

Association between childhood and adult attention deficit hyperactivity disorder symptoms in Korean young adults with Internet addiction

DONGILL KIM^{1,2}, DEOKJONG LEE^{1,2}, JUNGHAN LEE^{1,2}, KEE NAMKOONG^{1,2} and YOUNG-CHUL JUNG^{1,2*}

¹Department of Psychiatry, Yonsei University College of Medicine, Seoul, South Korea

²Institute of Behavioral Science in Medicine, Yonsei University College of Medicine, Seoul, South Korea

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Background and aims: Attention deficit hyperactivity disorder (ADHD) is one of the most common psychiatric comorbidities of Internet addiction (IA); however, the possible mechanisms that contribute to this high comorbidity are still under debate. This study aims to analyze these possible mechanisms by comparing the effect of IA severity and childhood ADHD on inattention, hyperactivity, and impulsivity in young adults with IA. We hypothesized that IA might have associations with ADHD-like cognitive and behavior symptoms aside from childhood ADHD. *Methods:* Study participants consisted of 61 young male adults. Participants were administered a structured interview. The severity of IA, childhood and current ADHD symptoms, and psychiatry comorbid symptoms were assessed through self-rating scales. The associations between the severity of IA and ADHD symptoms were examined through hierarchical regression analyses. *Results:* Hierarchical regression analyses showed that the severity of IA significantly predicted most dimensions of ADHD symptoms. By contrast, childhood ADHD predicted only one dimension. *Discussion:* The high comorbidity of inattention and hyperactivity symptoms in IA should not solely be accounted by an independent ADHD disorder but should consider the possibility of cognitive symptoms related to IA. Functional and structural brain abnormalities associated with excessive and pathologic Internet usage might be related to these ADHD-like symptoms. *Conclusion:* Inattention and hyperactivity in young adults with IA are more significantly associated with the severity of IA than that of childhood ADHD.

Keywords: Internet addiction, attention deficit hyperactivity disorder, inattention, hyperactivity, impulsivity

INTRODUCTION

As the Internet accessibility and users increase, Internet addiction (IA) has become a prime concern in many areas and societies. Even though the publication of the *Diagnostic and Statistical Manual of Mental Disorder*, Fifth Edition (DSM-5) in 2013 has caused more confusion on defining IA after the adoption of Internet gaming disorder (Kuss, Griffiths, & Pontes, 2017), according to Young (1998b, 1999; Young & Rogers, 1998), IA can be defined as the excessive, obsessive-compulsive, uncontrollable, tolerance-causing use of the Internet, which also causes significant distress and impairments in daily functioning. In addition to IA itself, high psychiatric comorbidity and conditions among people with IA have attracted much attention. Ho et al. (2014) reported that IA is significantly associated with attention deficit hyperactivity disorder (ADHD), depression, and anxiety. Particularly, Carli et al. (2013) demonstrated strongest correlation between ADHD and pathological Internet use on their systematic review, and Ho et al. (2014) concluded that the prevalence of ADHD among IA patients was 21.7%. Notwithstanding this high comorbidity, and this may indicate the causal relationship or common etiology shared by them (Mueser, Drake, & Wallach, 1998), the possible mechanisms that contribute to this high comorbidity are still under debate.

ADHD is one of the most common psychiatric disorders which occurs in about 5.3% of youth including children and adolescents, and about 4.4% of adults (Kessler et al., 2006; Polanczyk, de Lima, Horta, Biederman, & Rohde, 2007). ADHD is characterized by cognitive and behavioral symptoms of inattention, hyperactivity, and impulsivity, which are associated with IA (Yen, Ko, Yen, Wu, & Yang, 2007; Yen, Yen, Chen, Tang, & Ko, 2009; Yoo et al., 2004). In addition to IA, a considerable amount of patients with ADHD are also present with one or more comorbid psychiatric conditions including mood, anxiety, and substance use, which complicate the diagnostic picture of ADHD especially for adult. (Gillberg et al., 2004; Sobanski, 2006). According to the DSM-5, ADHD is a childhood onset neurodevelopmental disorder, prior to age of 12, thus the adult ADHD represents a continuation of the childhood condition. However, Moffitt et al. (2015) presented new data challenging the assumption that the adult ADHD is a continuation of the childhood onset ADHD, and this finding suggested another possibility that two distinct childhood onset and adulthood onset ADHD might exist. Hypothesis

* Corresponding author: Young-Chul Jung, MD, PhD; Department of Psychiatry, Yonsei University College of Medicine, 50-1 Yonsei-ro, Seodaemun-gu, Seoul 03722, South Korea; Phone/Fax: +82 2 2228 1620; E-mail: eugenejung@yuhs.ac

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supporting the existence of distinct adulthood onset ADHD suggests that poor maturation of cortical control during the adolescent might lead the ADHD-like symptoms in adulthood (Castellanos, 2015; Moffitt et al., 2015) and considering IA is associated with changes in function and structure of the brain (Hong et al., 2013a, 2013b; Kuss & Griffiths, 2012; Weng et al., 2013; Yuan et al., 2011; Zhou et al., 2011), this may explain the high comorbidity between IA and ADHD.

In this study, we compared the two investigated possibilities that can explain high comorbidity between IA and ADHD. First, individuals with childhood ADHD are more vulnerable to develop IA and their childhood ADHD symptoms persist until adulthood. Second, IA might be associated with adult ADHD-like cognitive symptoms aside from childhood ADHD and other psychiatric conditions. The objective of this study was to validate these two possibilities; therefore, we compared the effect of IA severity and childhood ADHD symptoms on adult ADHD symptoms in young adults with IA. We hypothesized that the level of IA would be positively associated with the severity of adult ADHD symptoms even after controlling the childhood ADHD and other psychiatric conditions.

METHODS

Participants and procedure

Participants were 61 men of age from 20 to 29 years old (mean age: 23.61 ± 2.34 years old), recruited from online advertising. Participants were asked whether they had psychiatric medication on a regular basis, whether they had medical, neurological disorders that might affect the experiment, and whether they had experienced previous head trauma or seizures. Participants were administered Structured Clinical Interview for the DSM, Fourth Edition and Korean Wechsler Adult Intelligence Scale, Fourth Edition by a clinical research psychologist to exclude those who met criteria for a lifetime Axis I psychiatric diagnosis and intellectual disabilities, except childhood and adult ADHD. Through this process, participants with current or past psychiatric disorders, traumatic brain injury, medical, and neurological illness were excluded.

Psychometric self-reports were used to assess the participants' behavioral and personality features, including the Korean Adolescent Internet Addiction Scale (K-AIAS), Beck Depression Inventory (BDI), Beck Anxiety Inventory (BAI), Barratt Impulsiveness Scale-11 (BIS-11), and Korean version of Alcohol Use Disorders Identification Test (AUDIT-K). We evaluated the severity of childhood and adult ADHD symptoms through Korean Short version of Wender Utah ADHD Rating Scale (WURS-KS) and Korean Short version of Conners' Adult ADHD Rating Scale (CAARS-KS).

Measures

Internet addiction severity. We used the K-AIAS to evaluate the severity of IA symptoms. The K-AIAS is a Korean translation of the Young's Internet Addiction Test (YIAT),

except for a few words to fit the situation of high-school students. The structure and components of the K-AIAS and YIAT are identical, 6-level Likert scale to 20 questions. A total score of 20–49 points represents the average Internet user, and a score of 50–79 points represents users who are often experiencing problems with the Internet usage. A score of 80–100 points indicates that the participants are experiencing significant difficulties in the life due to the use of the Internet. The K-AIAS has satisfactory reliability and validity and the Cronbach's α was .91 (Kim, Lee, & Oh, 2003; Young, 1998a).

Depression and anxiety. Depressive and anxiety symptoms were evaluated using the BDI (Korean version) and BAI (Korean version), respectively. BDI and BAI are composed of 21 items, and the patients rate each symptom on a 4-point Likert scale in an increasing severity. In BDI, following severity levels are suggested: scores between 0 and 13 indicate minimal, between 14 and 19 mild, between 20 and 28 moderate, and between 29 and 63 severe depression. In BAI, following severity levels are suggested: scores between 0 and 7 indicate no anxiety, between 8 and 15 mild, between 16 and 25 moderate, and between 26 and 63 severe anxiety. Both scales have been validated on Korean populations. The Cronbach's α was ranged from .78 to .85 for BDI and .91 for BAI (Beck & Steer, 1990; Beck, Steer, & Brown, 1996; Beck, Ward, Mendelson, Mock, & Erbaugh, 1961; Lee & Song, 1991; Yook & Kim, 1997).

Impulsivity. Impulsiveness symptom was evaluated using the Korean version of the BIS-11. The BIS-11 is one of the most often used tools to assess impulsivity. The original BIS-11 is composed of 30 items scored on a 4-point Likert scale and a level of impulsivity is measured by summing up the scores for each item. The higher score means more severe impulsiveness. It assesses the three main dimensions of impulsive behavior: attentional impulsiveness (a lack of focus on the ongoing task), motor impulsiveness (acting without thinking), and non-planning impulsiveness (items, orientation to the present rather than to the future). The Korean version of the BIS-11 consists of 23 items, so the number of items that measure each dimension is different, but the rest is the same. Heo et al. proved the reliability and validity of Korean version of BIS-11 in their study, and the Cronbach's α of the scale was .686 (Heo, Oh, & Kim, 2012; Patton, Stanford, & Barratt, 1995).

Alcohol use and related symptoms. We used the AUDIT-K to assess the participants' severity of alcohol use and related symptoms. AUDIT-K consists of 10 items; each question is scored from 0 to 4. Questions 1–3 evaluate participants' alcohol consumption, questions 4–6 examine abnormal drinking behavior, questions 7 and 8 assess adverse psychological reactions, and questions 9 and 10 evaluate alcohol-related problems. In the study with college students, Fleming et al. suggested the cut-off value of 8. Lee et al. proved the reliability and validity of AUDIT-K in their study and the Cronbach's α of the scale was .92 (Babor, De La Fuente, Saunders, & Grant, 1992; Fleming, Barry, & MacDonald, 1991; Lee, Lee, Lee, Choi, & Namkoong, 2000).

Childhood ADHD symptoms. We used a short version of WURS-KS, which was translated into Korean by Koo et al. to assess the childhood ADHD symptoms.

The WURS is a self-report questionnaire for the retrospective assessment of childhood ADHD symptoms in adults for ADHD. The original WURS was composed of 61 items, but in this study, the short version consisting of 25 items was used. The original version of WURS correctly identified 86% of patients with ADHD, and the short version of it also demonstrated high sensitivity and specificity to provide the diagnosis of childhood ADHD when 36 points were applied as cut-off value. The validity and reliability analysis of Korean short version of WURS was performed with normal female Korean adults and demonstrated satisfactory reliability and validity. The Cronbach's α was .93 (Koo et al., 2009; Ward, Wender, & Reimherr, 1993).

Adult ADHD symptoms. CAARS-KS was used to evaluate the adult ADHD symptoms in this study. The CAARS is one of the most widely used self-report questionnaire scales assessing adult ADHD symptoms, and we used its Korean short version, consisting of 20 items and four subscales: inattention–memory problems (IM), hyperactivity–restlessness (HR), impulsivity/emotional lability (IE), problems with self-concept (SC). It is known that T scores above 65 are clinically significant for each subscale. The reliability and validity of the CAARS-KS were established and the Cronbach's α was .92 (Chang, 2008; Conners, Erhardt, & Sparrow, 1999; Erhardt, Epstein, Conners, Parker, & Sitarenios, 1999).

Statistical analysis

Data analysis was performed using SPSS 21.0 statistical software (SPSS Inc., Chicago, IL, USA). First, to examine the correlations between IA, childhood ADHD symptoms, adult ADHD symptoms, depression, anxiety, impulsiveness, alcohol use, and related symptoms, we used the Pearson's correlations. Later, hierarchical multiple regression analysis was used to examine the individual association between the severity of IAs and the severity of adult ADHD symptoms. In every regression model, the effect of other psychiatric conditions including childhood ADHD symptoms was controlled. A two-tailed p value of less than .05 was considered statistically significant.

Ethics

This study was carried out under the guidelines for the use of human participants established by the Institutional Review Board at Yonsei University. The Institutional Review Board of the Yonsei University approved the study. Following a complete description of the scope of the study to all participants, written informed consent was obtained.

RESULTS

Participants in this study were all males and their demographic and clinical characteristics are indicated in Table 1. The average K-AIAS score of the participants was 51.16 ($SD = 20.263$) points. In this study, there were 35 participants (57%) who exceeded 50 points, which is a criterion for mild Internet addiction. According to the structural

Table 1. Demographic and clinical characteristics of study sample ($N = 61$)

Age, median	23.61 \pm 2.340
Verbal IQ	102.62 \pm 12.636
Performance IQ	102.62 \pm 17.431
K-AIAS	51.16 \pm 20.263
WURS-KS	35.97 \pm 21.182
AUDIT-K	10.39 \pm 7.142
BDI	12.34 \pm 7.780
BAI	10.74 \pm 8.858
BIS-11	58.95 \pm 10.681
Cognitive impulsiveness	17.10 \pm 3.064
Motor impulsiveness	18.44 \pm 5.166
Non-planning impulsiveness	23.36 \pm 4.390
CAARS-KS	
Inattention/memory problems	53.15 \pm 7.916
Hyperactivity/restless	51.03 \pm 6.950
Impulsivity/emotional lability	53.02 \pm 7.544
Problems with self-concept	69.43 \pm 11.869

Note. Verbal intelligence quotient (IQ) and performance IQ were assessed with Korean Wechsler Adult Intelligence Scale, Fourth Edition (K-WAIS-IV). K-AIAS: Korean Adolescent Internet Addiction Scale; WURS-KS: Korean Short version of Wender Utah Rating Scale; AUDIT-K: Korean version of Alcohol Use Disorder Identification Test; BDI: Beck Depression Inventory; BAI: Beck Anxiety Inventory; BIS-11: Barratt Impulsiveness Scale-11; CAARS-KS: Korean Short version of Conner's Adult ADHD Rating Scale.

interview and CAARS-KS, only two participants (3%) met the clinical criteria of adult ADHD.

The results of correlation analysis are shown in Table 2. According to the results, all subscale scores of the adult ADHD symptoms showed significant correlations with IA, childhood ADHD, AUDIT-K scores, depression, and anxiety symptoms. On the other hands, impulsiveness symptom on BIS-11 did not significantly correlate with adult ADHD symptom dimensions, except SC dimension. As most of the psychiatric conditions showed significant correlations with adult ADHD symptoms, we used hierarchical multiple regression analysis to examine the individual associations between IA and each adult ADHD symptom dimension in three regression models.

The results of multiple regression analysis are shown in Table 3. Every adult ADHD symptom dimension measured by CAARS-KS is analyzed respectively. In Table 3, IM dimension is indicated. The results of model 1 ($F = 11.485$, $p < .001$) revealed that more severe depression symptom on the BDI was significantly associated with more severe IM symptom. Childhood ADHD symptom on the WURS-KS was then added to model 2 ($F = 10.400$, $p < .001$) and revealed that childhood ADHD symptom was not significantly associated the severity of IM. In model 3 ($F = 10.858$, $p < .001$), IA severity on the K-AIAS was added and the results showed that the more severe IA was associated with the more severe IM.

The result of HR dimension analysis is demonstrated in Table 3. In model 1 ($F = 14.867$, $p < .001$), more severe anxiety and alcohol-related symptoms on the BAI and AUDIT-K were significantly associated with more severe HR symptom. In model 2 ($F = 12.784$, $p < .001$), childhood

Table 2. Correlations between scale scores

	2	3	4	5	6	7	8	9	10	11	12	13
1. K-AIAS	0.485**	0.268*	0.518**	0.477**	0.334**	0.108	0.305*	0.361**	0.585**	0.579**	0.601**	0.568**
2. WURS-KS	-	0.312*	0.456**	0.648**	0.388**	0.110	0.446**	0.328**	0.507**	0.550**	0.572**	0.500**
3. AUDIT-K	-	-	0.262*	0.392**	0.182	-0.085	0.199	0.261*	0.314*	0.520**	0.412**	0.298*
4. BDI	-	-	-	0.712**	0.203	0.051	0.259*	0.133	0.634**	0.498**	0.531**	0.699**
5. BAI	-	-	-	-	0.209	-0.029	0.376**	0.079	0.586**	0.657**	0.630**	0.579**
6. BIS-11	-	-	-	-	-	0.789**	0.872**	0.845**	0.117	0.169	0.177	0.267*
7. BIS-Cog	-	-	-	-	-	-	0.546**	0.570**	-0.012	-0.040	0.000	0.107
8. BIS-Motor	-	-	-	-	-	-	-	0.555**	0.142	0.209	0.182	0.257*
9. BIS-Non	-	-	-	-	-	-	-	-	0.115	0.191	0.212	0.257*
10. C-IM	-	-	-	-	-	-	-	-	-	0.668**	0.718**	0.697**
11. C-HR	-	-	-	-	-	-	-	-	-	-	0.741**	0.599**
12. C-IE	-	-	-	-	-	-	-	-	-	-	-	0.589**
13. C-SC	-	-	-	-	-	-	-	-	-	-	-	-

Note. K-AIAS: Korean Adolescent Internet Addiction Scale; WURS-KS: Korean Short version of Wender Utah Rating Scale; AUDIT-K: Korean version of Alcohol Use Disorder Identification Test; BDI: Beck Depression Inventory; BAI: Beck Anxiety Inventory; BIS-11: Barratt Impulsiveness Scale-11; BIS-Cog: Barratt Impulsiveness Scale – cognitive impulsiveness; BIS-Motor: Barratt Impulsiveness Scale – motor impulsiveness; BIS-Non: Barratt Impulsiveness Scale – non-planning impulsiveness; CAARS-KS: Korean Short version of Conner’s Adult ADHD Rating Scale; C-IM: Conner’s Adult ADHD Rating Scale – inattention/memory problems; C-HR: Conner’s Adult ADHD Rating Scale – hyperactivity/restless; C-IE: Conner’s Adult ADHD Rating Scale – impulsivity/emotional lability; C-SC: Conner’s Adult ADHD Rating Scale – problems with self-concept.

* $p < .05$. ** $p < .01$.

ADHD symptom on the WURS-KS was added and showed no significant association with HR symptom dimension of adult ADHD symptoms. IA symptom on the K-AIAS was then added in model 3 ($F = 13.708, p < .001$), and the results showed that the more severe IA was significantly associated with the more severe HR.

The result of IE dimension is demonstrated in Table 3. The results of model 1 ($F = 11.194, p < .001$) indicated that more severe anxiety symptom on BAI was significantly associated with more severe IE symptom. Childhood ADHD symptom on the WURS-KS was then added to model 2 ($F = 10.473, p < .001$) and indicated that more severe childhood ADHD symptom was associated with more severe IE. In model 3 ($F = 11.528, p < .001$), IA severity on the K-AIAS was added, and demonstrated significant association between IA and IE.

The result of SC dimension is shown in Table 3. In model 1 ($F = 15.259, p < .001$), depression symptom on the BDI showed a significant association with SC symptom. In model 2 ($F = 12.870, p < .001$) and model 3 ($F = 11.846, p < .001$), childhood ADHD symptom and IA severity on WURS-KS and K-AIAS were added, respectively, but showed no significant association with the SC.

DISCUSSION

In this study, most of participants, 35 participants (57%), were classified to have IA when applying the Young’s criteria defining score 50 as mild IA (Hardie & Tee, 2007; Young, 1998b). Also, the average score of K-AIAS was high (mean score = 51.2, $SD = 20.3$), in comparison with the other psychiatric conditions like BDI, BAI, BIS-11, AUDIT-K, and WURS-KS.

Consistent with the previous studies (Dalbudak & Evren, 2014; Yen et al., 2009, 2017; Yoo et al., 2004), we found significant associations between the severity of IA and the severity of ADHD symptoms. Similarly, other psychiatric comorbid conditions like depression, anxiety, and alcohol-related symptoms also showed significant correlations with the adult ADHD symptoms in line with the previous studies (Fischer et al., 2007; Kessler et al., 2006; Ni & Gau, 2015; Sobanski et al., 2007).

The main finding of this study, which is also consistent with our hypothesis, was that the severity of IA was significantly associated with the level of most dimensions of adult ADHD symptoms even after controlling the childhood ADHD symptom and other psychiatric comorbid conditions. Only SC dimension, which presenting low self-regard and deficit in self-confidence, did not show the significant association with IA severity. This result can be explained by several studies by Chang (2008) and Kim, Lee, Cho, Lee, and Kim (2005), which indicated SC symptom dimension in CAARS-KS as an additional scale evaluating secondary problems caused by core symptoms of ADHD like hyperactivity, inattention, and impulsivity. In this study, only severity of depression symptom significantly predicted the level of SC symptom dimension. Considering these findings, it might be concluded that the severity of IA significantly predicted all core symptom dimensions of adult ADHD.

Table 3. Hierarchical linear regression model when difference scores of Conner’s Adult ADHD Rating Scale were taken as dependent variables

		Unstandardized coefficients		Standardized coefficient		
		<i>B</i>	Standard error	β	<i>t</i>	<i>p</i>
<i>Inattention/memory problems</i>						
Model 1 ^a	BDI	0.456	0.144	.448	3.166	.003**
	BAI	0.207	0.132	.232	1.563	.124
	AUDIT-K	0.126	0.120	.114	1.051	.298
	BIS-11	-0.032	0.076	-.043	-0.424	.673
Model 2 ^b	BDI	0.466	0.141	.458	3.313	.002**
	BAI	0.065	0.149	.073	0.437	.664
	AUDIT-K	0.115	0.117	.104	0.982	.330
	BIS-11	-0.083	0.078	-.112	-1.060	.294
Model 3 ^c	WURS-KS	0.098	0.050	.263	1.944	.057
	BDI	0.355	0.140	.349	2.545	.014*
	BAI	0.060	0.141	.067	0.425	.672
	AUDIT-K	0.092	0.112	.083	0.821	.415
	BIS-11	-0.119	0.076	-.161	-1.579	.120
	WURS-KS	0.071	0.049	.191	1.457	.151
	YIAT	0.122	0.045	.311	2.691	.009**
<i>Hyperactivity/restless</i>						
Model 1 ^d	BDI	0.065	0.119	.072	0.543	.589
	BAI	0.380	0.109	.484	3.474	.001**
	AUDIT-K	0.303	0.099	.312	3.060	.003**
	BIS-11	-0.002	0.063	-.003	-0.033	.974
Model 2 ^e	BDI	0.072	0.117	.080	0.612	.543
	BAI	0.280	0.124	.357	2.265	.027*
	AUDIT-K	0.296	0.098	.304	3.023	.004**
	BIS-11	-0.038	0.065	-.058	-0.579	.565
Model 3 ^f	WURS-KS	0.069	0.042	.210	1.635	.108
	BDI	-0.030	0.115	-.033	-0.261	.795
	BAI	0.275	0.116	.351	2.384	.021*
	AUDIT-K	0.274	0.092	.281	2.989	.004**
	BIS-11	-0.071	0.062	-.109	-1.143	.258
	WURS-KS	0.044	0.040	.134	1.098	.277
	YIAT	0.111	0.037	.325	3.003	.004**
<i>Impulsivity/emotional lability</i>						
Model 1 ^g	BDI	0.166	0.138	.171	1.201	.235
	BAI	0.365	0.127	.428	2.872	.006**
	AUDIT-K	0.207	0.115	.196	1.797	.078
	BIS-11	0.012	0.073	.017	0.169	.866
Model 2 ^h	BDI	0.177	0.134	.182	1.319	.193
	BAI	0.215	0.141	.252	1.519	.134
	AUDIT-K	0.195	0.112	.185	1.749	.086
	BIS-11	-0.042	0.075	-.059	-0.558	.579
Model 3 ⁱ	WURS-KS	0.104	0.048	.291	2.159	.035*
	BDI	0.060	0.131	.062	0.459	.648
	BAI	0.209	0.132	.246	1.586	.118
	AUDIT-K	0.170	0.105	.161	1.630	.109
	BIS-11	-0.080	0.071	-.113	-1.124	.266
	WURS-KS	0.075	0.046	.212	1.645	.106
	YIAT	0.128	0.042	.343	3.016	.004**
<i>Problems with self-concept</i>						
Model 1 ^j	BDI	0.873	0.202	.572	4.330	<.001**
	BAI	0.156	0.185	.116	0.841	.404
	AUDIT-K	0.136	0.168	.082	0.810	.421
	BIS-11	0.124	0.106	.112	1.172	0.246
Model 2 ^k	BDI	0.884	0.200	.579	4.424	<.001**
	BAI	0.005	0.211	.004	0.025	.980
	AUDIT-K	0.125	0.167	.075	0.748	.458

(Continued)

Table 3. (Continued)

	Unstandardized coefficients		Standardized coefficient			
	B	Standard error	β	t	p	
Model 3 ¹	BIS-11	0.070	0.111	.063	0.629	.532
	WURS-KS	0.104	0.072	.186	1.452	.152
	BDI	0.768	0.204	.504	3.763	<.001**
	BAI	<0.001	0.206	.000	0.000	.999
	AUDIT-K	0.100	0.163	.060	0.613	.543
	BIS-11	0.033	0.111	.029	0.295	.769
	WURS-KS	0.076	0.072	.136	1.064	.292
	YIAT	0.126	0.066	.215	1.907	.062

Note. BDI: Beck Depression Inventory; BAI: Beck Anxiety Inventory; BIS-11: Barratt Impulsiveness Scale-11; AUDIT-K: Korean version of Alcohol Use Disorder Identification Test; WURS-KS: Korean Short version of Wender Utah Rating Scale; YIAT: Korean version of Young's Internet Addiction Test.

^aVariables entered in the first step: BDI, BAI, AUDIT-K, BIS-11; $F = 11.485$; $df = 4, 56$; $p < .001$; adjusted $R^2 = 0.411$.

^bVariables entered in the second step: WURS-KS; $F = 10.400$; $df = 5, 55$; $p < .001$; adjusted $R^2 = 0.439$; R^2 change = 0.035.

^cVariables entered in the third step: YIAT; $F = 10.858$; $df = 6, 54$; $p < .001$; adjusted $R^2 = 0.496$; R^2 change = 0.061.

^dVariables entered in the first step: BDI, BAI, AUDIT-K, BIS-11; $F = 14.867$; $df = 4, 56$; $p < .001$; adjusted $R^2 = 0.480$.

^eVariables entered in the second step: WURS-KS; $F = 12.784$; $df = 5, 55$; $p < .001$; adjusted $R^2 = 0.495$; R^2 change = 0.022.

^fVariables entered in the third step: YIAT; $F = 13.708$; $df = 6, 54$; $p < .001$; adjusted $R^2 = 0.560$; R^2 change = 0.066.

^gVariables entered in the first step: BDI, BAI, AUDIT-K, BIS-11; $F = 11.194$; $df = 4, 56$; $p < .001$; adjusted $R^2 = 0.405$.

^hVariables entered in the second step: WURS-KS; $F = 10.473$; $df = 5, 55$; $p < .001$; adjusted $R^2 = 0.441$; R^2 change = 0.043.

ⁱVariables entered in the third step: YIAT; $F = 11.528$; $df = 6, 54$; $p < .001$; adjusted $R^2 = 0.513$; R^2 change = 0.074.

^jVariables entered in the first step: BDI, BAI, AUDIT-KS, BIS-11; $F = 15.259$; $df = 4, 56$; $p < .001$; adjusted $R^2 = 0.487$.

^kVariables entered in the second step: WURS-KS; $F = 12.870$; $df = 5, 55$; $p < .001$; adjusted $R^2 = 0.497$; R^2 change = 0.018.

^lVariables entered in the third step: YIAT; $F = 11.846$; $df = 6, 54$; $p < .001$; adjusted $R^2 = 0.520$; R^2 change = 0.029.

* $p < .05$. ** $p < .01$.

Another interesting finding was that, unlike the common belief, the severity of childhood ADHD symptom did not show significant associations with most dimensions of adult ADHD symptoms. Only IE dimension demonstrated significant association with childhood ADHD symptom in regression analysis model 2 (see Table 3). However, this significant association of childhood ADHD symptom with IE disappeared after IA severity was included into regression model, indicating that IA severity had more significant association with IE than did childhood ADHD.

Current findings in this study may shed light on the relationship between severity and ADHD. Either two possibilities explaining high comorbidity between IA and ADHD, our results supported the hypothesis indicating the existence of distinct adulthood onset ADHD-like symptoms. Contrary to the conventional concept of adult ADHD regarding as continuation of childhood

ADHD condition (Halperin, Trampush, Miller, Marks, & Newcorn, 2008; Lara et al., 2009), recent findings indicated that two distinct childhood onset and adulthood onset ADHD might exist and adult ADHD is not a simple continuation of childhood ADHD (Castellanos, 2015; Moffitt et al., 2015). In line with these findings, this study indicated that the current ADHD symptoms showed more significant associations with IA than the childhood ADHD symptom on WURS. Moreover, childhood ADHD symptom severity itself did not demonstrate significant correlations with core adult ADHD symptom except IE dimension in this study.

Previous studies indicated that the adult ADHD status is linked with the developmental trajectories of cortical components, and white matter alterations of several networks (Cortese et al., 2013; Karama & Evans, 2013; Shaw et al., 2013). Similarly, recent studies have demonstrated that IA might cause functional, structural changes, and

abnormalities in brain (Hong et al., 2013a, 2013b; Kuss & Griffiths, 2012; Lin et al., 2012; Weng et al., 2013; Yuan et al., 2011; Zhou et al., 2011). Based on these findings, we might speculate that functional and structural brain abnormalities related to IA might also be related to adult ADHD-like cognitive symptoms, which should be differentiated from an independent ADHD disorder. The high comorbidity between IA and ADHD (Ho et al., 2014) might be accounted by cognitive and behavior symptoms related to IA rather than symptoms of an independent ADHD disorder.

This study had some limitations. First of all, use of self-rating scales to evaluate IA and other psychiatric conditions can be considered as a limitation. Second, all participants were young adult males with no psychiatric history who recruited from online advertisements. This kind of self-selected convenience sampling method might have biased the findings of the study. In addition, this restricted participant selection limits the extent of generalizability of the findings in the study, making it not possible to generalize to the females, different age groups, and patients who need clinical interventions. Especially, since the psychiatric symptoms of the participants who have no psychiatric history were evaluated, it is considered that there is a limit to apply the results of this study to clinical psychiatric patients. To generalize the present results, we need to study more representative sample of the population and actual psychiatric patients. Third, as this study was based on retrospective recall of childhood symptoms, participants' report of childhood symptoms could not be validated and we could not establish causal relationships among variables.

CONCLUSIONS

Inattention and hyperactivity symptoms in young adults with IA are more significantly associated with the severity of IA than that of childhood ADHD. This study may suggest better understanding on the possible mechanism of the high comorbidity between IA and ADHD in young adults.

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