Validity and reliability of a computerized cognitive assessment tool ‘Higher Brain Functional Balancer’ for healthy elderly people

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Objective: The objective of this study was to prove the validity and reliability of 9 of the 29 tasks on the new computerized assessment software, the Higher Brain Functional Balancer (HBFB).

Methods: A total of 70 apparently healthy elderly subjects (aged 63 to 86 y; 27 males, 43 females) participated in this prospective study. The association between the MMSE and HBFB was tested by Pearson’s correlation coefficient analysis; internal consistency of 9 tasks of the HBFB was checked by Cronbach’s coefficient alpha (Cronbach’s α), and test-retest reliability of each task was established using intra-class correlations (ICC). For test-retest reliability, subjects were administered 9 tasks of the HBFB twice at a 1-month interval. The test-retest HBFB quotient, data on age, length of education, and results of the Mini-Mental State Examination (MMSE) were recorded.

Results: Pearson’s correlation coefficient analysis showed that the state of cognitive function according to the total scores of the MMSE correlated significantly with the total quotients of the HBFB (r=0.356, p=0.002). The 9 tasks of the HBFB had appropriate internal consistency (Cronbach’s α=0.735). Test-retest reliability analysis indicated that the “modified Trail Making Test”, “Flashing-Light Memory”, “Story” and “Route-99” tasks on the HBFB had fair-to-good reliability (ICC=0.364-0.742); however, reliability was poor with regard to scores of the other 5 tasks.

Conclusions: This study provides evidence for the validity of total quotients of all tasks for screening of total cognitive function and for the reliability of 4 of the 9 tasks from the HBFB with regard to cognitive function in elderly people.

Introduction

Dementia, mainly characterized by learning and memory loss, mood changes and communication problems, has been increasingly recognized as an important component of the disease spectrum in most neurodegenerative diseases including Alzheimer’s disease (AD) and Parkinson’s disease (PD). Dementia has drawn extensive attention due to its high prevalence among older people, which is underscored in a rapidly aging world population. In an aging society, a method to screen apparently healthy elderly people for cognitive impairment is desirable. On neuropsychological examination, memory impairment is evident by poor performance on tests such as the Mini-Mental State Examination (MMSE). On the other hand, seemingly healthy elderly people seldom receive neuropsychological testing by a specialist before significant symptoms of dementia are noticeable, as such testing is time-consuming and requires special training to administer.

An environment that would allow healthy elderly...
persons to be screened for cognitive impairment is desirable. We aim to measure cognitive function with a new computerized assessment software program, the Higher Brain Functional Balancer (HBFB) in healthy elderly subjects (Software was developed by K. Hashimoto, M. Takahama and LEDEX Corporation, Tokyo, 2008). Our clinical experience suggests that 9 of the 29 tasks in the HBFB are most useful in assessing cognitive function. These 9 tasks may be regarded as assessing reality orientation, attention, working memory, delayed memory, information processing, higher executive function, and spatial cognition. We have already provided evidence of the predictive value of the HBFB. But the reliability of this computerized cognitive assessment tool remains a concern. The objective of this study was not only to confirm the concurrent validity of 9 of the tasks on the HBFB but also to test their reliability through a test-retest procedure.

I. Materials and Methods

A group of 70 apparently healthy elderly volunteers (27 males, 43 females) between the age of 63 and 86 years without any history of neuropsychological disorders participated in this prospective study. We recruited all subjects from the Silver Volunteer Center in Machida City in Tokyo. Subjects all gave informed consent prior to participation.

The HBFB test and training PC-software were developed by LEDEX Corporation in 2008. The HBFB can be found and purchased in bookstores or on the Internet at a low price (3,800 yen). At these locations, a full description of the instrument, which is in the Japanese language, can be obtained.

As noted above, our clinical experience has indicated that 9 of the 29 tasks on the HBFB are the most useful in evaluating cognitive function. These are: Orientation (subject is asked to select the correct date and time from 14 choices), “modified Trail Making Test (mTMT)” (subject selects letters in alphabetical or numerical order as quickly as possible; For example, subject clicks letters or numbers in turn such as A, B, C, D, . . ., or 1, 2, 3, 4, . . .; Figure 1), “Cancellation” (subject selects one number or letter and clicks all that appear on the
screen as quickly as possible; for example all letters or numbers such as B, B, B, ..., or 12, 12, 12, 12, ...; Figure 2), “Flashing-light Memory” (subject must click the button in order of the color of the flashing light with the task increasing in difficulty until failure; for example, blue, yellow as the first step, blue, yellow, red as the next step, and blue, yellow, red, yellow, etc.; Figure 3), “One-back Memory” (subject must remember what was on the previous card, and clicks ‘Yes’ when the same card appears subsequently), “Continuous Memory” (subject tries to remember all cards in a series, and clicks ‘Yes’ when he or she sees the same card as before in the same series).
and answers a question about the content), “Route-99” (subject must select all numbers in turn in the blocks from the start to the goal; Figure 5), and “Just Fit” (subject selects the same figure as on the top line from the various choices; Figure 6). These individual tasks may be said to measure reality-orientation, attention, working memory, delayed memory, information processing, higher executive function, or spatial cognition. The analysis described in this paper is therefore focused on these 9 tasks as variables. In addition to the HBFB test and retest, the Japanese version of Mini-Mental Examination (MMSE) was also administered.

To determine the correlations between the HBFB and MMSE, the subjects were tested serially with HBFB, which took 30 minutes to complete, and with the MMSE, which took 15 minutes to complete. Half of the subjects were administered the HBFB at a 15-minute interval after the MMSE, while the other half were administered the MMSE at a 15-minute interval after the HBFB. One month after the first testing, 41 of the 70 subjects were given a retest-HBFB. Measurements of speed (reaction time in milliseconds) and accuracy (percent correct) were automatically generated for each subject on all 9 HBFB tasks, and the HBFB scores were calculated from these measurements of speed and accuracy for each task. Scores were divided by standard values for normal subjects to display quotients. Using Pearson’s correlation coefficient analysis, we examined the strength of the association between the total scores of the MMSE and total quotient for the 9 HBFB tasks. Additional variables included age and length of education, and we examined which of these additional variables correlated with the MMSE scores. Internal consistency of 9 tasks of HBFB was checked by Cronbach’s coefficient alpha (Cronbach’s $\alpha$). And test-retest reliability of each task was established using intra-class correlations. Data were analyzed using SPSS 12.0 J software (SPSS Japan, Inc., Tokyo).

This study was performed in accordance with the Ethics Committee of the LEDEX Corporation.

II. Results

Pearson’s correlations between the MMSE scores and HBFB performance quotients, age and length of education for the 70 study subjects are shown in Table 1. Pearson’s correlation coefficient analysis showed that scores of the “modified Trail Making Test” and “Route-99” and total quotients of all 9 HBFB tasks significantly correlated with the total scores of the MMSE (Table 1). The 9 tasks of HBFB had appropriate internal consistency (Cronbach’s $\alpha$=0.735). And the results of test-retest reliability analysis indicated that the “modified Trail Making Test”, “Flashing-Light Memory”, “Story” and “Route-99” items on the HBFB had fair-to-good reliability (ICC=0.364-0.742) (Table 2). However, reliability was poor for the scores of the other 5 tasks.

III. Discussion

Recently it has been proposed from results of several investigations that computerized cognitive tests may provide very reliable indications of cognitive function. For example, Cho et al. developed the Computerized Dementia Screening Test (CDST) to be used in the primary care setting in Korea and concluded that the validity and reliability of the CDST were adequate to justify its use as a screening tool to identify mild cognitive impairment and early dementia in the Korean primary care setting. Tamura et al. developed a modified trail-making test using a PC and touch panel and compared it with the MMSE and concluded that this test may be a useful indicator of
focal frontal lesions and can be used as an early screening test for Alzheimer’s disease. Fredrickson et al. demonstrated that the validity and reliability of a computerized cognitive test (CogState) had good acceptability and stability for repeated assessment of cognitive function in older people. However, the effectiveness of computerized cognitive tests involving multiple tests within one package using PC software available in the general marketplace had not been demonstrated.

Results of the present study indicate that the 9 items examined from the HBFB battery provide a measurement of cognitive function that is significantly reliable when administered to healthy elderly people. An aspect of its convenience is that this instrument is appropriate for elderly people and their families who want to screen their own cognitive impairment at an early stage without seeing a physician or specialist.

The results also suggested that in apparently healthy elderly adults, measures of attention (mTMT) and executive function (Route-99) are more valuable for screening of cognitive function than the other variables or the tasks to determine cognitive function in the MMSE. One of the reasons that the two tasks are useful for screening of cognitive function is that they are easy to understand and require not only the function of attention and executive function but also information processing, working memory, and visual cognition.

The tasks for attention (mTMT), working memory (Flashing-light Memory), episode memory (Story Recall), and executive function (Route-99) were found to be more reliable measurements than the other tasks in the HBFB. Reasons might be that those tasks are easily understood by the subject and that the mouse was easy to control. On the other hand, the other 5 tasks did not have significant reliability. It may be that it is difficult for elderly people to complete all of the 9 tasks at once. Therefore, an easier system of computerized cognitive testing is desirable. A new system that consists of fewer computerized cognitive tests is desirable so that many elderly people and their

| Table 1. Pearson’s correlation between MMSE score and HBFB performance quotients, age and length of education in 70 apparently healthy elderly individuals. |
|-----------------------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|                | n=70 (27 males, 43 females) |                  |                  |                  |                  |                  |
|                | Mean±SD | Min | Max | r   | p     |                  |                  |                  |                  |
| MMSE          | 27.9±2.0 | 22  | 30  | −0.059 | NS    |                  |                  |                  |                  |
| Age           | 72.3±5.3 | 63  | 86  | 0.226 | NS    |                  |                  |                  |                  |
| Length of education | 12.5±2.6 | 6   | 17  | 0.238 | NS    |                  |                  |                  |                  |
| Orientation   | 127.4±33.5 | 39.3 | 180.6 | 0.416** | 0.001 |                  |                  |                  |                  |
| mTMT          | 91.6±34.5 | 13.8 | 147.9 | 0.173 | NS    |                  |                  |                  |                  |
| Cancellation  | 113.9±22.2 | 14.8 | 140 | 0.069 | NS    |                  |                  |                  |                  |
| Flashing-light Memory | 42.4±37.5 | 0   | 121.1 | 0.108 | NS    |                  |                  |                  |                  |
| One-back Memory | 103.8±39.5 | 0   | 161 | 0.08 | NS    |                  |                  |                  |                  |
| Continuous Memory | 97.2±26.6 | 21  | 145 | 0.212 | NS    |                  |                  |                  |                  |
| Story Recall  | 82.8±33.6 | 0   | 149 | 0.389** | 0.001 |                  |                  |                  |                  |
| Route-99      | 62.5±35.4 | 0   | 140 | 0.183 | NS    |                  |                  |                  |                  |
| Just Fit      | 64.6±40.1 | 0   | 149.5 | 0.356** | 0.002 |                  |                  |                  |                  |
| Total         | 718.7±276.9 | 718.7 | 1134.8 |                  |                  |                  |                  |                  |

Mini=minimum, Max=maximum, SD=standard deviation, NS=not significant, mTMT=modified Trail Making Test, **=significant correlated with MMSE.
families could easily check their own cognitive function and keep the data for future comparison. However, comprehensive face-to-face measurement of the mental function of patients by physicians or psychologists is essential. Therefore, we must recognize the limitations of patients evaluating cognitive function only by a computer instrument such as this PC software.

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Acknowledgments

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