
| Sex, n (%)               |                                                 |                                      | .130    |
| Men                     | 175 (45.2)                                     | 33145 (41.4)                        |         |
| Women                   | 212 (54.8)                                     | 46859 (58.6)                        |         |
| Living alone, n (%)      | 172 (45.0)                                     | 35053 (47.0)                        | .071    |
| Diagnosis types, n (%)   |                                                 |                                      | <.001   |
| AD                      | 160 (41.3)                                     | 25038 (31.3)                        |         |
| MD                      | 126 (32.6)                                     | 14971 (18.7)                        |         |
| VAD                     | 73 (18.9)                                      | 15190 (19.0)                        |         |
| LBD                     | 16 (4.1)                                       | 1699 (2.1)                          |         |
| PDD                     | 12 (3.1)                                       | 1204 (1.5)                          |         |
| Others                  | 0 (0.0)                                        | 21902 (27.4)                        |         |
| MMSE score, median (IQR) | 23.0 (20.0, 25.0) | 22.0 (18.0, 25.0) | <.001 |
| MoCA score, median (IQR) | 18.0 (14.0, 21.0) | 18.0 (14.0, 21.0) | .770   |

IQR, interquartile range; MD, mixed dementia.

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**Supplementary Table 2**  
ROC Curves and Cut-Off Points for MMSE and MoCA in Differentiating Different Dementia Types

| Comparison                      | MMSE           | MoCA            |
|---------------------------------|----------------|-----------------|
|                                 | Cut-Off | AUC (95%CI) | Cut-Off | AUC (95%CI) |
| AD vs VAD                       | 21.5    | 0.55 (0.48–0.63) | 14.5    | 0.53 (0.46–0.60) |
| AD vs PDD/DLB                   | 21.5    | 0.57 (0.46–0.67) | 12.5    | 0.52 (0.39–0.64) |
| VAD vs PDD/DLB                  | 21.5    | 0.63 (0.50–0.75) | 11.5    | 0.55 (0.41–0.69) |
| Dementia with stroke vs dementia without stroke | 20.5 | 0.57 (0.49–0.65) | 14.5    | 0.55 (0.46–0.64) |

AUC, area under the curve; CI, confidence interval.