The validity and reliability of a Computerized Dementia Screening Test developed in Korea

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Abstract

Objective: This study was done to verify the validity and the reliability of the newly developed Computerized Dementia Screening Test (CDST) to be easily used in the primary care setting of Korea. Design: Comparison of the results of CDST between 103 healthy control subjects and 41 patients who were diagnosed as having mild cognitive impairment or early dementia, having a clinical dementia rate of 0.5–1 from one health examination center and two neurology clinics in university hospitals. Measurements: In order to estimate the criterion-related validity, logistic regression analysis for dementia was done using the four individual test results of CDST, age and educational level. The correlation between Korean Mini-Mental State Examination (K-MMSE) and the predicted probability of mild cognitive impairment and early dementia from the logistic regression was measured to verify its validity. The reliability of CDST was measured by test–retest reliability. Results: The sensitivity and specificity of CDST were 75.6% and 94.2%, respectively, if the cut-off point was set to be 0.5 in the logistic regression model. The Pearson’s Correlation Coefficient between K-MMSE and the predicted probability of mild cognitive impairment and early dementia from the logistic regression analysis was 0.59 (P<0.001). The overall test–retest reliability using the predicted probability of dementia from the logistic regression analysis of CDST was 0.89 (P=0.01). Conclusion: The validity and reliability of CDST is adequate for use as a screening tool to identify mild cognitive impairment and early dementia in Korean primary care.

We are developing an Internet medical service provider for the use of patients of various dementia disorders, their caregivers, health professionals and common people who are concerned about Alzheimer’s disease and related disorders. We hope that this computerized screening test tool will be used to screen people with cognitive impairment regardless of the etiologies.

Keywords: Dementia; Screening test; Computerization; Validity; Reliability

1. Introduction

As the prevalence of dementia increases, and novel and better interventions to delay the progression of dementia become available, the detection of early dementia, especially in the primary care setting, becomes important. Unfortunately, most of the present dementia screening test tools have difficulty detecting early dementia and are not easy used in the primary care setting.

Accordingly, we developed a new screening test tool taking into account these problems. Initially, we reviewed studies on dementia detection and selected four tests which would be easy to do but relatively sensitive. These four tests check different characteristics, so we hoped they would be synergistic when combined. Subsequently, we modified the tests to be easily done on a computer.

We designed and performed this study to see if this computerized tool could detect mild dementia in a person effectively, i.e. its validity and reliability.

2. Subjects and methods

2.1. Healthy control subjects

From March 2001 to June 2001, we recruited 103 healthy control subjects from people who had visited a health examination center at a university hospital. They were
enrolled as healthy control subjects after the two authors had screened them using the exclusion criteria for screening the normal elderly. Screening included the Korean criteria, modified from the health screening exclusion criteria of Christensen et al. [1], the semistructured questionnaire about cognitive function (Korean Dementia Screening Questionnaire) and medical history taking.

2.2. Patient group

Forty-one patients were enrolled from the memory disorder and dementia clinics of two university hospitals. Their clinical dementia rating scale (CDR) [2] score was 0.5–1 using the current version and scoring rules [3]. A CDR of 0.5 means mild cognitive impairment (MCI) [4] and a CDR of 1 indicates early dementia according to DSM-IV criteria [5]. Of the 41 patients, 30 were CDR = 0.5 and 11 were CDR = 1.0.

2.3. Computerized Dementia Screening Test (CDST)

CDST consists of four test items which are all computerized as one program: the block test for spatial span, the memory impairment screen of Buschke, the judgment of the line orientation test and the Go No-go test. These four individual tests have been reported to be sensitive to Alzheimer’s disease.

2.3.1. Spatial Span Test

The block test is used to assess visuospatial memory and attention; it yields a low score in the case of patients with Alzheimer’s disease [6]. The test was computerized using a spatial span technique. Nine green blocks were irregularly placed on white background. A series of blocks were lightened in a predetermined order and subjects were requested to replicate the same sequence from two to six blocks (forward span). The subjects were then requested to replicate the reverse sequence from two to six blocks (backward span). The maximum forward span score was six points and similarly for the backward span yielding a total maximum score for both of 12 points.

2.3.2. Memory Impairment Screen

Grober et al. [7] and Buschke et al. [8] initially described the memory impairment screen, which is thought to be a good screening tool for Alzheimer’s disease. Patients with dementia have difficulty in information storage and gain no benefit to recall from cues provided. This test is based on the memory impairment screen of Buschke and developed in consideration of Korean cultural and social issues. Four words from different categories were shown on the monitor. The subjects were asked to read the items, from the screen, aloud after listening to the recorded names and then asked to identify and name each item when the examiner said its category cue. The words would then disappear from the monitor. After performing a line orientation test and a Go No-Go test as nonsemantic interference tasks, the subjects were asked for free recall of the four items in any order. The category cues were then presented to elicit cued recall of only those items that were not retrieved by free recall. For each word, the score for a correct answer by free recall was two points and for cued recall, one point. This gave a maximum score, using the memory impairment screen, of 8 points.

2.3.3. Judgment of line orientation

Most patients with dementia showed low visuospatial performance. One of the tests that can assess visuospatial performance is the line orientation test [9]. The patients were shown, on screen, nine lines at an angle of 18°; underneath this, a test line was shown. The subjects were then asked to identify which line above had the same orientation with the test line. A total of 10 test lines at different angles were presented to each subject. Five of the 10 test lines had the same length as the nine lines on the top and the other five were half the length. The maximum score was 10 points.

2.3.4. Go No-Go test

The Go No-Go test assesses executive function through response control and ability to adapt, which is associated with frontal lobe function [10]. The test showed one or two blue circles on the monitor. In the first part of the test, subjects were asked to press the space bar of the keyboard twice for one circle and once for two circles. In the second part of the test, the rules were changed; subjects were asked to press the space bar twice for one circle and not at all for two circles. The total possible score in the first part is 10 points and the total possible score in the second part is also 10 points. The total score of the Go No-go test is, therefore, out of 20.

2.4. Geriatric Depression Scale

We used the Geriatric Depression Scale—Short Form, Korean version (GDSSF-K) [11,12] to assess depressive symptoms. GDSSF-K contains 15 questions coming from the Geriatric Depression Scale (GDS). The Geriatric Depression Scale was developed by Yesavage et al. [13] as a self-administered depression assessment scale consisting of 30 questions, which provide a simple and easy assessment for elderly people. A higher score indicates more depressive symptoms.

2.5. Mini-Mental State Examination

To determine construct validity, all subjects were tested using the Korean version of the Mini-Mental State Examination (K-MMSE) [14], which is the MMSE of Folstein et al. [15] but adapted for Korean use.

2.6. Statistical analyses

The differences in the four individual tests between the healthy control subjects and the patients with mild cognitive
impairment and early dementia were analyzed using the Wilcoxon Rank Sum test.

To determine the degree to which CDST discriminated between healthy control subjects and patients with MCI or early dementia, logistic regression analysis was estimated using the four individual test scores from CDST, plus age and educational level. From the logistic regression model, the predicted probability of dementia was derived, and based on this probability, the cut-off point was determined and sensitivity and specificity were calculated.

We determined the construct validity using a correlation analysis between K-MMSE and the predicted probability from the logistic regression. The reliability of CDST was determined by test–retest reliability using the Pearson’s Correlation Coefficient.

Finally, a correlation analysis between the Geriatric Depression Scale—Short Form, Korea version (GDSSF-K) and the predicted probability of dementia was also done.

3. Results

3.1. Demographic characteristics

The mean age of the healthy control subjects was 62.73 (± 5.85) years and that of patients was 69.22 (± 6.72) years; the difference was statistically significant (P < 0.001). The mean number of years of education for the healthy control subjects was 10.58 (± 5.13) and that of the patients with MCI or early dementia was 8.17 (± 5.77); the difference was statistically significant (P = 0.015). Gender was not a significant factor between two groups (Table 1).

3.2. Results of individual tests

The mean scores and standard deviations of the individuals’ tests were compared using the Wilcoxon Rank Sum test. All the results of the individual tests showed significant differences between the control and patient groups (Table 2).

![Image](image.png)

Table 1
The demographic characteristics of healthy controls and patients with dementia

<table>
<thead>
<tr>
<th></th>
<th>Control group (N=103)</th>
<th>Patient group (N=41)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years, mean ± S.D.) *</td>
<td>62.73 (± 5.85)</td>
<td>69.22 (± 6.72)</td>
</tr>
<tr>
<td>Education (years, mean ± S.D.)†</td>
<td>10.58 (± 5.13)</td>
<td>8.17 (± 5.77)</td>
</tr>
<tr>
<td>Sex (M/F)</td>
<td>48/55</td>
<td>18/23</td>
</tr>
<tr>
<td>K-MMSE *</td>
<td>27.31 (± 1.70)</td>
<td>23.88 (± 2.86)</td>
</tr>
<tr>
<td>GDSSF-K</td>
<td>4.48 (± 3.68)</td>
<td>6.64 (± 3.83)</td>
</tr>
</tbody>
</table>

K-MMSE: Korean version of Mini-Mental State Examination. GDSSF-K: Geriatric Depression Score—Short Form, Korea version.

* P < 0.001.
† P = 0.015 by independent sample t-test.

![Image](image.png)

3.3. The validity of CDST

The four individual tests, plus age, education and sex were originally thought to be the predictor variables of the logistic regression model. When logistic regression analysis was done using the above 7 predictor variables one after another, sex was not statistically significant but the four individual tests, age and education were. To determine criterion-related validity, logistic regression analysis for cognitive impairment was estimated using the four individual tests of CDST, plus age and educational level. The logistic regression model was as follows:

\[
\log \left( \frac{P_i}{1 - P_i} \right) = \beta_0 + \beta_1 \ast \text{SST}_i + \beta_2 \ast \text{MIS}_i \\
+ \beta_3 \ast \text{LOT}_i + \beta_4 \ast \text{GNG}_i \\
+ \beta_5 \ast \text{Age} + \beta_6 \ast \text{Education} + \epsilon_i
\]

where \(P_i\): probability of dementia, SST: Spatial Span Test, MIS: Memory Impairment Screen, LOT: Line Orientation Test, GNG Go No-go test.

2). Figs. 1–4 show the distribution of block scores of the four individual tests.
The estimating model of 103 healthy control subjects and 41 patients gave the following results (Table 3). Final logistic regression model was as follows:

\[
\log\left(\frac{P_i}{1-P_i}\right) = 6.491 - 0.321*\text{SST}_i - 0.581*\text{MIS}_i - 0.408*\text{LOT}_i - 0.187*\text{GNG}_i + 0.074*\text{Age} + 0.034*\text{Education}
\]

where \(P_i\): probability of dementia, SST: Spatial Span Test, MIS: Memory Impairment Screen, LOT: Line Orientation Test, GNG: Go No-go test.

Fig. 2 shows the distribution of the memory impairment screen score in CDST.

![Memory Impairment Screen](image)

**Table 3**

<table>
<thead>
<tr>
<th></th>
<th>Beta</th>
<th>S.E.</th>
<th>P-value</th>
<th>Odds ratio (95% C.I.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total span</td>
<td>-0.321</td>
<td>0.221</td>
<td>0.147</td>
<td>0.725 (0.470–1.119)</td>
</tr>
<tr>
<td>MIS *</td>
<td>-0.581</td>
<td>0.125</td>
<td>&lt;0.001</td>
<td>0.559 (0.438–0.714)</td>
</tr>
<tr>
<td>LOT (^\dagger)</td>
<td>-0.408</td>
<td>0.215</td>
<td>0.058</td>
<td>0.665 (0.436–1.013)</td>
</tr>
<tr>
<td>Go No-go</td>
<td>-0.187</td>
<td>0.113</td>
<td>0.098</td>
<td>0.829 (0.665–1.035)</td>
</tr>
<tr>
<td>Age</td>
<td>0.074</td>
<td>0.045</td>
<td>0.102</td>
<td>1.067 (0.985–1.176)</td>
</tr>
<tr>
<td>Education</td>
<td>0.034</td>
<td>0.058</td>
<td>0.557</td>
<td>1.035 (0.923–1.160)</td>
</tr>
</tbody>
</table>

**Beta:** parameter estimate, S.E.: standard error, C.I.: confidence interval.

* MIS: Memory Impairment Screen.

\(^\dagger\) LOT: Line Orientation Test.

Fig. 3 shows the distribution of the line orientation test score in CDST.

![Line Orientation Test](image)

The reliability of CDST was estimated by test–retest. The test–retest reliability was evaluated in 10 healthy control subjects by readministration, 1–2 months after the initial administration. Individual test–retest reliabilities used point according to the predicted probability, the predicted probability of 0.5 was considered to be the best cut-off point. The sensitivity and specificity of CDST at this point were 75.6% and 94.2%, respectively. At the prevalence rate of 5%, the positive predictability was 40.7% and the negative predictability was 98.7%. At a prevalence rate of 10%, the positive and negative predictabilities were 59.2% and 97.2%, respectively. At the prevalence rate of 15%, the positive and negative predictabilities were 69.7% and 95.6%, respectively. Finally, at the prevalence rate of 20%, the positive and negative predictabilities were 76.5% and 93.9%, respectively.

To determine construct validity, a correlation analysis between Korean Version of Mini-Mental State Examination (K-MMSE) and the predicted probability from the logistic regression was done. The Pearson’s Correlation Coefficient \((r)\) was 0.59 (\(P<0.001\)).

3.4. The reliability of CDST

The reliability of CDST was estimated by test–retest. The test–retest reliability was evaluated in 10 healthy control subjects by readministration, 1–2 months after the initial administration. Individual test–retest reliabilities used
the Spatial Span Test ($r = 0.70$), Memory Impairment Screen ($r = 0.65$), Line Orientation Test ($r = 0.63$) and Go No-go test ($r = 0.75$). The overall test–retest reliability using the predicted probability from the logistic regression analysis of CDST was $r = 0.89$ ($P = 0.01$).

3.5. Administration time

The mean time to complete the four tests of CDST in healthy control subjects was 13 min and 16 s (range: from 9 min and 30 s to 20 min and 47 s). The mean administration time in patients with dementia was 16 min and 32 s (range: from 14 min and 16 s to 20 min and 3 s). This meant that the patients took on average 3 min and 16 s longer than control subjects ($P < 0.001$).

3.6. Geriatric Depression Scale

Geriatric Depression Scale—Short Form, Korean version (GDSSF-K) was done on 102 of the 103 healthy control subjects. For healthy control subjects, the mean score of GDSSF-K was 4.48 ($\pm 3.68$) and the range was 0–15. GDSSF-K and the predicted probability from the logistic regression analysis were not significantly correlated ($r = 0.075$, $P = 0.125$).

GDSSF-K was done on 25 of the 41 patients with MCI or early dementia. For these, the mean score of GDSSF-K was 6.64 ($\pm 3.83$) and the range was 1–15. GDSSF-K and the predicted probability of dementia from the logistic regression analysis were not significantly correlated ($r = 0.22$, $P = 0.29$).

4. Discussion

We designed a new computerized test tool to screen persons with cognitive impairment regardless of the etiologies or stage. However, the results of the multiple logistic regression model shows that only one of the four tests, used in the CDST memory impairment screen test, was statistically significant in predicting dementia. These four individual tests of CDST were previously reported as being good screening methods to detect cognitive function. The reasons for the discrepancy may be the following. (1) The computerized environment is different from the previous test environment. (2) Distinguishing between a mild cognitive impaired patient (CDR = 0.5–1) and a healthy one is more difficult than for the original study results, which dealt with more demented patients.

We concluded that the memory impairment screen test is the best subtest in CDST, especially if we want to detect early dementia. The sensitivity and specificity of the model using only the memory impairment screen test were 70.7% and 89.3%, respectively. However, the other tests showed that they could detect different characteristics of the cognitive function decline, and so we continue to use them together. The sensitivity and specificity of the model with the four individual tests, plus age and education were higher than the model with only the memory impairment screen.

A maximum total score using GDSSF-K is 15 points and greater than four points indicates the possibility of depression [12]. A mean score using GDSSF-K of healthy control subjects was 4.48 ($\pm 3.68$) and of the 103 healthy control subjects, 43 had in excess of four points. However, these 43 healthy subjects do not meet the DSM-IV criteria for major depression and do not have a past medical history of depression. For the healthy control subjects, the correlation between GDSSF-K and the predicted probability of cognitive impairment using logistic regression analysis was not statistically significant ($P = 0.125$). Accordingly, depressive symptoms do not have an effect on CDST results in this study; but the effect of major depression on CDST should be further evaluated.

The validity and reliability of CDST is high and CDST can be used effectively in screening of cognitive dysfunction of mild cognitive impairment (CDR = 0.5) or early dementia (CDR = 1). CDST is a computerized program, which can be administered by personnel with little training and thus can be easily used in a primary care setting.

Acknowledgements

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References