The aim of this study was to determine the clinical utility of the Finnish version of the MoCA test for screening Alzheimer’s disease and MCI. The purpose was to examine the ability (sensitivity and specificity) of the MoCA to distinguish patients with AD and MCI from cognitively normal controls.

The study population consists of three participant groups: patients with AD (n=25), patients meeting the criteria for MCI (n=18), and cognitively normal controls (NC) (n=39). The AD group consists of subjects with very mild (CDR= 0.5, n=12), mild (CDR=1, n=12), and moderate (CDR=2, n=1) dementia, and they were given a diagnosis of dementia by using the revised NINCDS-ARDRA criteria. The normal control group (NC) consists of 39 cognitively normal volunteer participants.

The three study groups differed from each other in terms of sex, age, and level of education. The NCs were younger than the subjects with AD (t [37,374] = 3.265, p = 0.002) and MCI (t [30,800] = 4.306, p < 0.001). The NCs were also better-educated than the patients with AD (t [54,975] = -3.419, p = 0.001) and MCI (t [40,782] = -3.008, p = 0.004). The sensitivity and specificity of the MoCA in detecting AD and MCI was done according to various cutoff points. With a cut-off score of 26, the MoCA had a sensitivity of 100% to detect subjects with AD and a sensitivity of 100% to detect subjects with MCI. The specificity was 79.5%. With a cutoff score of 24, which was the best threshold in the present study, the MoCA not only had a high sensitivity to detect subjects with AD (96%) and MCI (89%) but also delivered a high specificity (97%).

The MoCA has a high sensitivity and specificity to detect subjects with AD and MCI with a cutoff score of 24/30. The Finnish version of the MoCA is a feasible screening instrument for assessing cognitive decline. According to our study, the optimal cutoff score of the MoCA is 24/30.

Key words: MoCA, MCI, AD, cognitive decline

This research was partially supported by the Päijät-Hämeen hyvinvointiyhtymä grant no. 3319. T. Nortunen and J. Puustinen contributed equally to this work.
INTRODUCTION

Mild cognitive impairment (MCI) is the intermediate stage between the cognitive changes of normal aging and dementia that does not significantly interfere with the activities of daily life [1]. The estimates of the incidence of dementia in individuals with MCI vary significantly between different studies, and there is evidence suggesting that some forms of MCI are recognizable as an early manifestation of dementia [2]. In many cases, MCI progresses to dementia, and MCI with memory deficits can thus be regarded as a risk state for Alzheimer’s disease (AD) [1]. The annual conversion rates from MCI to dementia range from 5 to 16 percent [3,4,5].

The Montreal Cognitive Assessment (MoCA) test is a brief cognitive screening assessment developed to distinguish MCI from normal aging [6]. The MoCA has been shown to have a high sensitivity for the detection of MCI [6-9] and mild AD [8]. However, in some studies, the original cutoff score of 26/30 (25 or below indicating impairment) has been evaluated to be too high and has identified a large number of false positives [10-14]. It has been estimated that a lower cutoff score might be more valid [11,15]. In some studies, the cutoff score of 24/30 has been shown to be more useful [12,13,16]. A cutoff score of 24/30 has also been suggested for patients with cardiovascular diseases and diabetes [17]. Some studies estimate that a cutoff score of 23/30 is optimal for detecting cognitive impairment [10,18]. The cutoff score of 23/30 has also received support from a recent meta-analysis [19]. An even lower cutoff value of 17/30 has been proposed for MCI [20]. It has been shown that the original MoCA cutoff score of 26/30 has poor specificity especially among the less-educated [16], and those with a lower education seem to have a higher variance in their MoCA scores [21,22]. Higher levels of education appear to be associated with superior MoCA performance, while older subjects show an impairment in their MoCA test performance [23].

The aim of this study was to determine the clinical utility of the Finnish version of the MoCA for screening Alzheimer’s disease and MCI. The purpose was to examine the ability (sensitivity and specificity) of the MoCA to distinguish patients with AD and MCI from cognitively normal controls. As discussed in the above, there have been many proposals for the best MoCA cutoff score. We explored the valid cutoff score for the Finnish population in detecting MCI and Alzheimer’s disease. The MoCA was compared with the Mini-Mental State Examination (MMSE) [24] which is the most commonly used cognitive screening test in many countries, including Finland.

MATERIAL AND METHODS

The study population consisted of three participant groups: patients with AD (n=25), patients meeting the criteria for MCI (n=18), and cognitively normal controls (NC) (n=39). The AD group consisted of subjects with very mild (CDR= 0.5, n=12), mild (CDR=1, n=12), and moderate (CDR=2, n=1) dementia, and they were given a diagnosis of dementia by using the revised NINCDS-ARDRA crite-
MCI was defined according to the criteria by Winblad et al. [26] and by using a CDR of 0.5 and an MMSE score of ≥ 24. The normal control group (NC) consisted of 39 cognitively normal volunteer participants.

The following study inclusion criteria for the patients were used: probable cognitive disorder on the grounds of the referral, age ≥ 50 years, none-to-moderate dementia (MMSE>15, CDR 0–2), and a stable condition with no acute comorbidities. The exclusion criteria for all subjects were either a mental disorder diagnosed during the previous 6 months or motor or sensory deficiencies that would have complicated the evaluation of cognitive function. In addition, the exclusion criteria for the NC group were diseases affecting cognitive function and subjective memory decline in the previous six months. The fact that all the NC participants were employed gave us additional evidence for normal cognition. All participants gave informed consent. The demographic characteristics and MoCA and MMSE scores of the study participants are provided in Table 1.

We conducted this study between May 2011 and April 2014 at the Neurology Outpatient Clinic of Päijät-Häme Central Hospital in Finland, to which patients with impaired cognition were referred from public health care centers and private sector units. The NC subjects were recruited through an advertisement in the Päijät-Häme Health Care Group's personnel journal. The MoCA was administered to all subjects as part of a standard neuropsychological assessment. All patients met a neurologist, who made a diagnosis of suspected dementia or MCI and estimated the stage of dementia by using the Clinical Dementia Rating Scale (CDR). We performed a set of laboratory tests and either brain magnetic resonance imaging (29) or computed tomography (14) on all of our patients to rule out other causes of dementia-like symptoms. We analyzed the cerebrospinal fluid biomarkers (A42, tau, and phosphotau) in 27 patients. The MoCA test was not used for diagnosing MCI or AD. Ethical approval for the study was granted by the Ethics Committee of the Pirkanmaa Hospital District.

The MoCA test is a one-page, 10-minute cognitive screening tool which assesses cognitive aspects through several tasks. Visuospatial and executive abilities are assessed using a short version of the Trail Making B test (1 point), a cube copy (1 point), and a clock-drawing test (3 points). Memory is evaluated by using an immediate and a delayed recall test of five words (5 points). Attention and working memory are assessed using a target detection task (1 point), a subtraction task (3 points), and forward and backward digit spans (2 points). Language is evaluated using the naming of three animals (3 points), the repetition of two sentences (2 points), a phonemic fluency test (1 point), and a verbal abstraction task (2 points). Additionally, orientation to time and place are evaluated (6 points). The maximum score is 30 points. If the subject has not participated in any form of education for more than twelve years, 1 point is added to his or her total score to compensate for the lack of information and skills gained from adult learning.

For our study, the MoCA was translated into Finnish and back-translated to check the linguistic accuracy.
Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS), Version 21.0. Analysis of variance (ANOVA) was used for age and education comparisons between the study groups, and a post-hoc analysis was performed by applying the Tukey’s test. The χ²-test was used for sex comparisons. The MoCA and MMSE scores were not normally distributed and, therefore, the non-parametric test was used. The differences between the groups in their MoCA and MMSE scores were examined using the Kruskal-Wallis test, and subgroup comparisons were performed using the Mann Whitney U-test. The diagnostic accuracy of the MoCA for screening dementia and MCI was assessed by calculating the area under the receiver operating characteristic (ROC) curve (AUC) and the sensitivity and specificity by using positive and negative predictive values for the different threshold scores.

RESULTS

The three study groups differed from each other in terms of sex, age, and level of education. The NCs were younger than subjects with AD (t [37,374] = 3.265, p = 0.002) and MCI (t [30,800] = 4.306, p = < 0.001). The NCs were also better-educated than patients with AD (t [54,975] = -3.419, p = 0.001) and MCI (t [40,782] = -3.008, p = 0.004).

Table 1 shows the MoCA and MMSE scores of the three study groups. The Kruskal-Wallis analysis revealed significant differences between the study groups in both the MoCA (p<0.001) and MMSE (p<0.001) scores. Pairwise comparisons revealed significant differences (p<0.001) between the AD and NC groups in both the MoCA and MMSE scores. The MCI and NC groups also differed significantly (p<0.001) from each other in terms of MoCA and MMSE scores.

The predictive accuracy of the MoCA for both AD and MCI was high; the AUC was 0.997 (95% CI = 0.991–1.00) for AD and 0.980 (95% CI = 0.952–1.00) for MCI. The corresponding values for the MMSE were 0.962 (95% CI = 0.919–1.000) for AD and 0.913 (95% CI = 0.838–0.989) for MCI. The AUC and the 95% CI values for the MMSE and MoCA overlap and are not statistically different.

Table 1. Gender, Age, Education and MoCA and MMSE scores of patients with Alzheimer’s disease, patients with MCI and cognitively normal controls. χ²-test was used for gender comparisons and ANOVA was used for age and education comparisons. Kruskal-Wallis test was used for MoCA and MMSE comparisons.

<table>
<thead>
<tr>
<th></th>
<th>AD (n=25)</th>
<th>MCI (n=18)</th>
<th>NC (n=39)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female, %</td>
<td>60.0</td>
<td>61.1</td>
<td>92.3</td>
<td>0.004</td>
</tr>
<tr>
<td>Age, years Mean (SD) min-max</td>
<td>63.0 (6.3) 50-75</td>
<td>64.8 (5.4) 54-74</td>
<td>58.3 (4.1) 50-67</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Education, years Mean (SD) min-max</td>
<td>11.0 (3.2) 6-17</td>
<td>11.4 (3.4) 7-20</td>
<td>13.9 (3.5) 7-21</td>
<td>0.002</td>
</tr>
<tr>
<td>MoCA score Md (Q1, Q3) min-max</td>
<td>17 (14.0, 20.0) 8-24</td>
<td>20.5 (19.8, 22.3) 17-25</td>
<td>27 (26.0, 28.0) 22-30</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>MMSE score Md (Q1, Q3) min-max</td>
<td>23 (19.5, 25.5) 15-28</td>
<td>26 (25.0, 26.3) 24-28</td>
<td>29 (27.0, 29.0) 24-30</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
Table 2. The sensitivity and specificity with positive (PPV) and negative (NPV) predictive values of different cut-off scores of MoCA in discriminating patients with Alzheimer’s disease (n=25) and MCI (n=18) from cognitively normal controls (n=39)

<table>
<thead>
<tr>
<th>Cut-off score</th>
<th>AD</th>
<th>MCI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sensitivity</td>
<td>Specificity</td>
</tr>
<tr>
<td>&lt;15</td>
<td>0.360</td>
<td>1.000</td>
</tr>
<tr>
<td>&lt;16</td>
<td>0.440</td>
<td>1.000</td>
</tr>
<tr>
<td>&lt;17</td>
<td>0.480</td>
<td>1.000</td>
</tr>
<tr>
<td>&lt;18</td>
<td>0.560</td>
<td>1.000</td>
</tr>
<tr>
<td>&lt;19</td>
<td>0.560</td>
<td>1.000</td>
</tr>
<tr>
<td>&lt;20</td>
<td>0.680</td>
<td>1.000</td>
</tr>
<tr>
<td>&lt;21</td>
<td>0.800</td>
<td>1.000</td>
</tr>
<tr>
<td>&lt;22</td>
<td>0.920</td>
<td>1.000</td>
</tr>
<tr>
<td>&lt;23</td>
<td>0.960</td>
<td>0.974</td>
</tr>
<tr>
<td>&lt;24</td>
<td>0.960</td>
<td>0.974</td>
</tr>
<tr>
<td>&lt;25</td>
<td>1.000</td>
<td>0.923</td>
</tr>
<tr>
<td>&lt;26</td>
<td>1.000</td>
<td>0.795</td>
</tr>
<tr>
<td>&lt;27</td>
<td>1.000</td>
<td>0.667</td>
</tr>
<tr>
<td>&lt;28</td>
<td>1.000</td>
<td>0.385</td>
</tr>
<tr>
<td>&lt;29</td>
<td>1.000</td>
<td>0.128</td>
</tr>
<tr>
<td>&lt;30</td>
<td>1.000</td>
<td>0.026</td>
</tr>
</tbody>
</table>

The MoCA is a brief screening test developed to detect MCI. Several studies indicate its sensitivity to distinguish patients with MCI or dementia from cognitively healthy controls [6-9,16]. However, the original cutoff score of 26/30 has been challenged in several later studies [10,12,13,16,19]. It has been recommended that thresholds lower than 26 are likely to be more useful for optimal diagnostic accuracy and to improve the specificity while also retaining high sensitivity [10,12,15,16]. There have been many proposals for the best cutoff score. Some studies indicate that a cutoff score of 24/30 [12,13,16,17] or 23/30 [10,18] will optimize the diagnostic accuracy of the MoCA. In one study [20], an even lower cutoff score of 17/30 was suggested to capture early and late MCI cases. The present paper explores
the accuracy of the Finnish version of the MoCA test to detect MCI and AD.

According to our study, the optimal cutoff score of the Finnish version of the MoCA to detect AD and MCI is 24/30. With this cutoff score, the MoCA not only had a high sensitivity to detect subjects with AD (96%) and MCI (89%) but also an excellent specificity (97%), while the original cutoff score of <26 yielded a lower specificity (79.5%). This result is in line with the previous studies [12,13,16] that also indicate the high sensitivity and specificity of the MoCA cutoff score of 24/30 in screening cognitive impairment. However, in our study, the specificity of the original cutoff score of <26 was higher than in some other studies (31% [13], 35% [10], 52% [12] and 58% [16]) but lower than in Nasreddine’s original study (87%) [6].

In our study, the sensitivity of the MMSE in the detection of AD with the commonly used cutoff score of 24 was poor (56%). This is similar to previous studies [6,7,10,12,18,28] demonstrating that the MoCA has better sensitivity than the MMSE in detecting cognitive impairment. However, in our sample, the MMSE also had high sensitivity (92%) and specificity (92%) if the optimal cutoff score of 27 was used. These figures were only slightly lower than the corresponding ones with the MoCA test. The sensitivity of the MMSE in detecting MCI with the cutoff score of 27 was good (78%), and the specificity was high (92%).

Previous studies have shown that a higher number of years spent in school seems to be associated with higher MoCA scores [16,21-23,29]. Despite the fact that the NCs in our study were relatively highly educated, 20% of them scored lower in the MoCA test than the original cutoff score of 26/30. This result provides support for a lower cutoff score in order to improve the specificity of the MoCA and agrees with some previous studies [10,11,17,18].

In our study, the mean age of each group (AD, MCI and normal controls) was under 65 years, which suggests that the MoCA could be used in Finland to screen older middle-aged subjects. Some caution should be exercised in generalizing these results to elderly subjects, especially those with lower educational levels.

This study has some limitations. The recruitment was made by a single psychologist over several years, which resulted to a non-consecutive sample. This may have caused some bias to the sample. The normal controls in our study were younger and had more years of education than the subjects in the AD and MCI groups. However, it is highly unlikely that this should alter the recommendation for the lower cutoff score. It has to be taken into consideration that education and age may affect the score, and even a lower cutoff score might be used for the clinical assessment of a population with lower education and older age. Almost all (92.3%) of the NCs in our study were female, but according to the previous studies, there is no relationship between sex and MoCA test performance [7,23,29]. The potential weaknesses of the present study also include the relatively small sample size and the lack of a classification of MCI into subtypes (single/multiple domain and amnestic/non-amnestic MCI). Also, the definition of MCI used in our study [26] is considered nowadays out of date. According to updated criteria [30], objective evidence of impairment in one or more cognitive domains is required. The CDR by itself is nowadays considered insufficient.
CONCLUSIONS

The MoCA has a high sensitivity and specificity to detect subjects with AD and MCI with the cutoff score of 24/30. The Finnish version of the MoCA test is a feasible screening instrument for assessing cognitive decline. According to our study, the optimal cutoff score of the MoCA is 24/30.

REFERENCES


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