Original Article

Validity of Brief Cognitive Function Examination

Daisuke Kimura*, Tokunori Takeda*, Nobuyuki Sunahara**, Takashi Fujita*, Masako Notoya**

Abstract

Objective: To validate a brief cognitive function examination （BCFE） by defining cutoff points, and analyzing sensitivity and specificity.

Methods: The concurrent and discriminant validity of the BCFE were evaluated in 135 participants （aged ≥ 65 years） between 2007 and 2010. We derived optimal cutoff scores for sensitivity and specificity criteria for cognitive impairment.

Results: BCFE scores were significantly correlated with full Mini-Mental State Examination （MMSE） scores （r = .938, p < .05） and scores on the Hasegawa Dementia Scale-Revised （r = .638, p < .05） , indicating high concurrent validity of the BCFE. The BCFE scores differed significantly between Clinical Dementia Rating Scale （CDR） 0.0 and 0.5 groups （p < .05） . The optimal cutoff score was 7/8, with sensitivity and specificity of 92.0% and 78.3%, respectively.

Conclusions: The BCFE may be useful for detection of cognitive impairment in community-dwelling older adults in Japan.

Introdaction

The average age of the Japanese population is rapidly increasing, and the prevalence of dementia in people aged ≥65, ≥70, ≥75, ≥80, and ≥85 years is estimated at 1.1%, 3.3%, 7.0%, 15.6%, and 29.8%, respectively[1),2),3)]. Since the proportion of people aged ≥65 years suffering from dementia in Japan is expected to rise from 7.3% in 2001 to 10.0% in 2026, their numbers are also expected to increase from 1.7 million to 3.3 million in the same time frame[1)]. In previous studies conducted in Japan, the overall prevalence of dementia among elderly patients （>65 years） ranged from 5.6% （Hisayama 1992） to 11.3% （Amacho 2008）. It was found that compared to the study carried out in Okinawa in 1992, studies conducted in later years （1994 （Hiroshima）, 1998 （Tajiri）, 2005 （Hisayama）, and 2008 （Amacho）） had a higher prevalence of all-cause dementia, after controlling for age and sex [3)]. Although the prevalence of dementia is increasing significantly, interventions are now more widely available. There is a need for accurate screening tests to facilitate early detection of dementia and mild cognitive impairment （MCI）. Ideally, such tests should be sufficiently sensitive and specific to identify individuals with cognitive impairments who require more-comprehensive evaluation and management, and the tests should be quick and easy to administer for not only physicians but also for other trained healthcare personnel.

The Mini-Mental State Examination （MMSE） is the most widely used screening instrument for dementia[4),5),6)]. The full version of the MMSE （fMMSE） contains 19 items and has a maximum score of 30 points （10, 6, 5, 5, 3, and 1 for orientation, verbal memory, concentration and calculation, language, praxis, and visuospatial construction, respectively）. The Japanese version has been standardized, with normative values based on data from older Japanese adults[7)]. In addition, one diagnostic criterion for dementia is an fMMSE score of >24 points along with a normal score on a memory test. The fMMSE

* 　 Division of Occupational Therapy, Faculty of Care and Rehabilitation, Seijoh University
** 　 School of Health Sciences; College of Medical, Pharmaceutical and Health Sciences; Kanazawa University

is also useful for detection of dementia.

In its current form, the fMMSE has several limitations when used among community-dwelling older adults[8]. First, administration is difficult for untrained individuals[9], and second, the test requires approximately ten minutes to administer, which is too long for community-dwelling older adults[9]. Therefore, a shorter version that anyone can administer in a shorter period is desirable. In previous studies, researchers have examined cognitive function via short versions of establlished assessments. For example, The Mini-Cog is a very short cognitive function examination comprising three sections: testing, a Clock Drowning Test, and a recall test[10]. Preparation and explanation are necessary to perform the Clock Drawing Test. However, it is included in the Mini-Cog. Six-Item Cognitive Impairment Test (6CIT) is a very short cognitive function examination with high sensitivity for dementia[11]. Researchers have not considered whether the Six-Item Cognitive Impairment Test (6CIT) is useful for destination of MCI. Hence, in the present study, we used a shorter version of the MMSE (BCFE) to screen for cognitive impairment among community-dwelling older adults[12].

The advantage of the BCFE is that even a change in test administrator influences test results little. BCFE is constructed excluding an item of repetition task depending on the administrator reads. The reason is that in the repetition task (i.e., ask the subject to repeat), the speed at which the administrator reads the sentence affects the test results[13]. In addition, the BCFE focuses on a task for which performance deteriorates in the early stage of Alzheimer's disease[11]. Therefore, the BCFE might be a reliable tool for diagnosis of Alzheimer's disease in its initial stage.

Additionally, since the BCFE can be completed in a short time, subjects can respond easily; therefore, their responses can be interpreted more rapidly. Since MCI is a pre-dementia stage that changes into dementia with high probability, early detection of MCI and cognitive functional decline may facilitate and lead to early initiation of prevention and treatments.

In the present study, we aimed to investigate the validity of the BCFE, determine its optimal cutoff points, and evaluate its sensitivity and specificity.

Methods

1. Participants

A total of 150 participants from Japanese community support projects were enrolled in this study. One hundred thirty-five of the 150 participants were enrolled in 2007–2010; they served as subjects of the follow-up survey. Furthermore, 15 participants were enrolled for an additional study in 2013.

All participants were of Japanese nationality, they were aged ≥65 years, and 105 were female. All were functionally independent in the community and did not show any obvious cognitive impairment (there was no diagnosis of dementia from the doctor by Diagnostic and Statistical Manual of Mental Disorders IV TR). Subjects who answered "no" to the following questions, "Do you require assistance while walking?" and "Do you require assistance in daily life?" were categorized as functionally independent.

All study participants gave written informed consent, and the study was approved by the research ethics committee of Seijoh University. The purpose of this study was explained to the participants, and those who agreed to participate were enrolled. Japanese Community support projects are interventions designed to provide community-dwelling older adults with strategies to improve health and longevity, build safe and secure communities, and extend healthy life expectancy.

2. Development of the BCFE

This paper documents the first attempt to develop the BCFE, and this examination consisted of three components: registration, delayed recall, and Serial 7s. The three components were adapted from the fMMSE Japanese edition. The delayed recall and Serial7s tasks assess aspects of cognitive function that begin to decline from an early stage in older adults[14]. Furthermore, these three items were chosen because a prior study of 66 community-dwelling older adults showed a decline in these tasks, when extracted from the fMMSE and Hasegawa Dementia Scale-Revised (HDS-R), permitting simple and easy screening for cognitive impairment[12]. In the previous study, the researchers performed discriminant analysis (stepwise) on the items of the MMSE and treated HDS-R results as an independent variable and Clinical Dementia Rating Scale (CDR0.5) as a dependent variable.

In the present study, the BCFE score was calculated from the scores of three items (3-word registration,

Serial7s, and recall) extracted from the fMMSE. A total of the BCFE is 11 points. The components of registration and delayed recall are worth 3 points each, and Serial7s is 5 points.

3. Procedures

We used the full versions of the MMSE, HDS-R[15], and CDR[16] to evaluate the concurrent validity of the BCFE. Mori et al. used the fMMSE to develop the Japanese version in 1985[7]. We explained the implementation of each measure and conducted a demonstration; those participants who underwent all measures were included as subjects. We administered all assessments in an isolated room with the test taker and administrator sitting at a desk facing each other. We administered the measures in the following order: fMMSE, CDR, and then HDS-R. CDR was administered to remove that fMMSE influenced HDS-R. It is because CDR is a questionnaire. No participants seemes confused. In one published report[16], a CDR value of ≥0.5 (in the absence of cerebrovascular lesion), indicated pathological findings that reveal changes specific to Alzheimer's dementia. Neuropsychological testing revealed mild cognitive impairment. Thus, in the present study, CDR of ≥0.5 was used to define cognitive impairment [17].

Even though we should ideally administer the two tests separately to avoid interviewer or information bias, we assessed the BCFE at the same time as the fMMSE. Therefore, we conducted an additional examination. As additional examinations, the participants completed the BCFE and fMMSE independently with the following timing: The additional examination comprised the BCFE, and the participants completed the fMMSE one week later. Then, the participants completed the BCFE again one week after they underwent the fMMSE. The subjects were newly recruited for the above specific study.

4. Analysis

In order to evaluate concurrent validity, the correlations between the fMMSE and the HDS-R were examined using 2-tailed Spearman's rank correlation coefficients. To evaluate discriminant validity, we compared the mean scores (BCFE, fMMSE, and HDS-R) between the groups with CDR = 0 and CDR = 0.5 by a Mann-Whitney U test. We derived optimal cutoff scores to satisfy both sensitivity and specificity criteria for cognitive impairment (CDR = 0.5 and CDR = 0, respectively) using receiver-operator characteristic curve analysis. In addition, we tested the significance of the area under the receiver-operator characteristic curve (AUC) for the BCFE.

In an additional examination, in order to evaluate concurrent validity, we obtained the Spearman's rank correlation coefficient between the first BCFE and fMMSE scores. Furthermore, we confirmed the test-retest reliability of the BCFE from the first and second examinations of the BCFE using interclass correlation coefficients. We performed all statistical analyses using Statistical Package for the Social Sciences (SPSS), version 17 (SPSS, Inc., Chicago, Illinois, USA).

Results

1. Final examination

In total, 135 participants (38 male and 97 female) were included in the present study. Among all participants, 113 had normal cognitive function (CDR = 0), whereas 22 showed cognitive impairment (CDR = 0.5). The CDR is judged from four phases from 0 to 3, where 0 is normal and 3 is severe. The demographic characteristics of all participants are summarized in Table 1.

BCFE scores were significantly correlated with fMMSE scores (r = .938, p < .05) and HDS-R scores (r = .638, p < .05), indicating that the BCFE has high concurrent validity (Figure 1).

As shown in Table 2, BCFE scores differed significantly between the normal and cognitive impairment groups. Cognitive impairment scores on the CDR were

Table 1 Subject characteristics

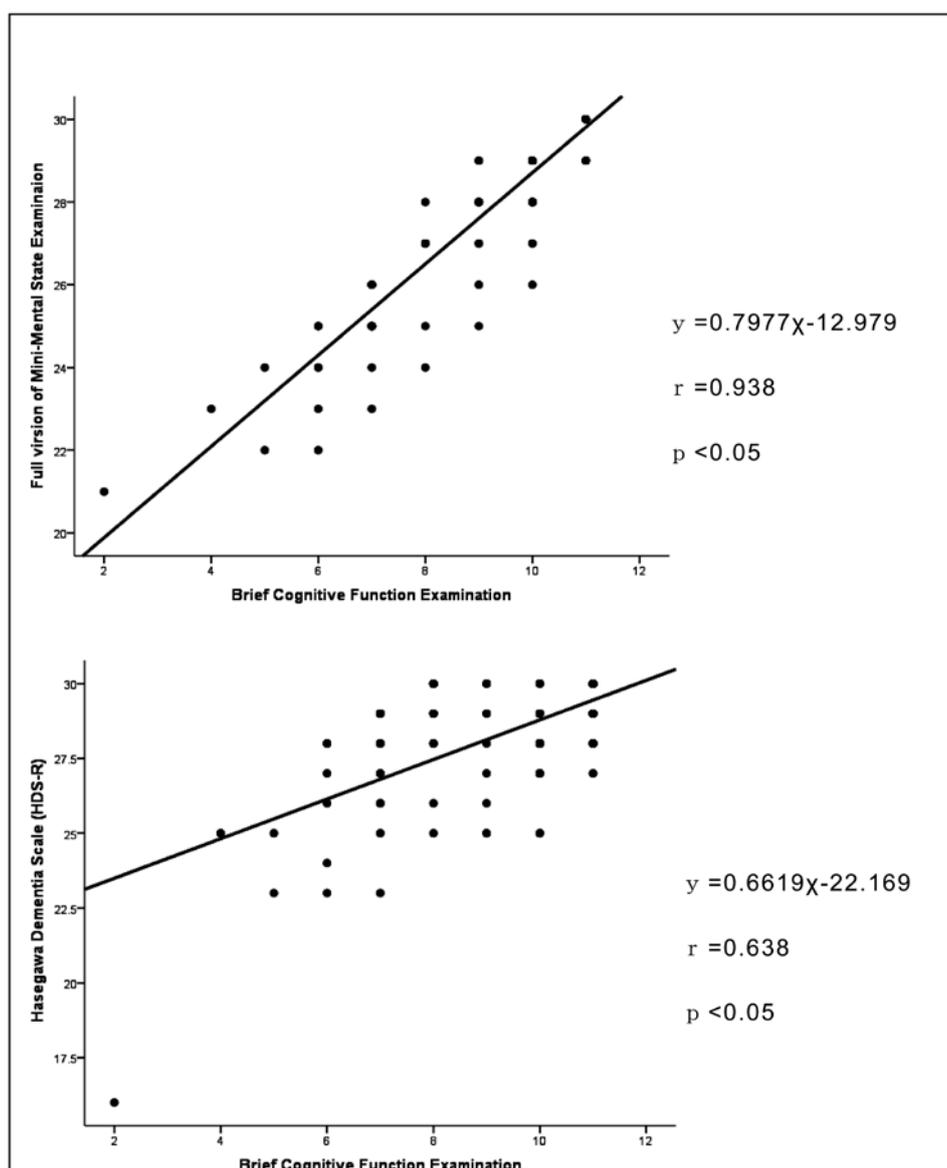|		CDR0.0	CDR0.5	Additional examination
Number	150	113	22	15
Age (years; mean (SD))	66.4 (5.7)	66.4 (5.8)	67.0 (4.2)	79.8 (3.5)
Gender (male/female)	45/105	31/82	7/15	7/8

Figure 1. Concurrent validity of the BCFE.
Correlations between the full version of the Mini-Mental State Examination and the Hasegawa Dementia Scale
*2-tailed Spearman's rank correlation coefficient

Table 2 Discriminant validity of BCFE

	CDR = 0.0	CDR = 0.5	p-value
Number	113	22	—
Brief Cognitive Function Examination	9.9 (1.3)	6.7 (1.7)	< .05
Brief Cognitive Function Examination	28.7 (1.5)	24.7 (1.8)	< .05
Hasegawa Dementia Scale	28.8 (1.3)	26.0 (2.9)	< .05

Values are presented as mean (SD)

significantly negatively associated with BCFE scores in the normal group (p < .05). BCFE scores were significantly lower in older adults with cognitive impairment compared with normal individuals, indicating that the BCFE could discriminate validly between the normal and cognitive impairment groups.

At .933 (95% CI: .885 – .981), the AUC value of the BCFE was greater than the cutoff of 0.80, indicating that this test was useful for detection of cognitive impairment; this AUC was significantly larger than 0.5. Receiver Operatorating Characteristic curve (ROC) analysis indicated that the optimal cutoff score was 7/8; the sensitivity (prediction value) and specificity (prediction value) for this score were 92.0% (95.4%) and 78.3% (69.2%), respectively (Figure 2).

2. Additional examination results

In total, 15 participants (7 male and 8 female) were included in the present study. Among all participants, BCFE scores were significantly correlated with fMMSE scores (r = .908, p < .01); this indicates that the BCFE demonstrated high concurrent validity (Figure 3).

On the other hand, the interclass correlation coefficients (ICC) of the first and second BCFE administrations was significantly high (r = .988; p < .01). Landis showed that coefficients more than .81 were almost perfect[18]. Therefore, BCFE demonstrated high test-retest reliability.

Discussion

In the present study, we aimed to develop a validated test—the BCFE—for cognitive assessment in older adults. We developed the BCFE by applying item-reduction analysis to a cognitive test for dementia[19]. The BCFE allows for quick assessment of cognitive impairment, as the number of items—reduced from 19 to 3—is
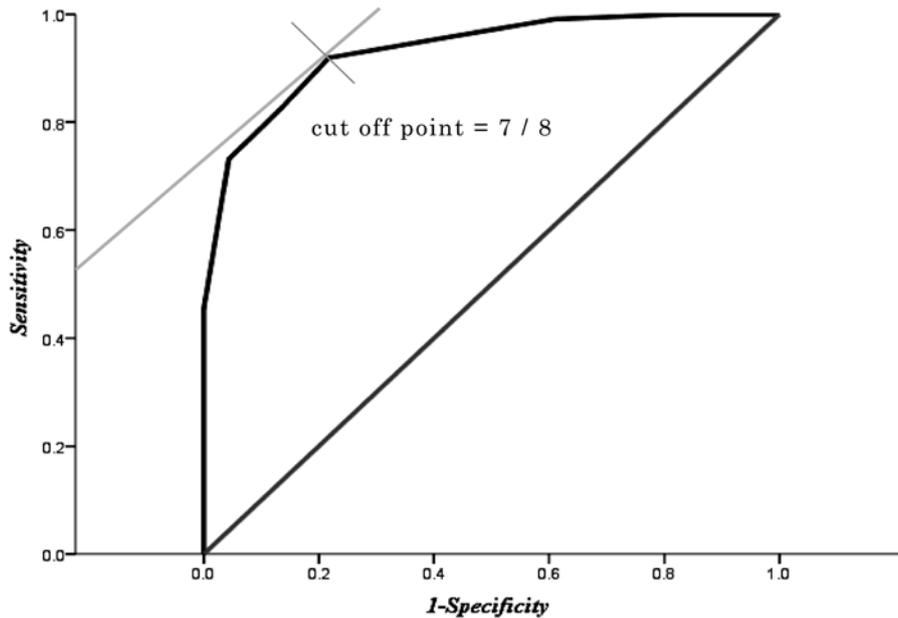
Area	SE	95%CL		p-value
0.93	0.02	0.89	0.98	P<0.05

Figure2. Receiver-operator characteristic curve of the short version of the Brief Cognitive Function Examination (BCFE) and the area under the curve of the BCFE.
The AUC is compared with the area (0.5) under the 45-degree straight line
ROC: Receiver-operator characteristic curve
AUC: Area under the receiver-operator curve (Area Under the Curve)
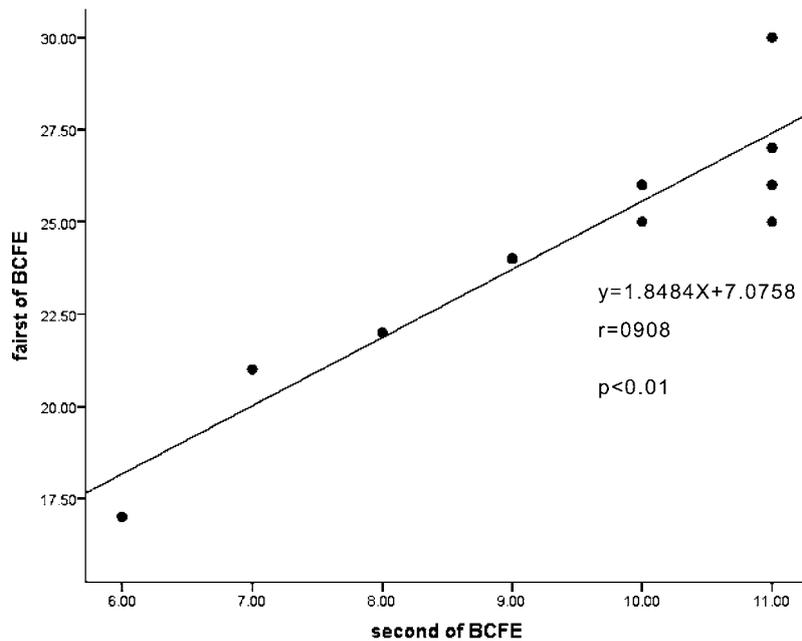Area: Beyond that under the 45-degree straight line
SE: Standard Error

Figure3. Concurrent validity of the BCFE (additional examination).
Correlations between first and second administrations of BCFE
*2-tailed Spearman's rank correlation coefficient

considerably lower than in the fMMSE.

Cross-validation of the BCFE and fMMSE showed that the BCFE has high sensitivity. Hence, the BCFE can diagnostically assess the presence of cognitive impairment in a relatively shorter time.

We examined the validity of the BCFE; its scores were highly correlated with those on both the fMMSE (r = .938, p < .05) and the HDS-R (r = .638, p < .05). Additional study to examine validity of the BCFE revealed that its scores were highly correlated with those on the fMMSE (r = .908, p < .01). In addition, the BCFE could validly discriminate between the normal and cognitive impairment groups (p < .05). These results suggest that the BCFE has validity. The AUC was .933 (.885- .981), and ROC analysis indicated an optimal cutoff score of 7/8, with sensitivity and specificity of 92.0% and 78.3%, respectively.

The fMMSE has sensitivity of 58% and specificity of 84%, in discrimination between MCI and healthy cognitive status when the cutoff score is 27/28; thus, its specificity is high, but its sensitivity is insufficient[15]. Therefore, the BCFE's sensitivity was higher than that of the fMMSE. Compared with those in the fMMSE, the relative weights of measures for memory were stronger in the BCFE. Furthermore, in a cohort study of community-

dwelling older adults, subjects with poor delayed recall had a higher probability of onset of Alzheimer's disease. Therefore, the BCFE, which was designed with recall as the primary item, should provide results with higher discriminatory ability[12]. The memory test is an item that can predict the onset of dementia[18),20)], so the sensitivity of the BCFE was higher than that of the fMMSE. Another study among community-dwelling older adults in Japan that assessed the relationship between regional cerebral blood flow and neuropsychological examinations for MCI showed that scores on the 3-word recall test correlated with decreased blood flow in the posterior cingulate gyrus, precuneus, and parietal cortex. The same cerebral blood flows are implicated as areas of decreased regional cerebral blood flow in AD. An assessment of MCI has a strong correlation with brain regional blood flow in patients who convert from MCI to AD[21]. Since neuroimaging techniques were not used in the present study, it is difficult to replicate prior studies' links between the 3-phrase delayed recall challenge and brain functioning; however, declining temporal and parietal cortical function have also been related to conversion from MCI to dementia in other previous studies[22),23)]. Therefore, we conclude that the 3-word delayed recall test is the optimal measurement for assessment of early signs of

incipient dementia. Consequently, the BCFE—along with the 3-word delayed recall test—can be useful in screening for cognitive impairment and MCI among community-dwelling older adults.

However, cognitive impairment scores were higher on the BCFE than on the fMMSE, because for the BCFE, we selected many people who did not have apparent cognitive impairment on the basis of the memory test alone. Cognitive impairment may be caused by a disorder of the cognitive domain, with the exception of those impairments that affect memory. For example, cognitive impairment affects verbal fluency or attention tasks. This proves that the coefficient of correlation of HDS-R is low, perhaps because of the inclusion of the verbal fluency task. This result suggests that the BCFE score lower than the cutoff is more likely to indicate cognitive impairment than a score higher than the cutoff. Therefore, to distinguish cognitive impairment clearly, we should conduct additional types of assessment; this would support prior findings.

Nevertheless, the BCFE is constructed from recall and Serial7s tasks, both of which are known to be diagnostic for early dementia[24),25),26)]. Kimura et al[12)] identified recall and Serial7s as predictors of cognitive impairment in a prior study. The BCFE attained good sensitivity in screening for cognitive impairment among community-dwelling older adults.

Limitations

Certain limitations are apparent in the present study. We examined the concurrent validity of the BCFE with that of the fMMSE, and the two tests have items in common. This might have exaggerated the observed correlation coefficients. In addition, the BCFE was performed at the same time as the fMMSE; the two tests should ideally be administered separately to avoid interviewer or information bias.

Conclusion

The BCFE consists of only three items and can be completed in a shorter period than that of fMMSE requires. In addition, the BCFE is strongly correlated with the fMMSE. Consequently, the BCFE can be a very useful tool for evaluation of cognitive function among older adults.

References

1) Ogawa N, Takeda T.（Eds.）: Occupational Therapy of Dementia—Uniting of Evidence and Narrative, Ishiyaku, Tokyo, 2009

2) Sekita A, Ninomiya T, Tanizaki Y, et al: Trends in prevalence of Alzheimer's disease and vascular dementia in a Japanese community: the Hisayama Study. Acta Psychiatrica Scandinavica 122（4）: 319-325, 2010

3) Dodge HH, Buracchio TJ, Fisher GG, et al: Trends in the prevalence of dementia in Japan. International journal of Alzheimer's disease 2012:02012

4) Folstein MF, Folstein SE, McHugh PR: "Mini-mental state": a practical method for grading the cognitive state of patients for the clinician. Journal of psychiatric research 12（3）: 189-198, 1975

5) Malloy PF, Cummings, JL, Coffey CE, et al: Cognitive screening instruments in neuropsychiatry: a report of the Committee on Research of the American Neuropsychiatric Association. The Journal of neuropsychiatry and clinical neurosciences 9（2）: 189-197, 1996

6) Tombaugh TN, McIntyre NJ: The mini-mental state examination: a comprehensive review. Journal of the American Geriatrics Society 40（9）: 922-935, 1992

7) Mori E, Mitani Y, Yamadori A: Usefulness of a Japanese version of the Mini-Mental State Test in neurological patients. Jpn J Neuropsychol 1: 82-90, 1985

8) Tierney M C, Szalai JP, Dunn E, et al: Prediction of probable Alzheimer disease in patients with symptoms suggestive of memory impairment. Value of the Mini-Mental State Examination. Archives of family medicine 9（6）: 527-532, 2000

9) Kalbe E, Kessler J, Calabrese P, et al: DemTect: a new, sensitive cognitive screening test to support the diagnosis of mild cognitive impairment and early dementia. International journal of geriatric psychiatry 19（2）: 136-143, 2004

10) Borson S, Scanlan JM, Chen P, et al: The Mini‐Cog as a screen for dementia: validation in a population‐based sample. Journal of the American Geriatrics Society 51（10）: 1451-1454, 2003

11) Brooke P, Bullock R: Validation of a 6 item cognitive impairment test with a view to primary care usage. International journal of geriatric psychiatry 14（11）: 936-940, 1999

12) Kimura D, Takeda T, Ota T: The investigation of the potential screen of brief cognitive assessment to discriminate cognitive function decline from cognitively healthy subjects in community. The Journal of Japanese association of occupational therapists 30（5）: 626-630, 2011

13） Chapey R（eds.）: Language Intervention Strategies in Adult Aphasia, Williams & Wilkins, Baltimore, 1981

14） Smith EE, Jonides J: Storage and executive processes in the frontal lobes. Science 283（5408）: 1657-1661, 1999

15） Imai Y: The revised Hasegawa's dementia scale（HDS-R）: evaluation of its usefulness as a screening test for dementia. J Hong Kong Coll Psychiatr 4（2）: 20-4, 1994.

16） Morris JC: The Clinical Dementia Rating（CDR）: current version and scoring rules Neurology: 43（11）, 2412, 1993

17） Morris JC, McKeel Jr DW, Storandt M, et al: Very mild Alzheimer's disease: informant-based clinical, psychometric, and pathologic distinction from normal aging. Neurology,41（4）, 469-478.（1991）.

18） Luis CA, Keegan AP, Mullan M: Cross validation of the Montreal Cognitive Assessment in community dwelling older adults residing in the Southeastern US. International journal of geriatric psychiatry 24（2）: 197-201,2009

19） Landis JR, Koch GG: The measurement of observer agreement for categorical data. biometrics 33（1）: 159-174, 1977

20） Elias MF, Beiser A, Wolf PA, et al: The preclinical phase of Alzheimer disease: a 22-year prospective study of the Framingham Cohort. Archives of Neurology 57（6）: 808-813, 2000

21） Masur DM, Sliwinski M, Lipton RB, et al: Neuropsychological prediction of dementia and the absence of dementia in healthy elderly persons. Neurology 44（8）: 1427-1432, 1994

22） Linn RT, Wolf P A, Bachman DL, et al: The 'Preclinical Phase' of Probable Alzheimer's Disease: A 13-Year Prospective Study of the Framingham Cohort. Archives of Neurology 52（5）: 485-490,1995

23） Sugimura M, Matsuda H, Seigo N, et al: Relationship between regional cerebral blood flow and neuropsychological examinations in evaluating mild cognitive impairment（MCI）: Ajimu Project. Japanese journal of geriatric psychiatry 18（10）: 1113–1122,2007

24） Gómez-Tortosa E, Mahillo-Fernández I, Guerrero R, et al: Outcome of mild cognitive impairment comparing early memory profiles. The American Journal of Geriatric Psychiatry 20（10）: 827-835, 2012

25） Rosen AM, Fox HA: Tests of cognition and their relationship to psychiatric diagnosis and demographic variables. The Journal of clinical psychiatry 47（10）: 495-498, 1986

26） Celsis P, Agniel A, Cardebat D, et al: Age related cognitive decline: a clinical entity? A longitudinal study of cerebral blood flow and memory performance. Journal of Neurology, Neurosurgery & Psychiatry 62（6）: 601-608, 1997

簡易認知機能検査の妥当性の検討

木村　大介 *，竹田　徳則 *，砂原　伸行 **，藤田　高史 *，能登谷晶子 **

要　　旨

　介護予防事業での認知機能評価には，短時間で実施可能な的確で簡便な評価法が求められる．我々は，先行研究において早期認知機能低下の予測因子である即時再生（3 点），連続計算（5 点），遅延再生（3 点）で構成される計 11 点の簡易認知評価を介護予防事業での認知機能低下のスクリーニングに用いてきている．本研究の目的は，簡易認知評価の基準関連妥当性とカットオフ値を検討することである．対象は 2007 年から 2010 年までに実施された介護予防事象参加者でお元気チェックと称する評価を受けたサロン運営ボランティア 137 名（平均年齢 66.4 ± 5.7 歳，男性 42 名，女性 95 名）である．基準関連妥当性の検討には，①外的基準との相関を求める併存妥当性，② CDR0.5 と 0 での二群間で平均値を比較する構成概念妥当性，③また，ROC 曲線からカットオフ値とその時の感度，特異度を算出した．結果は，①では，HDS-R と MMSE を外的基準とした相関係数は，HDS-R（ r =0.638，p<0.05），MMSE（r=0.938，p<0.05）で，中等度から高い相関が認められた．②では，簡易認知評価の平均値は，有意差が認められた．③では，CDR0.5 を基準とする ROC 曲線からカットオフは7/8 点（感度 0.920，特異度 0.783）と算出された．簡易認知評価の併存妥当性，構造概念妥当性が示され，AUC から検査適性も確認できた．また，認知機能低下のスクリーニングでは CDR0.5 が指標でカットオフ値 7/8 である可能性が示唆された．