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Beyond Attention-Deficit Hyperactivity Disorder: Exploring Psychiatric Comorbidities and Their Neuropsychological Consequences in Adults

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Objectives: This study aimed to identify the psychiatric comorbidity status of adult patients diagnosed with attention-deficit hyperactivity disorder (ADHD) and determine the impact of comorbidities on neuropsychological outcomes in ADHD.
Methods: The study participants were 124 adult patients with ADHD. Clinical psychiatric assessments were performed by two board-certified psychiatrists in accordance with the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition. All participants were assessed using the Mini-International Neuropsychiatric Interview Plus version 5.0.0 to evaluate comorbidities. After screening, neuropsychological outcomes were assessed using the Comprehensive Attention Test (CAT) and the Korean version of the Wechsler Adult Intelligence Scale, Fourth Edition (K-WAIS-IV).
Results: Mood disorders (38.7%) were the most common comorbidity of ADHD, followed by anxiety (18.5%) and substance use disorders (13.7%). The ADHD with comorbidities group showed worse results on the Perceptual Organization Index and Working Memory Index sections of the K-WAIS than the ADHD-alone group (p=0.015 and p=0.024, respectively). In addition, the presence of comorbidities was associated with worse performance on simple visual commission errors in the CAT tests (p=0.024).
Conclusion: These findings suggest that psychiatric comorbidities are associated with poor neuropsychological outcomes in adult patients with ADHD, highlighting the need to identify comorbidities in these patients.

Keywords: ADHD; Adult; Comorbidity; Wechsler Adult Intelligence Scale-Revised; Continuous performance task; Working memory.

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INTRODUCTION

Attention-deficit hyperactivity disorder (ADHD) is one of the most common neurodevelopmental disorders and is classified as a psychiatric disorder. ADHD is characterized by improper development of inattention and/or impulsivity and hyperactivity levels during development [1]. ADHD was initially studied in pediatric populations, with the first clinical diagnosis made in the 1930s [2]. When the concept of ADHD was first introduced, it was considered as a childhood disorder [3]. However, longitudinal studies have shown that symp-

toms persist into adulthood [3], resulting in increased interest in studying the clinical presentation of ADHD in the adult population. ADHD is a pervasive and chronic disorder, with nearly two-thirds (65%) of children diagnosed with ADHD reporting persistence of symptoms into adulthood [4,5]. Adults with ADHD are affected by ADHD symptoms in many areas of life, such as family conditions, education, and employment, and have higher rates of accidents and forensic and criminal issues [6]. One study reported that adults with ADHD experienced average annual income losses between $8900 and $15400 [7]. In addition, adult patients with ADHD have psychiatric comorbidity rates as high as 80% [8]. Moreover, the rate of comorbid psychiatric disorders in adults with ADHD tends to increase with age [9], indicating the need for extensive research on adult ADHD. Substance use, mood, and anxiety disorders are the most prevalent comorbidities, with personality disorders and learning difficulties also being commonly reported [10,11]. According to a Korean guideline development study [12], approximately 38.3% of adult patients with ADHD have a mood disorder as a comorbidity, and approximately 20% have bipolar disorder. The prevalence of anxiety disorders ranges from 23% to 47.1%, with generalized anxiety disorder being the most common type of anxiety disorder [12].

Several studies have focused on genetic and neurological theories underlying ADHD [3]. Despite several ongoing studies, the exact pathogenesis of ADHD remains unclear. However, the most prominent attention deficits are generally associated with frontal-subcortical dysfunction, which is linked to executive function [13,14]. In addition to these research trends, research on topics related to the analysis of neuropsychological outcomes in ADHD has gained interest [3,14,15] because they can characterize the manifestations of functional impairment in adult ADHD. One study that compared the neuropsychological profiles of two groups of adults with and without ADHD using the Wechsler Adult Intelligence Scale-IV (WAIS-IV) found that the ADHD group showed significant reductions in working memory and processing speed subtest scores [15].

However, despite the high prevalence of psychiatric comorbidities in the population with ADHD, research on the influence of comorbidities in the ADHD population is lacking in several areas, such as differences in neuropsychological outcomes and prognosis in patients with psychiatric comorbidities. Therefore, this study aimed to identify the psychiatric comorbidity status of patients diagnosed with ADHD to improve our understanding of the epidemiology of ADHD in South Korea and determine the influence of comorbidities on neuropsychological outcomes in adults diagnosed with ADHD.

METHODS

Participants and procedures

All participants were enrolled from the outpatient departments of eight university medical centers (Kyung Hee University Hospital, Inje University Sanggye Paik Hospital, Ewha Womans University Hospital, Chung-Ang University Hospital, Soonchunhyang Bucheon Hospital, Nowon Eulji Hospital, Samsung Seoul Hospital, and Myongji Hospital) between January 2017 and December 2018. Individuals who agreed to participate in the study provided written consent after being adequately informed of the research. The study's inclusion criteria were individuals who were referred for an assessment of ADHD, aged between 17 and 65 years. Individuals with congenital genetic disorders, organic brain diseases, or severe physical conditions necessitating medical management (e.g., renal failure, liver disease, and cancer) were excluded. Additionally, those with a history of schizophrenia, bipolar I disorder, and other psychotic disorders within the past six months, as well as individuals with autism spectrum disorder and intellectual disability, were excluded from the study.

Two board-certified psychiatrists performed clinical psychiatric assessments in accordance with the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5). All study participants underwent evaluation using the Mini-International Neuropsychiatric Interview (MINI) Plus version 5.0.0 (MINI-Plus V.5.0.0) to assess the presence of comorbidities. Additionally, they were given the Adult ADHD Self-Report Scale Symptoms Checklist version 1.1 (ASRS-V1.1) to assess their ADHD-related symptoms. A total of 135 individuals diagnosed with ADHD were recruited from eight hospitals and included in the study; however, 11 individuals diagnosed with ADHD were excluded because they did not complete the MINI-Plus V.5.0.0. Thus, 124 individuals with ADHD were included in the analysis. The Comprehensive Attention Test (CAT) was used to evaluate attentional skills, and the Korean version of the WAIS-IV (K-WAIS-IV), was administered to assess intelligence levels in all participants. These assessments have been previously described in detail [16-18].

MINI-Plus V5.0.0 structured interview

The MINI is a concise and structured diagnostic interview designed for the DSM, Fourth Edition, Text Revision and International Classification of Diseases-10 criteria. It was collaboratively developed by mental health professionals in the United States and Europe. It is used to assess the current DSM-IV Axis I psychiatric morbidities [19].

Korean version of ASRS and Korean version of the Adult ADHD Rating Scale

ASRS-V1.1 is an 18-item self-reported scale rooted in the symptom criteria of the DSM-IV [19]. The ASRS was developed by the Workgroup for Adult ADHD in conjunction with the World Health Organization. The validity of the Korean version of the ASRS (K-ASRS) was established in a preceding study [20]. The comprehensive score on this scale ranges from 0 to 72. The Adult ADHD Rating Scale (AARS), which consists of 18 items, is designed for use with children and adolescents, and its Korean version (K-AARS) was validated, demonstrating commendable reliability [21].

K-WAIS-IV

WAIS-IV is the benchmark for the comprehensive evaluation of cognitive function in the adult population. In addition to the full-scale intelligence quotient (FSIQ), which offers an estimate of overall intellectual capacity, the discrete indices below serve as discerning indicators of cognitive challenges and exhibit distinct correlations with clinical characteristics [22]: the verbal comprehension index (VCI), perceptual organization index (POI), working memory index (WMI), and processing speed index. K-WAIS-IV has undergone prior validation [23].

Computerized CAT

CAT necessitates approximately 40–45 min for completion and encompasses evaluations of various attentional facets, including simple selective attention (both visual and auditory), continuous inhibition, interference selection, divided attention, and working memory assessments [20]. All subtests were conducted via computer administration. At the initiation of each subtest, the participants were provided with both voice and text instructions, which were subsequently verified by trained researchers to ensure comprehension.

Statistical analysis

All data analyses were performed using IBM SPSS software (version 21.0; IBM Corp., Armonk, NY, USA). Group comparisons for categorical variables were assessed using Pearson's χ^2 test, whereas mean disparities in continuous variables were examined using the independent-sample t-test. The analysis of variance (ANOVA) test was performed to compare the means of the different groups. According to the ANOVA results, post hoc analyses were performed to check for specific differences between groups and correct for multiple comparisons. For post hoc tests, a Scheffe's test was used. Statistical significance was set at $p<0.05$.

Research ethics

The research protocol was approved by the Institutional Review Boards of the respective institutes from where the participant were recruited: Kyung Hee University Hospital (KMCIRB 2017-02-054), Sanggye Paik Hospital (SGPAIK-2017-05-012-005), Ewha Womans University Hospital (EUMC 2017-01-013), Chung-Ang University Hospital (IRB No. 1741-005-279), Soonchunhyang University Hospital (SCHBC 2016-11-012-006), Eulji University Hospital (EMCS 2016-07-001), Sungkyunkwan University Samsung Medical Center (SMC 2016-07-061), and Myongji Hospital (MJH 2017-07-013-001). All participants provided written informed consent prior to participation. Certain data concerning the participants in this study have been previously published [16-18].

This study adhered to the ethical principles outlined in the Declaration of Helsinki II, with a strong emphasis on upholding standards related to informed consent, voluntary participation, and preserving anonymity.

RESULTS

Demographic and sociological characteristics of the participants

In total, 124 individuals with ADHD were recruited for this study. The demographic and sociological characteristics of the participants are presented in Table 1. The study population comprised of 85 males (68.5%) and 39 females (31.5%). The average patient age was 27.21 years (standard deviation [SD]=9.21 years). In terms of educational level, the largest group was the high school group (n=77, 62.1%). In terms of employment status, 37 (29.8%) participants were students, 56 (45.2%) were employed, and 31 (25.0%) were unemployed.

Psychiatric comorbidities in patients with adult ADHD

The psychiatric comorbidities in patients with adult ADHD is presented in Table 1. Fifty-one patients (41.1%) were diagnosed with ADHD alone, whereas 73 patients (58.9%) were diagnosed with ADHD and other psychiatric comorbidities. The most common comorbidities were mood disorders (n=48; 38.7%), anxiety disorders (n=23; 18.5%), and substance abuse disorders (n=17; 13.7%). The number of psychiatric comorbidities in patients with adult ADHD is shown in Table 1. Among the patients with comorbidities (n=73), approximately 37% (n=27) had two or more comorbidities.

Comparison of ASRS and AARS scores, intelligence quotient, and CAT scores between adult ADHD patients with and without comorbidities

The results of the statistical analyses are presented in Table 2.

Table 1. Demographic characteristics and psychiatric comorbidities of the participants

Adult ADHD	Value (n=124)
Age (yr)	27.21±9.21
Sex, male	85 (68.5)
Education	
Middle school or less	5 (4.0)
High school	77 (62.1)
College or university	30 (24.2)
Graduate school	12 (9.7)
Employment	
Job	56 (45.2)
No job	31 (25.0)
Student	37 (29.8)
Only ADHD	51 (41.1)
With comorbidities	73 (58.9)
n=1	46 (37.1)
n=2	18 (14.5)
n≥3	9 (7.3)
Mood disorder	48 (38.7)
Anxiety disorder	23 (18.5)
Substance use disorder	17 (13.7)
OCD	8 (6.4)
Bulimia nervosa	4 (3.0)
Personality disorder	4 (3.0)
PTSD	2 (1.6)
Tic disorder	1 (0.8)
Somatic disorder	1 (0.8)
Suicidality	11 (8.9)

Values are presented as mean±standard deviation or number (%). ADHD, attention-deficit hyperactivity disorder; OCD, obsessive-compulsive disorder; PTSD, posttraumatic stress disorder

When comparing the K-ASRS and K-AARS results, Parts A and B, the K-ASRS total score and the scores for impulsivity (IM), antisocial/conduct disorder/oppositional defiant disorder (APD/CD/ODD), dysregulation (DYS), disorganization (DIS), and impairment (IMPA) sections had significantly higher mean values.

In the K-WAIS assessment, the indices that showed significant differences between the two groups were POI and WMI. The mean WMI scores in the comorbidity and ADHD-alone groups were 59.52 and 102.31, respectively, representing a significant difference of nearly 1.7-fold between the two groups (T=-2.288, p=0.024). The CAT results showed that the comorbidity group performed worse in the area of simple visual commission errors (T=-2.306, p=0.024).

Association between number of psychiatric comorbidities and ASRS and AARS scores, intelligence quotient, and CAT scores

The results of the statistical analyses are presented in Table 3. The results were tested using Scheffé's post hoc analysis. While the ADHD-alone group showed lower scores on the K-AARS, IMPA (F=4.994, p=0.008), DYS (F=4.869, p=0.009), and APD/CD/ODD (F=4.590, p=0.012) assessments, it showed higher scores on the K-WAIS, VCI (F=3.924, p=0.023), and POI (F=3.485, p=0.034) assessments.

DISCUSSION

In this study, 124 adult patients with ADHD were recruited and 58.9% (n=73) had other psychiatric comorbidities. Previous studies have suggested that 50%–80% of people with ADHD have psychiatric comorbidities [10,24,25]. Some studies have attributed these high rates of psychiatric comorbidities in ADHD to shared genetic and environmental vulnerabilities that lead to a higher prevalence of other disorders [7,25]. ADHD shows substantial symptomatic overlap with other psychiatric comorbidities (e.g., emotional dysregulation), and ADHD symptoms may be masked by other disorders (e.g., patients may experience ADHD symptom relief from substance use in substance use disorders) [7,25]. In this regard, the importance of psychiatric comorbidities in ADHD has been recognized, and their role in the diagnosis and treatment of ADHD has been discussed [26].

Although the comorbidity rate of 58.9% in our study was not significantly different from those reported in previous studies, it was slightly lower. Previous studies have reported that substance use disorder is the most common comorbidity in patients with ADHD, with incidence rates ranging from 39.2% [10] to 41.2% [11]; however, in our study, the prevalence of substance use disorder as a comorbidity was 13.7% (n=17). Of the 17 patients diagnosed with substance use disorder, majority (n=15) had alcohol-related disorders. The relatively small number of patients with substance use disorders may have reduced overall comorbidity rates.

There are several possible explanations for the differences in the prevalence of substance use disorders between our study and previous studies. Stimulants, such as nicotine and cocaine, have been reported to temporarily increase cognitive performance, whereas marijuana and opiates have been shown to reduce problems such as emotional dysregulation and inner restlessness, thus increasing the possibility of addiction to these substances [9,11]. Among these, marijuana (67%), cocaine (23%), and stimulants (18%) have been reported to be the most commonly abused substances in patients with ADHD compared to healthy controls. The results for alcohol abuse or dependence vary in the literature, but some reports have shown no significant difference between adult ADHD and control participants in the absence of other drug addictions [9]. However, substances that alleviate ADHD

Table 2. Comparison of ASRS and AARS scores, intelligence quotients, and Comprehensive Attention Test (CAT) scores between adult ADHD patients with and without comorbidities

Assessment	With comorbidity	ADHD only	T	p
K-ASRS				
Part A	15.06±4.71	13.37±5.13	1.989	0.049*
Part B	27.31±9.79	22.14±10.08	2.395	0.019*
Total	42.20±13.41	34.35±14.08	2.632	0.010*
K-AARS				
IA	55.01±13.45	20.94±15.42	1.637	0.104
HY	12.25±4.73	12.49±4.55	-0.303	0.762
IM	25.13±9.68	20.97±7.21	2.832	0.005**
APD/CD/ODD	14.07±5.42	11.84±4.72	2.558	0.012*
DYS	43.69±11.04	37.84±11.27	3.049	0.003**
DIS	18.76±5.97	16.37±5.36	2.448	0.016*
Total	168.93±41.67	151.45±40.49	2.613	0.010*
IMPA	15.95±7.58	12.38±6.03	2.865	0.005**
DRIV	26.36±23.32	33.03±22.22	-1.195	0.236
K-WAIS-IV				
VCI	101.52±14.67	106.58±15.24	-1.800	0.075
POI	97.85±17.59	105.58±15.27	-2.471	0.015*
WMI	59.52±15.08	102.31±16.41	-2.288	0.024*
PSI	94.47±19.08	97.36±17.48	-0.836	0.405
FSIQ	97.74±16.70	102.36±17.30	-1.474	0.143
CAT				
Simple visual OE	92.98±23.16	97.36±8.67	-1.368	0.175
Simple visual CE	92.86±12.43	99.42±5.59	-2.306	0.024*
Simple auditory OE	93.12±14.62	91.64±22.80	0.421	0.675
Simple auditory CE	87.40±21.04	93.10±17.23	-1.608	0.111
Continuous inhibition OE	94.94±15.09	91.96±18.74	1.012	0.313
Continuous inhibition CE	95.03±19.27	99.06±13.93	-1.380	0.170
Interference selection OE	91.77±19.89	96.39±7.20	-1.774	0.080
Interference selection CE	93.03±17.72	94.25±18.05	-0.394	0.694
Divided OE	75.29±30.21	80.30±27.92	-0.993	0.322
Divided CE	93.56±21.67	98.06±14.62	-1.402	0.164
Working memory forward	94.36±22.06	97.33±24.06	-0.740	0.460
Working memory backward	95.12±18.13	97.36±12.61	-0.825	0.411

Values are presented as mean±standard deviation. *p<0.05; **p<0.01. ADHD, attention-deficit hyperactivity disorder; APD, antisocial; CD, conduct disorder; CE, commission errors; DIS, disorganization; DRIV, driving; DYS, dysregulation; FSIQ, full-scale intelligence quotient; HY, hyperactivity; IA, inattention; IM, impulsivity; IMPA, impairment; K-AARS, Korean Adult Attention-deficit Hyperactivity Disorder Rating Scale; K-ASRS, Korean Adult Attention-deficit Hyperactivity Disorder Self-report Scale; K-WAIS-IV, Korean version of Wechsler Adult Intelligence Scale, Fourth Edition; ODD, oppositional defiant disorder; OE, omission errors; POI, perceptual organization index; PSI, processing speed index; VCI, verbal comprehension index; WMI, working memory index

symptoms, such as marijuana and cocaine, are more difficult to obtain in South Korea than in other countries, which may explain the relatively low prevalence of substance use disorder comorbidities. In our study, out of 17 people diagnosed with a substance use disorder, 15 had alcohol-related problems, and only two had another substance use disorder. In addition, this study assessed substance use disorders using the MINI; therefore, nicotine addiction was excluded from the analysis, which may have contributed to the low prevalence of substance use disorders. Our findings are consistent with the results of previous studies on ADHD comorbidities in Korea, in which substance use disorders showed a lower prevalence than other comorbidities [25].

In this study, the three most common comorbidities were mood disorders (38.7%), anxiety disorders (18.5%), and substance use disorders (13.7%), which is consistent with the pattern reported in previous studies [10,11] wherein the most common comorbidities were substance use disorders, fol-

Table 3. Association between number of psychiatric comorbidities and ASRS and ASRS scores, intelligence quotients, and Comprehensive Attention Test (CAT) scores

Assessment	ADHD only (a)	With 1 comorbidity (b)	With ≥2 comorbidities (c)	F	p	Scheffe
K-ASRS						
Part A	13.37±5.13	14.93±4.70	15.28±4.81	2.007	0.139	
Part B	22.14±10.08	27.74±9.45	26.77±10.38	2.895	0.061	
Total	34.35±14.08	42.33±12.56	42.05±14.69	3.424	0.037*	
K-AARS						
IA	50.94±15.42	54.74±14.34	55.48±12.02	1.350	0.263	
HY	12.49±4.55	12.05±4.84	12.60±4.62	0.157	0.855	
IM	20.97±7.21	25.09±10.64	25.20±7.92	3.982	0.021*	
APD/CD/ODD	11.84±7.21	25.09±10.64	25.20±7.92	4.590	0.012*	a<b, c
DYS	37.84±11.27	42.98±10.29	44.92±12.36	4.869	0.009**	a<b, c
DIS	16.37±5.36	18.51±5.91	19.20±6.18	3.095	0.049*	
Total	150.45±40.49	166.70±42.18	172.76±41.35	3.567	0.031*	
IMPA	12.38±6.03	15.08±7.96	17.41±6.82	4.994	0.008**	a<b, c
DRIV	33.03±22.22	25.96±23.57	27.25±23.76	0.716	0.492	
K-WAIS-IV						
VCI	106.73±15.35	104.50±13.49	96.48±15.13	3.924	0.023*	b, c<a
POI	105.28±15.27	99.39±17.10	95.30±18.47	3.485	0.034*	b, c<a
WMI	102.31±16.41	95.21±16.19	96.04±13.40	2.615	0.283	
PSI	97.23±17.62	96.37±20.70	91.74±15.68	0.738	0.480	
FSIQ	102.36±17.30	99.32±16.73	95.25±16.68	1.506	0.226	
CAT						
Simple visual OE	97.33±8.75	92.58±24.05	93.91±21.61	0.893	0.412	
Simple visual CE	99.42±5.59	88.66±26.27	99.83±3.27	6.379	0.024*	
Simple auditory OE	91.49±22.97	90.84±17.89	97.17±3.38	0.916	0.403	
Simple auditory CE	93.21±17.36	82.66±25.16	95.22±4.52	4.596	0.012*	-
Continuous inhibition OE	91.91±19.01	93.51±17.95	97.28±6.72	0.898	0.410	
Continuous inhibition CE	99.12±13.98	91.84±22.56	100.68±8.71	3.235	0.043*	-
Interference selection OE	96.37±7.31	88.86±23.81	97.20±6.00	4.062	0.019*	b<a, c
Interference selection CE	94.28±18.28	92.81±15.86	93.44±20.37	0.088	0.916	
Divided OE	80.23±28.25	74.44±29.61	77.32±30.86	0.513	0.600	
Divided CE	97.92±14.79	90.07±24.46	100.28±12.82	3.329	0.039*	
Working memory forward	96.62±24.04	94.56±23.16	96.12±20.94	-0.740	0.460	
Working memory backward	94.25±12.79	96.21±17.34	93.72±19.06	0.459	0.633	

Values are presented as mean±standard deviation. *p<0.05; **p<0.01. ADHD, attention-deficit hyperactivity disorder; APD, antisocial; CD, conduct disorder; CE, commission errors; DIS, disorganization; DRIV, driving; DYS, dysregulation; FSIQ, full-scale intelligence quotient; HY, hyperactivity; IA, inattention; IM, impulsivity; IMPA, impairment; K-AARS, Korean Adult Attention-deficit Hyperactivity Disorder Rating Scale; K-ASRS, Korean Adult Attention-deficit Hyperactivity Disorder Self-report Scale; K-WAIS-IV, Korean version of Wechsler Adult Intelligence Scale, Fourth Edition; ODD, oppositional defiant disorder; OE, omission errors; POI, perceptual organization index; PSI, processing speed index; VCI, verbal comprehension index; WMI, working memory index

lowed by mood disorders and anxiety disorders. The prevalence of mood disorders (8.6%–55%) and anxiety disorders (4.3%–47.1%) was also similar to that reported in previous studies [11].

In the K-ASRS assessments, the comorbidity group showed a higher mean value of 27.31 in Part B, which examined the severity of patients' symptoms and the influence of ADHD symptoms on their lives (the ADHD-alone group had a mean score of 22.14; F=2.395, p=0.019). The AARS also showed higher scores in several areas, including the IM, DYS, DIS, and IMPA sections in the comorbidity group. These results suggest that the comorbidity group was more likely to have symptomatic difficulties in daily life and a higher severity of ADHD-associated symptoms than patients with ADHD alone.

In this study, WMI, which is considered an important cog-

nitive factor that differs between normal and ADHD groups, showed a large discrepancy within the ADHD group in relation to the presence or absence of comorbidities. The mean WMI score was 59.52 (SD=15.08) in the group with comorbidities, which was approximately 43 points lower than that in the ADHD-alone group (102.31; SD=16.41, $p<0.024$). Recent studies on ADHD have consistently reported impairments in working memory, even though patients do not show significant differences in FSIQ compared with normal controls. Although these impairments have been suggested to be associated with attention problems, the exact processes involved are not yet fully understood. Impairments in working memory are considered the most important cognitive feature of the differences between the ADHD and non-ADHD groups [13,27]. Since previous studies have suggested that working memory impairment plays a significant role in ADHD, the finding that the reduction in WMI is greater in patients with ADHD and comorbidities warrants further investigation.

Since the presence of comorbidities in adult patients with ADHD has been found to impair neuropsychological outcomes in several areas, and comorbidities can affect the quality of life and symptom severity of patients with ADHD [6], a more multidimensional approach and research may be required to understand comorbidities in patients with ADHD [7]. Further research is needed to determine whether neuropsychological outcomes differ depending on the type of comorbidity, and how such comorbidities relate to ADHD in areas such as pathogenesis. It would also be interesting to determine whether WMI assessments can be used clinically as a diagnostic tool to diagnose ADHD or the type of comorbidity.

This study has several limitations. We did not examine the moderators that may have influenced the analysis of the WAIS or CAT results in the two groups. The results of the WAIS and CAT assessments were not analyzed after controlling for variables, such as previous treatment history and parental education, that may have influenced their findings; therefore, the mediating effects of these variables were not clearly understood. In addition, this study identified comorbidities at only one time point; therefore, may have missed additional comorbidities that could have occurred during the long-term follow-up. This study included only participants recruited from eight hospitals; therefore, there is a possibility of selection bias. This may limit the generalizability of the findings to the population at large, and therefore, future studies should expand the sample size. In addition, unipolar and bipolar depression have different effects on ADHD comorbidity [28] and we wanted to provide a review of this, but only one case was associated with bipolar disorder in the mood disorder. Therefore, a study involving a larger cohort of adults with ADHD is required to address this issue.

Despite these limitations, this study had several strengths. First, both the WAIS and CAT were administered to all patients to accurately compare neuropsychological outcomes. Second, the diagnostic reliability of ADHD was high because it was assessed by two board-certified psychiatrists according to the DSM-5. Third, psychiatric comorbidities were also precisely assessed by board-certified clinicians through structured interviews, such as the MINI Plus V5.0.0; therefore, the diagnostic reliability of comorbidities was very high, which is one of the notable strengths of this study.

CONCLUSION

Despite its chronic course, ADHD is a frequently unrecognized, underdiagnosed, and undertreated condition in adults. In particular, the presence of comorbidities in adult patients with ADHD has been associated not only with more symptom distress in real life but also with poorer neuropsychological outcomes in several domains. In the present study, deterioration was observed in the POI and WMI domains of the WAIS and in the simple visual commission errors of the CAT. Therefore, identifying the coexistence of comorbidities in the management of patients with ADHD in clinical practice should be considered an important aspect of ADHD treatment and prognosis. In addition, ADHD should be systematically ruled out in all patients seeking psychiatric treatment to facilitate improved access to effective treatment and management, especially for those with mood, substance use, and anxiety disorders.

Availability of Data and Material

The datasets generated or analyzed during the study are not publicly available due to specific restrictions outlined in the informed consent agreements obtained from the research participants or data owners but are available from the corresponding author on reasonable request.

Conflicts of Interest

Geon Ho Bahn and Minha Hong, a contributing editor of the *Journal of the Korean Academy of Child and Adolescent Psychiatry*, were not involved in the editorial evaluation or decision to publish this article. All remaining authors have declared no conflicts of interest.

Author Contributions

Conceptualization: Hanik K Yoo, Soo-Young Bhang. Data curation: all authors. Formal analysis: Hyun Jae Roh, Geon Ho Bahn, Seung Yup Lee, Yoo-Sook Joung, Bongseog Kim, Eui-Jung Kim, Soyoung Irene Lee, Minha Hong, Doug Hyun Han, Young Sik Lee. Methodology: Hanik K Yoo, Soo-Young Bhang. Supervision: Soo-Young Bhang. Validation: Geon Ho Bahn, Seung Yup Lee, Yoo-Sook Joung, Bongseog Kim, Eui-Jung Kim, Soyoung Irene Lee, Minha Hong, Doug Hyun Han, Young Sik Lee. Visualization: Hyun Jae Roh, Soo-Young Bhang. Writing—original draft: Hyun Jae Roh, Soo-Young Bhang.

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