ORIGINAL ARTICLE
eISSN 2233-9183
J Korean Acad Child Adolesc Psychiatry 2023;34(3):181-187
https://doi.org/10.5765/jkacap.230025

Check for updates

Association of the Comprehensive Attention Test and the Korean Wechsler Intelligence Scale for Children-Fourth Edition in Children and Adolescents With Attention-Deficit/Hyperactivity Disorder

Min-Su Jang[1], Sang-Keun Chung[1,2], Jong-Chul Yang[1,2], Jong-Il Park[1,2], Joo-Han Kwon[1], and Tae-Won Park[1,2]

[1]Department of Psychiatry, Jeonbuk National University Hospital, Jeonju, Korea
[2]Department of Psychiatry, Jeonbuk National University College of Medicine, Jeonju, Korea

Objectives: This study aimed to investigate the correlation between the Comprehensive Attention Test, Korean-Wechsler Intelligence Scale for Children-Fourth Edition, and Attention-Deficit/Hyperactivity Disorder (ADHD) Rating Scale-IV scores in children and adolescents with ADHD.

Methods: Fifty-five children and adolescents diagnosed with ADHD and not taking psychiatric medications were included in this retrospective study. A correlation analysis was performed.

Results: Although simple visual and auditory selective attention have diagnostic value in traditional continuous performance tests, this study revealed that inhibition-sustained attention and interference-selective attention are also effective in evaluating ADHD. Furthermore, the correlation between the attention and intelligence test scores varied depending on the use of visual or auditory stimuli.

Conclusion: The findings of this study contribute to clarifying our understanding of the cognitive characteristics of children and adolescents with ADHD and can be used in future research.

Keywords: Attention-deficit/hyperactivity disorder; WISC-IV; Continuous performance test; Rating scale.

Received: April 8, 2023 / **Revised:** June 2, 2023 / **Accepted:** June 13, 2023
Address for correspondence: Tae-Won Park, Department of Psychiatry, Jeonbuk National University College of Medicine, 20 Geonji-ro, Deokjin-gu, Jeonju 54907, Korea
Tel: +82-63-250-2028, Fax: +82-63-275-3157, E-mail: ptaewon@jbnu.ac.kr

INTRODUCTION

Attention-deficit/hyperactivity disorder (ADHD), a commonly observed behavioral disorder in children and adolescents, is a neurodevelopmental disorder represented by inattention, hyperactivity, and impulsivity. It is characterized by difficulties with selective attention, i.e., inhibiting one's responses to irrelevant stimuli and selectively responding to relevant stimuli, and impediment with sustained attention, i.e., maintaining one's concentration for long periods. Particularly, it is associated with low performance in tasks requiring high levels of attentional capacity and span [1]. In addition to attention difficulties, impaired executive function in the frontal lobe occur in ADHD [2].

The Comprehensive Attention Test (CAT) is commonly used in South Korea to evaluate neuropsychological problems in children and adolescents with ADHD. It is a computerized continuous performance test (CPT) that evaluates attention and can quantitatively measure attention and impulse control abilities. Yoo et al. [3] standardized the Korean version of this test. Although CAT has a high sensitivity in collectively diagnosing ADHD in children and adolescents, proving its diagnostic usefulness [4], it has low sensitivity and specificity for individual behavioral symptoms of ADHD [3].

The Wechsler Intelligence Scale for Children (WISC) is an individually administered representative intelligence test that reflects the information processing abilities of children and adolescents [5]. The fourth edition of WISC (WISC-IV) reveals significant differences between children with and without ADHD, particularly in General Ability Index (GAI) and Cognitive Proficiency Index (CPI) scores [5,6].

Behavior rating scales completed by parents and teachers objectively measure the severity of behavioral symptoms in children [7]. Among them, the ADHD Rating Scale (ARS) has a high validity in discriminating between patients with ADHD and healthy controls, effective when screening for ADHD in specific population groups but less effective in precisely diagnosing ADHD or evaluating its severity [8].

Attention and cognitive function have shown a general interaction in children with ADHD. A study examining the association between the Advanced Test of Attention (ATA), a commonly used CPT in South Korea, and Korean Wechsler Intellegence Scale for Children-fourth edition (K-WISC-IV) reported a significant correlation between the Working Memory Index (WMI) and Processing Speed Index (PSI) of K-WISC-IV and ATA [9]. However, unlike the CAT used in this study, CPTs such as ATA and the Test of Variables of Attention can only measure simple attentional abilities related to vision and hearing. Even if ADHD does not manifest as a significant decline in simple attentional abilities in children and adolescents, other areas, such as inhibition-sustained attention, interference-selective attention, divided attention, and working memory, may show impairment, which can interact with cognitive functioning.

The aim of the present study was to use CAT to explore the association between various indices of CPTs and K-WISC-IV and among parent-reported ARS, CAT, and K-WISC-IV.

METHODS

Participants

We retrospectively collected hospital data of children and adolescents aged 6–17 years who had visited the neuropsychiatric department of a provincial university hospital in South Korea for the first time between January 1, 2019, and December 31, 2021. ADHD and comorbid disorders were diagnosed by a child and adolescent psychiatrist according to the diagnostic criteria in the Diagnostic and Statistical Manual of Mental Disorders-5th edition [10] based on information obtained by interviewing the children and adolescents and their parents. Among the children and adolescents, we enrolled those who had been administered K-WISC-IV, CAT, or ARS during the same period. Children and adolescents whose full-scale intelligence quotient (FSIQ) of K-WISC-IV was less than 80 and those with a history of psychiatric medication usage in the past 3 months were excluded from the study to rule out the influence of problems other than ADHD on the test results. After excluding patients with a history of brain disease or serious medical or surgical conditions, 55 participants were included in the analyses. The study protocol was reviewed and approved by the Institutional Review Board of the Jeonbuk National University Hospital (2022-03-023).

Instruments

K-WISC-IV

Unlike the previous edition, WISC-IV [11] comprises four main indices: the Verbal Comprehension Index (VCI), Perceptual Reasoning Index (PRI), WMI, and PSI. Furthermore, compared to the previous edition, GAI and CPI were calculated along with the FSIQ, resulting in a higher sensitivity to ADHD symptoms in this edition [12,13]. A previous study that used WISC-IV reported no significant differences in VCI or PRI of children with and without ADHD, whereas lower PSI and WMI were noted in children with ADHD [11-13]. Therefore, GAI (comprising VCI and PRI) and CPI (comprising PSI and WMI) clarify the cognitive characteristics of children with ADHD [5].

CAT

CAT is a computerized CPT that quantitatively measures attention and impulse control abilities. It comprises six subtests: inhibition-sustained attention, interference-selective attention, divided attention, visual working memory, simple visual selective attention, and simple auditory selective attention. These subsets were evaluated using existing CPTs. The combination of tests varied with the child's age. Three subtests were administered to children aged 4–5 years: simple visual selective attention, simple auditory selective attention, and inhibition-sustained attention. For children aged 6–8 years, interference-selective attention was added to four subtests, whereas for children and adolescents aged 9–17 years, divided attention and visual working memory were added. Further, all six subtests were administered. Similar to the other CPTs, each subtest calculates four indices: omission error, commission error, mean reaction time, and response time variability. The participants' test results were converted to age- and sex-standardized to a mean index value of 100 and a standard deviation (SD) of 15, and the final attention quotient (AQ) was calculated. AQ decreased with decreasing concentrations.

ARS

ARS is an 18-item scale completed by parents or teachers that is useful when screening for ADHD in population groups or evaluating the effect of treatments on ADHD symptoms. The total score of the odd-numbered items measures inattention symptoms, and the total score of the even-numbered items measures hyperactivity/impulsivity symptoms. Each item was evaluated on a 4-point scale ranging from 0 to 3 points, and the total score was calculated by adding the scores of each item. Parent- and teacher-reported versions' scores of ≥19 and ≥17 points indicate a high possibility of ADHD [14].

Statistical analysis

In this study, we collected the AQ values of each subscale of the CAT, the scores of each subscale of the K-WISC-IV, the total score of the ARS, and the sum of the even- and odd-item scores. Means and SDs were calculated for all continuous variables. We conducted a Pearson correlation analysis to examine the correlation between the CAT, K-WISC-IV, and ARS subscale scores. Statistical analyses were performed using IBM SPSS 28.0 for Windows (IBM Corp., Armonk, NY, USA), and the significance level was set at $p<0.05$.

RESULTS

Sociodemographic characteristics

We enrolled 55 children and adolescents diagnosed with ADHD, including 43 boys and 12 girls, with a mean age of 9.45 years. Among comorbid disorders, tic disorder (9.1%), post-traumatic stress disorder (5.5%), depressive disorder (3.6%), anxiety disorder (3.6%), and obsessive-compulsive disorder (3.6%) were noted. However, none of the participants exhibited symptoms severe enough to require medication.

Indices of K-WISC-IV

The mean FSIQ score of K-WISC-IV was 92.4±12.2. The mean CPI score was 87.7±13.4. The mean GAI score was 99.3±11.7. The mean CPI score was the lowest. Regarding cognitive function, the mean VCI score was 98.5±12.9; the mean PRI score was 100.0±12.8; the mean WMI score was 90.9±12.5; the mean PSI score was 88.1±15.3. The PRI, VCI, WMI, and PSI scores are listed in the order of decreasing mean scores (Table 1).

Correlation between CAT performance results and K-WISC-IV

Regarding simple visual selective attention, omission errors were positively correlated with FSIQ and CPI scores of K-WISC-IV. Commission errors were positively correlated with VCI, WMI, FSIQ, CPI, and GAI scores. Response time variability also positively correlated with the FSIQ, CPI, and GAI scores of K-WISC-IV.

For simple auditory selective attention, commission errors were positively correlated with the K-WISC-IV PSI, FSIQ, CPI, and GAI scores. Response-time variability was positively correlated with the FSIQ and CPI scores of K-WISC-IV.

Regarding inhibition-sustained attention, omission errors were positively correlated with the VCI, PSI, FSIQ, CPI, and GAI scores. Commission errors were positively correlated with the K-WISC-IV VCI, FSIQ, and CPI scores. The mean reaction time was positively correlated with the K-WISC-IV PSI score. Response time variability was positively correlat-

Table 1. Mean and standard deviation of each index of K-WISC-IV, CAT, and ARS

Index	Score (n=55)
K-WISC-IV	
FSIQ	92.4±12.2
GAI	99.3±11.7
CPI	87.7±13.4
VCI	98.5±12.9
PRI	100.0±12.8
WMI	90.9±12.5
PSI	88.1±15.3
CAT	
Visual simple selective attention	
Omission error	103.0±9.9
Commission error	109.0±14.2
Mean reaction time	89.3±14.3
Response time variability	90.3±16.9
Auditory simple selective attention	
Omission error	107.0±7.8
Commission error	108.0±9.9
Mean reaction time	90.0±13.4
Response time variability	101.0±16.2
Inhibition-sustained attention	
Omission error	95.0±12.5
Commission error	90.5±19.2
Mean reaction time	90.6±14.6
Response time variability	91.3±14.7
Interference-selective attention	
Omission error	87.0±16.4
Commission error	91.1±17.8
Mean reaction time	83.9±14.7
Response time variability	79.9±14.2
Divided attention (n=27)	
Omission error	98.9±15.5
Commission error	99.5±12.7
Mean reaction time	93.6±14.0
Response time variability	94.4±13.3
Working memory	
Forward correct response number	98.3±11.5
Forward memory span	97.1±12.4
Backward correct respinse number	102.0±15.3
Backward memory span	102.0±11.2
ARS	
Odd-numbered items, inattention	13.1±5.9
Even-numbered items, hyperactivity and impulsivity	11.1±6.0
Total score	24.2±10.2

Values are presented as mean±standard deviation. K-WISC-IV, Korean-Wechsler Intelligence Scale of Children, fourth edition; CAT, Comprehensive Attention test; ARS, Attention-Deficit/Hyperactivity Disorder Rating Scale; FSIQ, Fullscale intelligence quotient; GAI, General Ability Index; CPI, Cognitive Proficiency Index; VCI, Verbal Comprehension Index; PRI, Perceptual Reasoning Index; WMI, Working Memory Index; PSI, Processing Speed Index

Table 2. Correlation between indexes of K-WISC-IV and CAT performance result

Subtest of CAT	VCI	PRI	WMI	PSI	FSIQ	CPI	GAI
Visual, simple selective attention							
Omission error	0.230	0.158	0.243	0.191	0.292*	0.279*	0.241
Commission error	0.354**	0.189	0.275*	0.263	0.395**	0.348**	0.345**
Mean reaction time	-0.201	-0.164	-0.236	0.188	-0.090	-0.036	-0.242
Response time variability	0.212	0.232	0.210	0.245	0.397**	0.296*	0.276*
Auditory, simple selective attention							
Omission error	0.039	0.106	0.003	0.112	0.098	0.082	0.090
Commission error	0.256	0.219	0.168	0.328*	0.339*	0.333*	0.298*
Mean reaction time	-0.052	0.034	0.054	-0.047	0.008	-0.007	-0.008
Response time variability	0.193	0.132	0.220	0.242	0.348**	0.314*	0.214
Inhibition-sustained attention							
Omission error	0.323*	0.213	0.221	0.413**	0.419**	0.420**	0.338*
Commission error	0.343*	0.051	0.239	0.153	0.301*	0.269*	0.259
Mean reaction time	-0.093	-0.046	-0.052	0.273*	0.061	0.151	-0.094
Response time variability	0.312*	0.069	0.242	0.301*	0.348**	0.362**	0.246
Interference-selective attention							
Omission error	0.332*	0.183	0.257	0.299*	0.402**	0.365**	0.324*
Commission error	0.130	0.037	0.080	0.189	0.090	0.202	0.101
Mean reaction time	-0.107	0.063	-0.073	0.284*	0.119	0.142	-0.039
Response time variability	0.118	0.180	0.250	0.348**	0.348**	0.402**	0.179
Divided attention							
Omission error	0.090	-0.003	-0.088	0.200	0.035	0.103	0.049
Commission error	0.177	0.176	0.090	0.006	0.020	0.093	0.209
Mean reaction time	-0.244	-0.070	0.155	0.101	0.031	0.112	-0.179
Response time variability	0.159	0.111	0.410*	0.222	0.441*	0.410*	0.182
Working memory							
Forward correct response number	-0.075	0.365	0.065	-0.208	0.017	-0.096	0.168
Forward memory span	0.263	0.362	0.029	-0.049	0.226	0.026	0.386*
Backward correct respinse number	0.167	0.176	0.248	-0.121	-0.031	0.072	0.207
Backward memory span	0.130	0.164	0.198	-0.153	-0.002	0.013	0.188

*p<0.05; **p<0.01. K-WISC-IV, Korean-Wechsler Intelligence Scale of Children, fourth edition; CAT, Comprehensive attention test; VCI, Verbal Comprehension Index; PRI, Perceptual Reasoning Index; WMI, Working Memory Index; PSI, Processing Speed Index; FSIQ, Fullscale intelligence quotient; CPI, Cognitive Proficiency Index; GAI, General Ability Index

ed with the K-WISC-IV VCI, PSI, FSIQ, and CPI scores.

Regarding interference-selective attention, omission errors were positively correlated with the VCI, PSI, FSIQ, CPI, and GAI scores. Mean reaction time was positively correlated with the K-WISC-IV PSI score. Response time variability was positively correlated with K-WISC-IV PSI, FSIQ, and CPI scores.

Moreover, for divided attention, response time variability was positively correlated with the WMI, FSIQ, and CPI scores of K-WISC-IV. The visual working memory scores of CAT and WMI scores of K-WISC-IV were not correlated (Table 2).

Correlation analysis of the ARS score with CAT and K-WISC-IV scores

CAT indicators and ARS scores were not correlated. Additionally, K-WISC-IV and ARS scores were not correlated (Table 3).

DISCUSSION

Similar to previous studies [9], in this study, the K-WISC-IV subscale results showed lower PSI and WMI scores compared to other indicators. Additionally, all attention subtests in CAT, except divided attention, exhibited associations with PSI, FSIQ, and CPI scores in K-WISC-IV. Divided attention was associated with WMI, FSIQ, and CPI scores.

CAT indices, which mainly used visual stimuli, were associated with the sub-indices of K-WISC-IV, which used visual stimuli. However, they showed no association with the K-WISC-IV sub-indices that used auditory stimuli, such as

Table 3. Correlation between indexes of K-WISC-IV, CAT and ARS (n=55)

	ARS, total	ARS, odd-number	ARS, even-number
K-WISC-IV			
VCI	-0.118	-0.018	-0.181
PRI	0.165	0.083	0.196
WMI	-0.062	0.002	-0.107
PSI	0.051	0.053	0.034
FSIQ	0.058	0.070	0.029
CPI	0.011	0.059	-0.040
GAI	0.017	0.036	-0.007
CAT			
Visual, simple selective attention			
Omission error	0.009	-0.033	0.047
Commission error	-0.043	-0.027	-0.045
Mean reaction time	0.087	0.059	0.089
Response time variability	0.226	0.165	0.219
Auditory, simple selective attention			
Omission error	0.019	-0.177	0.206
Commission error	0.025	-0.011	0.054
Mean reaction time	0.055	-0.034	0.126
Response time variability	0.103	0.099	0.076
Inhibition-sustained attention			
Omission error	-0.151	-0.129	-0.128
Commission error	0.038	0.175	-0.108
Mean reaction time	0.073	-0.012	0.136
Response time variability	-0.024	0.012	-0.053
Interference-selective attention			
Omission error	-0.192	-0.101	-0.225
Commission error	0.136	0.248	-0.016
Mean reaction time	0.076	0.060	0.070
Response time variability	-0.060	0.004	-0.106
Divided attention (n=27)			
Omission error	0.117	-0.003	0.210
Commission error	-0.042	0.006	-0.081
Mean reaction time	0.283	0.288	0.218
Response time variability	0.080	0.117	0.027

K-WISC-IV, Korean-Wechsler Intelligence Scale of Children, fourth edition; CAT, Comprehensive attention test; ARS, Attention-Deficit/Hyperactivity Disorder Rating Scale; VCI, Verbal Comprehension Index; PRI, Perceptual Reasoning Index; WMI, Working Memory Index; PSI, Processing Speed Index; FSIQ, Fullscale intelligence quotient; CPI, Cognitive Proficiency Index; GAI, General Ability Index

WMI. In contrast, divided attention, which utilizes auditory stimuli, is associated with WMI. This indicated that the association between the CAT and K-WISC-IV scores varied with the type of stimulus used in the test. For example, in this study, no significant association was observed between the visual working memory of the CAT, which mainly uses visuospatial stimuli, and the WMI score of K-WISC-IV, which mainly uses auditory stimuli. This suggests that the indices evaluating the same working memory may differ depending on whether visual or auditory stimuli are used. This difference may be because different transmission systems and regions of the brain are activated to process visual and auditory stimuli [15]. This also suggests that visual and auditory working memory should be evaluated separately in cognitive tests for patients with ADHD. The results of this study support those of a previous study [9] reporting that the WMI score of WISC was strongly associated with the auditory attention test and that the PSI score was strongly associated with the visual attention test. Therefore, if differences based on the assessment method are considered in the cognitive evaluation of patients, they can be utilized for more comprehensive assessment and treatment. Reflecting on this point, K-

WISC, 5th edition adds picture memory using visual instead of arithmetic stimuli in the subtest measuring WMI. Future research investigating the characteristics of patients or differences in treatment effects based on whether visual or auditory working memory is impaired may help understand the pathophysiology of ADHD.

In particular, inhibition-sustained and interference-selective attention of CAT were strongly associated with the overall sub-indices of K-WISC-IV. This suggests that inhibition-sustained attention and interference-selective attention of CAT can best reflect the cognitive function of children with ADHD.

Moreover, the sub-indices of simple visual selective attention, inhibition-sustained attention, and interference-selective attention were associated with the VCI score. The VCI score exhibited relatively higher average scores than those other measures, such as the WMI or PSI score. Although severe language developmental delays are not frequently observed in children with ADHD, compared to typically developing children, they have a higher prevalence of language delays and expressive language problems [16]. Examining the sub-indices that showed associations with VCI in this study, only commission errors in inhibition-sustained attention exhibited a standalone association with VCI, whereas the remaining measures showed associations with WMI and PSI. Working memory impairment contributes to language difficulties in children with ADHD, causing deficits in processing speed and affecting language abilities, including reading and comprehension [17,18]. Therefore, although the language abilities of the study participants were within average levels in the current intelligence index, they may face difficulties fully utilizing their language and inference skills in more complex information-processing tasks and situations that require concentration compared to typically developing children. Understanding information-processing speed and working memory in children with ADHD can contribute to future educational and therapeutic approaches.

In this study, response time variability was associated with various subtests of K-WISC-IV for all types of attention, in contrast, to mean response time. Previous research [19] has shown that even after accounting for mean response time, children with ADHD continue to exhibit deficits in response time variability, and this characteristic is more prominent in children with ADHD than in adults with ADHD. The results regarding response time variability in this study also support the findings of a previous study [19], which reported that response time variability reflects a stable feature of ADHD and other clinical disorders.

This study had some limitations. First, the study sample was skewed toward male participants; thus, the influence of sex on the findings cannot be completely excluded. Second, although the ARS is a useful screening test, few studies have investigated whether these scores reflect symptom severity. Further studies are required to examine this association in terms of symptom severity. Additionally, structured, standardized assessment tools were not used to evaluate comorbidities in this study, which is a limitation in interpreting the findings. Finally, because the study participants were limited to children and adolescents with ADHD who had visited the hospital, the results cannot be generalized to individuals without ADHD or children and adolescents with ADHD who do not seek medical attention.

CONCLUSION

We examined the interrelationships among attention tests, intelligence tests, and parent-rated ADHD scales used to diagnose ADHD in children and adolescents in this study. Although simple visual and auditory selective attention are known to have diagnostic value in traditional CPTs, this study revealed that inhibition-sustained and interference-selective attention are also effective in evaluating ADHD. Furthermore, the correlation between attention and intelligence tests varied depending on whether visual or auditory stimuli were used. The results showed associations between the VCI scores of intelligence and attention tests and between intelligence tests and response time variability for all types of attention. These findings contribute to understanding the cognitive characteristics of children and adolescents with ADHD and can serve as a basis for further research.

Availability of Data and Material

All data generated or analyzed during the study are included in this published article.

Conflicts of Interest

The authors have no potential conflicts of interest to disclose.

Author Contributions

Conceptualization: Min-Su Jang, Joo-Han Kwon, Tae-Won Park. Data curation: Min-Su Jang, Tae-Won Park. Formal analysis: Min-Su Jang, Jong-Chul Yang. Investigation : Min-Su Jang, Sang-Keun Chung, Jong-Il Park, Tae-Won Park. Methodology: Min-Su Jang, Joo-Han Kwon, Tae-Won Park. Project administration: Tae-Won Park. Resources: Min-Su Jang, Jong-Il Park, Tae-Won Park. Software: Min-Su Jang, Tae-Won Park. Supervision: Sang-Keun Chung, Jong-Chul Yang, Jong-Il Park, Joo-Han Kwon, Tae-Won Park. Validation: Sang-Keun Chung, Jong-Chul Yang, Jong-Il Park. Visualization: Sang-Keun Chung. Writing—original draft: Min-Su Jang. Writing—review & editing: Min-Su Jang, Joo-Han Kwon, Tae-Won Park.

ORCID iDs

Min-Su Jang https://orcid.org/0009-0008-3475-3795
Sang-Keun Chung https://orcid.org/0000-0002-3488-6351

Jong-Chul Yang https://orcid.org/0000-0002-7701-2718
Jong-Il Park https://orcid.org/0000-0003-4690-397X
Joo-Han Kwon https://orcid.org/0009-0007-5831-1986
Tae-Won Park https://orcid.org/0000-0001-5980-0756

Funding Statement

None

REFERENCES

1) **Nigg JT.** Neuropsychologic theory and findings in attention-deficit/hyperactivity disorder: the state of the field and salient challenges for the coming decade. Biol Psychiatry 2005;57:1424-1435.
2) **Barkley RA.** Attention-deficit hyperactivity disorder: a handbook for diagnosis and treatment. 3rd ed. New York: Guilford Press;2006. p.297-334.
3) **Yoo HK, Lee JS, Kang SH, Park EH, Jung J, Kim BN, et al.** Standardization of the Comprehensive Attention Test for the Korean children and adolescents. J Korean Acad Child Adolesc Psychiatry 2009;20:68-75.
4) **Seo JM, Lee JS, Kim SY, Kim HW.** Diagnostic significance of Comprehensive Attention Test in children and adolescents with attention deficit hyperactivity disorder. J Korean Acad Child Adolesc Psychiatry 2011;22:246-252.
5) **Goo MJ, Oh SW, Lee SY, Paik YS, Lee JH, Hwang KS.** Cognitive characteristics of attention deficit hyperactivity disorder in Korean Wechsler Intelligence Scale for Children Fourth Edition: focused on General Ability Index and Cognitive Proficiency Index. J Korean Acad Child Adolesc Psychiatry 2016;27:313-318.
6) **Kwak KJ, Oh SW, Kim CT.** Korean Wechsler Intelligence Scale for children. 4th ed. Seoul: Hakjisa;2011.
7) **Jang SJ, Suh DS, Byun HJ.** Normative study of the K-ARS (Korean ADHD Rating Scale) for parents. J Korean Acad Child Adolesc Psychiatry 2007;18:38-48.
8) **So YK, Noh JS, Kim YS, Ko SG, Koh YJ.** The reliability and validity of Korean parent and teacher ADHD Rating Scale. J Korean Neuropsychiatr Assoc 2002;41:283-289.
9) **Koh M, Noh EA, Kim HW.** Korean Wechsler Intelligence Scale for children-fourth edition profiles in child and adolescent with attention-deficit hyperactivity disorder: retrospective study. J Korean Acad Child Adolesc Psychiatry 2015;26:183-189.
10) **American Psychiatric Association.** Diagnostic and Statistical Manual of Mental Disorders. 5th ed. Arlington, VA: American Psychiatric Association;2013.
11) **Wechsler D.** Wechsler Intelligence Scale for Children, fourth edition (WISC-IV). San Antonio, TX: Psychological Corporation;2003.
12) **Bremner D, McTaggart B, Saklofske DH, Janzen T.** WISC-IV GAI and CPI in psychoeducational assessment. Can J Sch Psychol 2011;26:209-219.
13) **Devena SE, Watkins MW.** Diagnostic utility of WISC-IV general abilities index and cognitive proficiency index difference scores among children with ADHD. J Appl Sch Psychol 2012;28:133-154.
14) **Kim JW, Park KH, Choi MJ.** Screening for attention deficit/hyperactivity disorder in community mental health services for children. J Korean Neuropsychiatr Assoc 2004;43:200-208.
15) **Lewis JW, Beauchamp MS, DeYoe EA.** A comparison of visual and auditory motion processing in human cerebral cortex. Cereb Cortex 2000;10:873-888.
16) **Ahn DH, Kim BN.** Attention-Deficit/Hyperactivity Disorder (ADHD). In: Hong KE, editor. Korean textbook of child psychiatry. Seoul: Hakjisa;2014. p.180-201.
17) **Bellani M, Moretti A, Perlini C, Brambilla P.** Language disturbances in ADHD. Epidemiol Psychiatr Sci 2011;20:311-315.
18) **Kibby MY, Vadnais SA, Jagger-Rickels AC.** Which components of processing speed are affected in ADHD subtypes? Child Neuropsychol 2019;25:964-979.
19) **Kofler MJ, Rapport MD, Sarver DE, Raiker JS, Orban SA, Friedman LM, et al.** Reaction time variability in ADHD: a meta-analytic review of 319 studies. Clin Psychol Rev 2013;33:795-811.