Print ISSN 1738-1495 / On-line ISSN 2384-0757
Dement Neurocogn Disord 2015;14(4):137-142 / http://dx.doi.org/10.12779/dnd.2015.14.4.137

ORIGINAL ARTICLE

Constructing a Composite Score for the Seoul Neuropsychological Screening Battery-Core

Seungmin Jahng,[1] Duk L. Na,[2] Yeonwook Kang[3,4]

[1]Department of Psychology, Sungkyunkwan University, Seoul, Korea
[2]Department of Neurology, Samsung Medical Center, College of Medicine, Sungkyunkwan University, Seoul, Korea
[3]Department of Psychology, Hallym University, Chuncheon, Korea
[4]Department of Neurology, Hallym University Sacred Heart Hospital, Anyang, Korea

Background and Purpose The brief version of the Seoul Neuropsychological Screening Battery (SNSB), the SNSB-Core (SNSB-C), has been developed. Although each subtest score of the SNSB-C provides information on different features of broad cognitive functioning or impairment, a composite score is needed to identify the severity of global cognitive impairment. We aimed to develop and validate a composite score of the SNSB-C that would provide a normative-based summary score of global cognitive functioning, especially for differentiating patients with cognitive impairment from normal elderly.

Methods A normative sample of 1067 elderly was used to develop a composite score of SNSB-C. The composite score was corrected for the effects of age, years of education, and sex by the regression method. Patients with Alzheimer's disease (n=41), vascular dementia (n=40), amnestic mild cognitive impairment (MCI) (n=73), vascular MCI (n=41), and Parkinson's disease with MCI (n=41) were differentiated from a normal sample (n=70) by the uncorrected and corrected composite scores using receiver operating characteristic (ROC) curve analysis.

Results Confirmatory factor analysis showed that the composite score equal weight to each standardized cognitive domain of SNSB-C is appropriate for indexing overall cognitive functioning. The corrected and uncorrected composite scores yielded a satisfactory size of the area under the ROC curve comparable to the Mini Mental State Examination (MMSE).

Conclusions The composite scores of SNSB-C, especially the corrected score, provide an index of overall cognitive functioning, and they can be used as an alternative to MMSE for screening patients with cognitive impairment.

Key Words Seoul Neuropsychological Screening Battery, Seoul Neuropsychological Screening Battery-Core, composite score, Mini Mental State Examination.

Received: December 2, 2015 **Revised:** December 20, 2015 **Accepted:** December 20, 2015

Correspondence: Yeonwook Kang, PhD, Department of Psychology, Hallym University, 1 Hallymdaehak-gil, Chuncheon 24252, Korea
Tel: +82-33-248-1724, **Fax:** +82-33-256-3424, **E-mail:** ykang@hallym.ac.kr

INTRODUCTION

The Seoul Neuropsychological Screening Battery (SNSB) is one of the most widely used neuropsychological screening batteries in South Korea.[1,2] The current version of SNSB (SNSB-II) is composed of comprehensive cognitive tests that evaluate the level of cognitive functioning or impairment in five different cognitive domains: attention, language and related functions, visuospatial functions, memory, and frontal/executive functions.[2] It also includes other related tests, such as clinical dementia rating (CDR), Barthel-activities of daily living (B-ADL), Korean-instrumental activities of daily living (K-IADL) and Geriatric Depression Scale (GDS). The estimated completion time of the whole battery is one and a half hours to two hours.

The brief version of the SNSB, named SNSB-Core (SNSB-C), has been developed to shorten completion time while evaluating core features of cognitive ability.[3] The SNSB-C is composed of fourteen subtests derived from the SNSB-II:[2] Vigilance Test, Digit Span Test,[4] Comprehension Test, Repetition Test,

short form of the Korean-Boston Naming Test,[5] Ideomotor Apraxia Test (IAT), Rey Complex Figure Test,[6] Seoul Verbal Learning Test-Elderly's version (SVLT-E), Contrasting Program, Go-No go Test, short form of the Korean-Color Word Stroop Test,[7] Controlled Oral Word Association Test (COWAT),[8] Korean-Trail Making Test-Elderly's version (K-TMT-E),[9] and Digit Symbol Coding.[10] Although each subtest score of the SNSB-C provides information on different features of broad cognitive functioning or impairment, a composite score depicting the overall level of cognitive ability is needed to identify the severity of global cognitive impairment. The present study aimed to develop and validate a composite score of the SNSB-C that would provide a normative based summary score of global cognitive functioning, especially for differentiating the elderly with cognitive impairment from the normal elderly.

METHODS

Subjects

We first used a normative sample to develop a composite score and then validated the score using different samples with cognitive impairment against a normal comparison group. For the normative sample, one thousand and sixty-seven elderly people, ranging in age from 45 to 90 years, were recruited across different regions in South Korea based on the Christensen's health screening criteria.[11] The mean age was 68.1 years with a standard deviation of 11.8. The average years of education was 8.3 (SD=5.4) years, including 8.7% of illiterates. There were 600 females in the sample (56.2%).

The validation samples included different groups of patients with cognitive impairment: 41 patients with Alzheimer's disease (AD), 40 patients with vascular dementia (VD), 73 patients with amnestic multi-domain mild cognitive impairment (amMCI), 41 patients with vascular MCI (VaMCI), and 41 patients with Parkinson's disease with MCI (PD-MCI). All dementia patients met the clinical criteria for probable AD proposed by the NINCDS-ADRDA[12] or for probable VD proposed by the NINDS-AIREN.[13] Patients with amMCI, VaMCI, and PD-MCI met Petersen's criteria for MCI,[14] American Heart Association/American Stroke Association's criteria for vascular cognitive impairment,[15] and Movement Disorder Society's criteria for PD-MCI,[16] respectively.

Additionally, 70 people without cognitive impairment were randomly selected from the normative sample for comparison with the patient groups. All of the subjects in the normative and the validation samples were administered all neuropsychological tests in the SNSB-II as well as the Korean-Mini Mental State Examination (K-MMSE)[17] by trained clinical neuropsychologists. The CDR, B-ADL, K-IADL, and short version of the GDS (SGDS) were also administered to all subjects in the validation samples. Standard administration of the SNSB-II has been previously described in detail.[2] Characteristics of the validation samples are presented in Table 1.

Average ages in the six groups were not statistically equivalent ($F_{(5,300)}$=6.37, p<0.001), but post hoc comparisons using Tukey's HSD adjustment revealed that the normal group did not show a significant mean difference compared with any other groups. Average years of education were not significantly different across the six groups ($F_{(5,300)}$=0.99, p=0.427). The validation groups differed in terms of mean SGDS ($F_{(5,274)}$=6.68, p<0.001), where the normal group was significantly different from the other patient groups. The VD group showed a significantly lower mean value of the B-ADL compared with

Table 1. Characteristics of the validation samples

	Normal	amMCI	VaMCI	PD-MCI	AD	VD
n	70	73	41	41	41	40
% Male	50.0	31.5	53.7	56.1	36.6	52.5
% CDR 0	100.0	0.0	0.0	0.0		
% CDR 0.5	0.0	100.0	100.0	100.0	22.0	17.5
% CDR 1+	0.0	0.0	0.0	0.0	78.0	82.5
Mean (SD)						
Age	72.8 (7.2)*†‡	69.5 (8.3)‡	71.2 (7.5)†‡	70.2 (7.8)‡	76.3 (6.1)*	75.0 (6.9)*†
Education	9.0 (4.3)	8.7 (4.5)	8.5 (5.2)	10.3 (4.1)	9.5 (4.1)	9.5 (5.1)
SGDS	3.0 (3.2)*	6.0 (4.1)†	5.9 (4.3)†	6.1 (4.5)†	6.2 (4.4)†	6.9 (4.6)†
B-ADL	20.0 (0)*	20.0 (0.3)*	20.0 (0.2)*	19.5 (1.6)*	19.5 (1.3)*	18.8 (2.5)†
K-MMSE	27.1 (2.1)*	25.2 (3.2)†	25.7 (2.0)*†	26.5 (2.1)*†	21.9 (3.3)‡	21.5 (3.5)‡

*†‡Groups with different symbols in the same row have significant mean differences at 0.05 alpha level, adjusted by Tukey's HSD.
AD: Alzheimer's disease, amMCI: amnestic multi-domain cognitive impairment, B-ADL: Barthel-activities of daily living, CDR: clinical dementia rating, K-MMSE: Korean-Mini Mental State Examination, PD-MCI: Parkinson's disease with mild cognitive impairment, SGDS: short version of the Geriatric Depression Scale, VaMCI: vascular mild cognitive impairment, VD: vascular dementia.

the other groups ($F_{(5,300)}$=7.14, p<0.001). The average K-MMSE scores in the AD and the VD groups were significantly lower than those in the other groups, and the normal group was different from the amMCI group but not from the VaMCI and PD-MCI groups ($F_{(5,300)}$=34.64, p<0.001).

Composite scores and statistical analysis

A composite score of the SNSB-C was developed using the normative sample. The subtest scores considered for the composite score are listed in Table 2 with their targeted cognitive domain. The COWAT score was calculated as sum of the semantic fluency score for the "animal" category and the phonemic fluency score for the phoneme "ㄱ." The K-TMT-E score in SNSB-C is the time in seconds, spent to complete the test with the limit of 300 seconds. Because the K-TMT-E score is negatively correlated with other subtest scores and distributed with high negative skewness, we used a log transformed K-TMT-E score [=$\log_e$(300/K-TMT-E)] to ensure that the transformed score has positive correlations with other subtest scores and less skewed distribution. These properties are desirable for constructing a composite score with other test scores. All three scores of immediate recall, delayed recall, and recognition on the SVLT-E were used in calculating the composite score.

Because the scales of subtests differ enormously (Table 2), standardized scores were used to construct a composite score. Two methods of standardization were explored: 1) a composite score that uses equal weight to each standardized subtest; 2) a composite score that uses equal weight to each standardized cognitive domain. To determine which composite score is better at representing overall cognitive ability, a confirmatory factor analysis (CFA) was conducted. The result of the general uni-factor model was compared to that of a higher-order factor model, where a first-order factor consists of subtests in the frontal domain and another first-order factor consists of subtests in the memory domain in terms of model fit indices.

Age, education, and gender effects on the general cognitive ability have been underscored in the literature.[18-20] Therefore, we developed a composite score corrected for age, education, and gender effects using the normative sample. Regression analysis was performed on the uncorrected composite score, where both the mean and the variance of the score were regressed on age, years of education, gender, and their plausible interactions. Details of the correction procedure can be found in the literature.[21]

Corrected and uncorrected composite scores were evaluated by receiver operating characteristic (ROC) curve analysis to differentiate patient groups with AD, VD, amMCI, VaMCI, or PD-MCI from the normal comparison group in the validation samples. Areas under the ROC curves for the composite scores were compared to those for the K-MMSE to ensure that they are comparable to K-MMSE in identifying general cognitive impairment.

RESULTS

Descriptive statistics and correlations of subtest scores are presented in Table 3. Overall, subtest scores were highly correlated with each other. On the other hand, scores of the other subtests not considered for the composite score, i.e., Vigilance Test, Comprehension Test, Repetition Test, Ideomotor Apraxia Test, Contrasting Program, and Go-No go Test, were not highly correlated with the ten subtest scores presented in Table 3 (all rs<0.41). In addition, most of the normative sample (65.3%, 95.3%) scored maximum points of the six subtest scores as expected.

The ten subtest scores, including the log transformed K-TMT-E score, were used to construct a composite score. CFA

Table 2. List of subtest scores considered for the composite score

Subtest	Cognitive domain	Maximum points possible
DST	Attention	17
S-K-BNT	Language	15
RCFT: Copy score	Visuospatial	36
SVLT-E: Immediate recall	Memory	36
SVLT-E: Delayed recall	Memory	12
SVLT-E: Recognition	Memory	24
S-K-CWST: Color reading	Frontal/executive	112
COWAT	Frontal/executive	Unlimited
K-TMT-E: Part B time	Frontal/executive	300
DSC	Frontal/executive	133

COWAT: Controlled Oral Word Association Test, DSC: Digit Symbol Coding, DST: Digit Span Test, K-TMT-E: Korean-Trail Making Test-Elderly's version, RCFT: Rey Complex Figure Test, S-K-BNT: short form of the Korean-Boston Naming Test, S-K-CWST: short form of the Korean-Color Word Stroop Test, SVLT-E: Seoul Verbal Learning Test-Elderly's version.

Table 3. Descriptive statistics and correlations of test scores

		n	Mean	SD	Correlation coefficients											
					1	2	3	4	5	6	7	8	9	10	11	12
1	DST	1067	9.33	2.55												
2	S-K-BNT	1064	11.22	2.75	0.56											
3	RCFT: copy	1060	30.13	7.11	0.54	0.62										
4	SVLT-E: IR	1066	19.39	5.55	0.50	0.44	0.45									
5	SVLT-E: DR	1066	6.07	2.79	0.48	0.44	0.45	0.81								
6	SVLT-E: REC	1065	20.57	2.40	0.43	0.45	0.40	0.66	0.69							
7	S-K-CWST	967	41.13	15.32	0.53	0.47	0.47	0.58	0.57	0.46						
8	COWAT	974	23.17	7.51	0.56	0.52	0.43	0.53	0.49	0.46	0.55					
9	K-TMT-E	926	63.34	49.70	-0.42	-0.48	-0.48	-0.44	-0.41	-0.40	-0.51	-0.49				
10	K-TMT-E2	926	1.78	0.64	0.51	0.50	0.47	0.50	0.48	0.44	0.59	0.56	-0.92			
11	DSC	1060	41.81	21.31	0.68	0.62	0.61	0.61	0.58	0.52	0.70	0.63	-0.61	0.72		
12	SNSB-C	1067	50.00	10.00	0.81	0.81	0.80	0.73	0.72	0.65	0.75	0.73	-0.67	0.75	0.84	
13	K-MMSE	1067	26.81	3.36	0.61	0.64	0.68	0.50	0.49	0.47	0.53	0.49	-0.53	0.54	0.64	0.77

All of the correlation coefficients were significant at α=0.0001.
COWAT: Controlled Oral Word Association Test, DR: delayed recall, DSC: Digit Symbol Coding, DST: Digit Span Test, IR: immediate recall, K-MMSE: Korean-Mini Mental State Examination, K-TMT-E: Korean-Trail Making Test-Elderly's version, K-TMT-E2: $\log_e(300/\text{K-TMT-E})$, RCFT: Rey Complex Figure Test, REC: recognition, S-K-BNT: short form of the Korean-Boston Naming Test, S-K-CWST: short form of the Korean-Color Word Stroop Test, SNSB-C: standardized uncorrected composite score of the Seoul Neuropsychological Screening Battery-Core, SVLT-E: Seoul Verbal Learning Test-Elderly's version.

Table 4. Means of the SNSB-C composite scores (SD)

Groups	Uncorrected	Corrected
Normal	49.4 (7.7)*	49.3 (8.8)*
amMCI	46.2 (7.6)*†	42.2 (9.5)†
VaMCI	44.6 (7.1)†	41.5 (9.8)†
PD-MCI	46.5 (6.4)*†	39.3 (9.7)†
AD	39.6 (6.8)‡	32.2 (11.9)‡
VD	35.8 (6.7)‡	24.3 (13.0)§

*†‡§Groups with different symbols in the same column have significant mean differences at 0.05 alpha level, adjusted by Tukey's HSD.
AD: Alzheimer's disease, amMCI: amnestic multi-domain cognitive impairment, PD-MCI: Parkinson's disease with mild cognitive impairment, SNSB-C: Seoul Neuropsychological Screening Battery-Core, VaMCI: vascular mild cognitive impairment, VD: vascular dementia.

revealed that the general uni-factor model was not satisfactory [RMSEA=0.155, 95% confidence interval (CI)=(0.146, 0.164); CFI=0.849; NNFI=0.849; SRMR=0.065], but the higher-order factor model fitted the data well [RMSEA=0.054, 95% CI=(0.044, 0.065); CFI=0.983; NNFI=0.976; SRMR=0.026]. Accordingly, we adopted the composite score that uses equal weight to each standardized cognitive domain score. Frontal domain score was calculated by summing up the four standardized subtest scores in frontal domain (Table 2). Memory domain score was calculated as the sum of the three SVLT-E scores with the delayed recall score doubled so as to make scales of the three scores more similar to each other. Each of the visuospatial, language, and attention domains were composed of a single subtest score. The five domain scores were standardized or z-transformed and then summed up to form the composite score of the SNSB-C. The composite score itself was rescaled to have a mean of 50 and a standard deviation of 10 for interpretive purpose. Correlations of the composite score with its subtest scores were 0.65 or higher. The SNSB-C composite score was also highly correlated with the K-MMSE score [r=0.77, 95% CI=(0.74, 0.79)] in the normative sample (Table 3).

The effects of sex, log of years of education, illiteracy, and age on the uncorrected composite score were found to be significant (all $|t|$s ≥2.85, all ps<0.01). In addition, the effect of log of years of education interacted with sex (t=-2.91, p=0.004) and age (t=3.14, p=0.002). Variance of the composite score was also affected by age (z=3.66, p<0.001) and log of years of education (z=-5.66, p<0.001). The age-education-sex corrected composite score was obtained by subtracting the estimated mean from the uncorrected composite score and dividing it by the square root of the estimated variance, i.e., the estimated standard deviation. The corrected composite score was rescaled to have a mean of 50 and a standard deviation of 10.

The uncorrected and corrected composite scores of the SNSB-C were examined across the patient groups with different cognitive impairments as well as the normal group in the validation samples. Means and standard deviations of the composite scores for the validation samples are presented in Table 4. Group means of the uncorrected SNSB-C composite score ($F_{(5,300)}$=23.36, p<0.001) and the corrected composite score ($F_{(5,300)}$=35.80, p<0.001) were significantly different ac-

Table 5. AUCs of the SNSB-C composite scores and the K-MMSE

	SNSB-C						K-MMSE		
	Uncorrected			Corrected					
	AUC	95% CI		AUC	95% CI		AUC	95% CI	
		LL	UL		LL	UL		LL	UL
Normal vs.									
amMCI	0.64	0.55	0.73	0.70	0.62	0.79	0.69	0.60	0.78
VaMCI	0.71	0.60	0.81	0.72	0.62	0.81	0.70	0.60	0.80
PD-MCI	0.64	0.54	0.75	0.78	0.70	0.87	0.60	0.49	0.70
AD	0.84	0.76	0.91	0.87	0.80	0.94	0.91	0.86	0.97
VD	0.90	0.84	0.96	0.95	0.92	0.99	0.92	0.87	0.97

AD: Alzheimer's disease, amMCI: amnestic mild cognitive impairment, AUC: area under the curve, CI: confidence interval, K-MMSE: Korean-Mini Mental State Examination, LL: lower limit, PD-MCI: Parkinson's disease with mild cognitive impairment, SNSB-C: standardized composite score of Seoul Neuropsychological Screening Battery-Core, UL: upper limit, VaMCI: vascular mild cognitive impairment, VD: vascular dementia.

ross the validation samples, but the corrected composite score showed more distinct mean differences across the groups. Although patients with MCI, i.e., the amMCI, VaMCI, and PD-MCI groups, did not show sizable group differences among them in both composite scores, all the groups were significantly different from the normal group in only the corrected SNSB-C score.

ROC analysis revealed that the SNSB-C composite scores were comparable to K-MMSE in differentiating normal people from the patients with cognitive impairment. Areas under the curve (AUCs) between the normal group and each patient group for the two composite scores and K-MMSE are presented in Table 5. The corrected composite score differentiated PD-MCI patients from the normal group significantly better than the K-MMSE total score [AUC difference=0.18, 95% CI=(0.06, 0.31)]. AUCs produced by the three scores were not significantly different from each other in all other discriminations.

DISCUSSION

This study was conducted to develop a composite score of the SNSB-C and to validate its usefulness as a screening measure for differentiating the MCI and dementia patients with various etiologies from the normal elderly. Confirmatory factor analyses showed that the composite score that uses equal weight to each standardized cognitive domain of SNSB-C is appropriate for indexing overall cognitive functioning. We developed two composite scores, uncorrected and age-education-sex corrected scores, with five cognitive domain scores derived from ten subtest scores of the SNSB-C.

The results showed that the corrected composite score could differentiate normal aging from MCI and MCI from dementia as well as normal aging from dementia. These findings suggest that the corrected composite score of the SNSB-C reflects the severity of cognitive dysfunction and can be used as a valid measure for tracking progression of a dementing process.

The results also demonstrated that the corrected and uncorrected composite scores yielded satisfactory size of the area under the ROC curve comparable to the K-MMSE. Both composite scores of the SNSB-C and K-MMSE total score showed quite similar discriminability of amMCI and VaMCI, as well as AD and VD. The corrected composite score in the PD-MCI group, however, showed better discriminability than the K-MMSE total score. Along with memory, frontal/executive function is the most common cognitive domain affected in PD-MCI.[22] The SNSB-C includes more frontal/executive function subtests than the MMSE which insufficiently probes executive function.[23] This result indicates that the corrected composite score of the SNSB-C is more sensitive to frontal/executive dysfunction than the K-MMSE score.

All these findings strongly support the claim that the composite scores of SNSB-C, especially the corrected score, provide an index of overall cognitive functioning, and they can be used as an alternative to K-MMSE for screening patients with cognitive impairment. We expect that the composite scores of SNSB-C will be widely used for the detection and progression monitoring of MCI and dementia. In addition, another benefit of using a composite score is that the score lends itself to data analysis and is useful for change over time analyses. Therefore, the composite scores of SNSB-C will be very useful in research relating to dementia, especially in longitudinal studies.

Conflicts of Interest

The authors have no financial conflicts of interest.

Acknowledgements

This work was supported by Hallym University Specialization Fund (HRF-S-22).

REFERENCES

1. Kang Y, Na DL. *Seoul Neuropsychological Screening Battery*. Incheon: Human Brain Research & Consulting Co., 2003.
2. Kang Y, Jahng S, Na DL. *Seoul Neuropsychological Screening Battery, 2nd Edition (SNSB-II)*. Seoul: Human Brain Research & Consulting Co., 2012.
3. Kang Y, Jahng S, Na DL. *Seoul Neuropsychological Screening Battery-Core (SNSB-C)*. Incheon: Human Brain Research & Consulting Co., 2015.
4. Kang Y, Chin JH, Na DL. A normative study of the digit span test for the elderly. *Korean J Clin Psychol* 2002;21:911-922.
5. Kang Y, Kim H, Na DL. A short form of the KoreanBoston Naming Test (K-BNT) for using in dementia patients. *Korean J Clin Psychol* 1999;18:125-138.
6. Meyers JE, Meyers KR. *Rey Complex Figure Test and Recognition Trial: Professional manual*. Odessa, FL: Psychological Assessment Resources, 1995.
7. Lee JH, Kang Y, Na DL. Efficiencies of stroop interference indexes in healthy older adults and dementia patients. *Korean J Clin Psychol* 2000;19:807-818.
8. Kang Y, Chin JH, Na DL, Lee JH, Park JS. A normative study of the Korean version of Controlled Oral Word Association Test (COWAT) in the elderly. *Korean J Clin Psychol* 2000;19:385-392.
9. Yi H, Chin JH, Lee BH, Kang Y, Na DL. Development and validation of Korean version of Trail Making Test for elderly persons. *Dement Neurocognitive Disord* 2007;6:54-66.
10. Joy S, Kaplan E, Fein D. Speed and memory in the WAIS-III Digit Symbol--Coding subtest across the adult lifespan. *Arch Clin Neuropsychol* 2004;19:759-767.
11. Christensen KJ, Multhaup KS, Nordstrom S, Voss K. A cognitive battery for dementia: development and measurement characteristics. *J Consult Clin Psychol* 1991;3:168-174.
12. McKhann G, Drachman D, Folstein M, Katzman R, Price D, Stadlan EM. Clinical diagnosis of Alzheimer's disease: report of the NINCDS-ADRDA Work Group under the auspices of Department of Health and Human Services Task Force on Alzheimer's Disease. *Neurology* 1984;34:939-944.
13. Román GC, Tatemichi TK, Erkinjuntti T, Cummings JL, Masdeu JC, Garcia JH, et al. Vascular dementia: diagnostic criteria for research studies. Report of the NINDS-AIREN International Workshop. *Neurology* 1993;43:250-260.
14. Petersen RC, Doody R, Kurz A, Mohs RC, Morris JC, Rabins PV, et al. Current concepts in mild cognitive impairment. *Arch Neurol* 2001;58:1985-1992.
15. Gorelick PB, Scuteri A, Black SE, Decarli C, Greenberg SM, Iadecola C, et al. Vascular contributions to cognitive impairment and dementia: a statement for healthcare professionals from the american heart association/american stroke association. *Stroke* 2011;42:2672-2713.
16. Litvan I, Goldman JG, Tröster AI, Schmand BA, Weintraub D, Petersen RC, et al. Diagnostic criteria for mild cognitive impairment in Parkinson's disease: Movement Disorder Society Task Force guidelines. *Mov Disord* 2012;27:349-356.
17. Kang Y, Na DL, Hahn S. A validity study on the Korean Mini-Mental State Examination (K-MMSE) in dementia patients. *J Korean Neurol Assoc* 1997;15:300-308.
18. Salthouse TA, Atkinson TM, Berish DE. Executive functioning as a potential mediator of age-related cognitive decline in normal adults. *J Exp Psychol Gen* 2003;132:566-594.
19. van Hooren SA, Valentijn AM, Bosma H, Ponds RW, van Boxtel MP, Jolles J. Cognitive functioning in healthy older adults aged 64-81: a cohort study into the effects of age, sex, and education. *Neuropsychol Dev Cogn B Aging Neuropsychol Cogn* 2007;14:40-54.
20. Caplan PJ, Crawford M, Hyde JS, Richardson JT. *Gender differences in human cognition*. New York: Oxford University Press, 1997.
21. Jahng S, Kang Y. A model-based approach to estimating psychological test norms under normality assumption. *Korean J Clin Psychol* 2012;31:923-944.
22. Goldman JG, Litvan I. Mild cognitive impairment in Parkinson's disease. *Minerva Med* 2011;102:441-459.
23. Hachinski V, Iadecola C, Petersen RC, Breteler MM, Nyenhuis DL, Black SE, et al. National Institute of Neurological Disorders and Stroke-Canadian Stroke Network vascular cognitive impairment harmonization standards. *Stroke* 2006;37:2220-2241.