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ORIGINAL ARTICLE

Impact of ADHD Coexistence on Internet Addiction Symptoms in Children with ASD: Effects of Family- and School-Related Factors and Sex Differences

Hiroyuki Kawabe[1,2,3] · Sayaka Kawakami[1,2] · Azusa Fujita[3] · Junichi Yamamura[3] · Atsushi Senju[1,2] · Kenji J. Tsuchiya[1,2] · Tomoko Nishimura[1,2]

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Abstract

Research is lacking on whether the coexistence of attention-deficit/hyperactivity disorder (ADHD) increases the risk for Internet addiction (IA) in children with autism spectrum disorder (ASD). This study examined the impact of ADHD coexistence on IA symptoms in children with ASD, controlling the influence of family- and school-related factors. We also analyzed male and female participants separately to examine sex differences. IA symptoms were assessed using the Internet Addiction Test in children with ASD ($n=71$) and ASD+ADHD ($n=93$) admitted to a child and adolescent psychiatric hospital. Multiple regression analysis was performed with IA symptoms as the outcome variable and family- and school-related factors as the potential confounders. Similarly, a subgroup analysis was conducted for each sex of the participants. Results showed no differences in self-reported IA symptoms between the ASD and ASD+ADHD groups, but females in the ASD group had higher IA symptoms than the ASD+ADHD group. Low school attendance was significantly associated with higher IA symptoms for the entire target population and for males. In addition, for females, medication and bullying victimization were associated with lower and higher IA symptoms, respectively. In males, socio-economic status (SES) was associated with higher IA symptoms. ASD+ADHD coexistence does not necessarily increase the severity of IA symptoms and may not be a combination of different neurodevelopmental disorders, ASD and ADHD. Further research should examine the impact of ASD+ADHD coexistence on IA symptoms, considering sex differences and family- and school-related factors.

Keywords Autism Spectrum Disorder · Attention-deficit/hyperactivity Disorder · Coexistence · Internet Addiction · Sex Differences

Although Internet gaming is a popular leisure activity for children and adolescents, it reportedly interferes with daily life among some children (King et al., 2018; Kuss & Griffiths, 2012). Reported difficulties include poor academic performance (Zhao, 2023), worsening family functioning (Ko et al., 2015), sleep disturbances (Cheung & Wong, 2011), and psychiatric symptoms, such as depression and anxiety (Alavi et al., 2011). The American Psychiatric Association (APA) includes problems related to excessive use of Internet gaming and related loss of control, i.e., dependency, in the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) as Internet gaming disorder (IGD). Similarly, the World Health Organization (WHO) has included gaming disorder (GD) in the International Classification of Diseases, 11th edition (World

✉ Tomoko Nishimura
nishimura.ugscd@osaka-u.ac.jp

1 United Graduate School of Child Development, The University of Osaka, Kanazawa University, Hamamatsu University School of Medicine, Chiba University and University of Fukui, Osaka, Japan

2 Research Center for Child Mental Development, Hamamatsu University School of Medicine, 1-20-1 Handayama, Tyuou-ku, Shizuoka 431-3192 Hamamatsu, Japan

3 Department of Child and Adolescent Psychiatry, National Hospital Organization, Tenryu Hospital, Hamamatsu, Japan

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Health Organization, 2022). The prevalence of IGD or GD has been reported to be 0.7–27.5%, depending on the individual's sex, age, and country (Fam, 2018; Mihara & Higuchi, 2017; Sugaya et al., 2019; Taechoyotin et al., 2020; Wichstrøm et al., 2019; Yang et al., 2020).

Internet Addiction Symptoms

In addition to IGD or GD, Internet addiction (IA) symptoms have been studied extensively, and various scales have been developed to measure such problems. Although different scales have different cutoff values and labels (Weinstein & Lejoyeux, 2010; Schlossarek et al., 2024) and most are self-report measures, reports indicate that 5.8–38.0% of children have problems related to Internet use (Dong et al., 2020; Durkee et al., 2012; Johansson & Götestam, 2004; Kim et al., 2006; Mei et al., 2016; Poli & Agrimi, 2012).

Relationship between Autism Spectrum Disorders and Internet Addition Symptoms

Autism spectrum disorders (ASD) is often reported to be associated with addictive or pathological use of Internet games (Kervin et al., 2021; Murray et al., 2022). Core symptoms of ASD include persistent impairment in reciprocal social communication and interaction, and restricted, repetitive patterns of behavior, interests, or activities (American Psychiatric Association, 2022). The unique cognitive and behavioral features of children with ASD, combined with the high degree of content tailored to an individual's specific interests, can potentially give rise to problematic media-use habits (Lane & Radesky, 2019). Online interactions can be less stressful for individuals with ASD regarding emotional, social, and time pressures, and such individuals may feel a sense of liberation and be equal to their peers (Benford, 2008; Benford & Standen, 2009). However, the feeling of liberation is also a risk of losing control (Murray et al., 2022). Restricted interests and repetitive behaviors were associated with addicted media use (Shane-Simpson et al., 2016). Mazurek and Wenstrup (2013) stated that the tendency to fixate on specific interests could make it difficult for these individuals to disengage from Internet games.

Relationship between Attention-deficit/Hyperactivity Disorder and IA Symptoms

Attention-deficit/hyperactivity disorder (ADHD) is also reported to be associated with addictive use of Internet games, with a reported coexistence rate of 21.7% for IA and ADHD (Ho et al., 2014). ADHD is characterized by chronic symptoms of inattention, impulsivity, and/or hyperactivity that lead to functional impairment experienced in multiple settings (American Psychiatric Association, 2022). These cognitive and behavioral features may also give rise to IA symptoms. A study has reported a positive association between the severity of inattentive and hyperactive symptoms and the severity of IA symptoms (Mathews et al., 2019). Inattention and hyperactivity in ADHD can be accompanied by a lack of inhibitory control, strategic flexibility, and interference with the self-regulation of Internet use (Yoo et al., 2004). Furthermore, high impulsivity in ADHD can lead to IA due to immediate reactions to stimuli (Cabelguen, 2021). Individuals with ADHD prefer games as they provide immediate support through missions and complement such individuals' executive functions (Castellanos & Tannock, 2002).

Relationship between IA Symptoms and Coexistence of ASD and ADHD

ADHD often coexists with ASD, with a coexistence rate of 40–70% according to Antshel and Russo (2019). Since both ASD and ADHD have been associated with IA and its symptoms, the risk of IA may increase by the coexistence of ASD and ADHD. However, whether the coexistence of ADHD increases the severity of IA symptoms in individuals with ASD remains unknown. A study (So et al., 2017) found no differences in IA symptoms among the ASD alone, ADHD alone, and ASD + ADHD groups; however, the prevalence of IA was higher in the ASD + ADHD group than in the ASD alone group (20.0% and 10.8%, respectively). Another study (Kawabe et al., 2019) found that among outpatients with ASD, adolescents with IA had higher ADHD traits than those without IA. A study compared adolescents with and without ASD and reported that ADHD traits were not associated with IA in the ASD group; however, they were positively associated with IA in the non-ASD group (Kawabe et al., 2022).

Influences of Family- and School-related Factors

Difficulties in family and/or school life are associated with ASD and ADHD and also IA symptoms. A meta-analysis of IGD identified 12 possible risk factors such as stress, long average game time, family dysfunction, and being bullied (Gao et al., 2022). We focused on family- and school-related factors as environmental factors because they can serve as the basis for prevention and intervention for IA symptoms. For example, problems with attachment formation, inadequate nurturing, such as adverse childhood experiences (ACE), low parental socioeconomic status (SES), and education level have been reported to increase the likelihood of developing IA, independent of the presence of ASD or

ADHD (Doi et al., 2021; Lan & Wang, 2020; Yang et al., 2020). Excessive gaming could lead to a decline in family functioning, which further exacerbates gaming (Park et al., 2008). Studies have investigated IA symptoms in children with ASD and reported that hiding Internet use from their parents to avoid social interaction and conflict was a central symptom (Hirota et al., 2021).

Furthermore, interpersonal relationships at school (e.g., bullying) and difficulties attending school are related to IA symptoms (Fujita et al., 2022; Mihara & Higuchi, 2017; Taş, 2017). A prior work has shown that some children with ASD and/or ADHD struggle with attending school (Black & Zablotsky, 2018). School attendance problems are one of the significant concerns in Japan. Most absences are due to refusing to go to school for reasons other than economic or illness (Ministry of Education, Culture, Sports, Science and Technology, 2024). These family- and school-related factors were known to be more severe in the ASD+ADHD group than in the ASD alone group (McClemont et al., 2021; Schneider et al., 2019). Therefore, these factors should be considered as confounders in the association between IA and ASD+ADHD coexistence.

Sex Differences

Sex is another factor to be considered. Males are more dependent on online gaming at home, while females are more dependent on social networking through smartphones (Mari et al., 2023; Tang et al., 2017; Tateno et al., 2018). These sex differences in media use also align with differences in IA symptoms by age: IA symptoms were higher among males in primary school and females in secondary school (Takahashi et al., 2018). In addition, both ASD and ADHD have sex differences in prevalence and phenotype (Mazurek et al., 2012; Yen et al., 2009). Furthermore, sex differences in the prevalence of ASD+ADHD coexistence reported in previous studies were inconsistent; some reported that ASD+ADHD coexistence was more common in males than in females (Hours et al., 2022; Wodka et al., 2022), while others reported the vice versa (Ottosen et al., 2019). Results on severity were also inconsistent; some studies reported no significant differences between sexes (Stacy et al., 2014), while others reported that males with ASD+ADHD coexistence were more severely affected than females (Casseus et al., 2023). A large study that examined sex differences in behavioral phenotypes reported that females with ASD+ADHD coexistence had higher repetitive behaviors than males with ASD+ADHD coexistence. However, no differences were observed in social communication symptoms or motor skills (Wodka et al., 2022). Thus, the results of studies on sex differences are mixed and need to be increasingly investigated. However, to our knowledge, no studies have examined sex differences in the association between IA and ASD+ADHD coexistence.

Existing Challenges and our Aims

To summarize, results are mixed in previous research, which studied the impact of ADHD coexistence on IA symptoms in individuals with ASD. In addition, the influence of family- or school-related factors and differences according to sex have not been examined. Therefore, this study aimed to investigate the impact of ADHD coexistence on IA symptoms in children with ASD, considering the influence of family- and school-related factors and examine the above associations according to sex.

First, we investigated whether ADHD coexistence increases IA symptoms in children with ASD. Given that both ASD and ADHD are associated with IA symptoms, we hypothesized that ASD+ADHD coexistence would increase the severity of IA symptoms. In a previous study (So et al., 2017), ASD+ADHD coexistence was not associated with increased IA symptoms, but it may have been statistically underpowered due to sample size. We investigated this in a larger sample. Second, we investigated how family- and school-related factors influence the association between ASD+ADHD coexistence and IA symptoms. Given that problems at home and/or at school may be greater in cases of coexistence and increase the risk of IA symptoms, these factors may be confounders of ASD+ADHD coexistence and increased IA symptoms. If confounding is observed, some of the increase in IA symptoms due to coexistence may be explained by family- and/or school-related factors. Third, we examined whether the association between ASD+ADHD coexistence and IA symptoms and the influence of family- and school-related factors would differ between males and females. Given sex differences in IA symptoms and the prevalence and phenotype of ASD and ADHD, sex differences would be expected. However, because there are few existing studies, it is difficult to predict how they will differ. Identifying factors associated with IA symptoms by sex would help improve IA symptoms or prevent increased IA symptoms.

Methods

Study Design

This was a retrospective observational study. In this study, participants' information was retrieved from their medical records. Information on the diagnosis and medication were recorded by the physician, and self-administered questionnaires were completed by the family or child in the presence

of the physician or psychologist. The information was stored in electronic health records (EHRs) and was accessible only to healthcare providers. The data for this study were retrieved from the EHRs and stripped of participant names and other identifiable information.

Setting

Participants were inpatients at a child and adolescent psychiatric hospital. This hospital included an inpatient and outpatient child psychiatric facility in Japan. All inpatients and their caregivers receive an admission questionnaire that includes Internet use and family- and school-related factors to help guide treatment. At that time, inpatients were informed that the information may be used for future research, and consent was obtained.

Participants

Participants were children hospitalized between December 2019 and November 2023. Inclusion criteria were those aged (a) 10–15 years, which was equivalent to being in the 4th–9th grade, (b) diagnosed with ASD, and (c) had completed an assessment of IA during hospitalization. In total, 217 children met these criteria. Exclusion criteria included those (a) diagnosed with intellectual and developmental disabilities or schizophrenia and (b) with a readmission history during the study period (only the first admission was included in the analysis). Figure 1 illustrates that inclusion and exclusion are processes. Of the 53 children excluded, 36 had a readmission history, 14 had intellectual developmental disorders, and three were diagnosed with schizophrenia. Hence, the final sample comprised 164 children, with 71 and 93 in the ASD and ASD+ADHD groups, respectively.

Ethical Considerations

This study was approved by the relevant Institutional Review Boards. Since this study utilized existing medical record information, and no new materials or information were acquired, the participants were not required to obtain written or verbal consent. Instead, information regarding the study was posted, and participants could refuse to be part of the research. All procedures contributing to this work comply with the ethical standards of the relevant national and institutional human committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2024.

Measurements

Internet Addiction Severity

Severity of IA symptoms, the primary outcome, was measured using the Internet Addiction Test (IAT) Japanese version (Osada, 2013). This self-administered questionnaire comprised 20 items rated on a 5-point Likert scale that ranged from 1 (never) to 5 (always). The total score ranged from 20 to 100 points. Higher total scores indicated more severe IA symptoms.

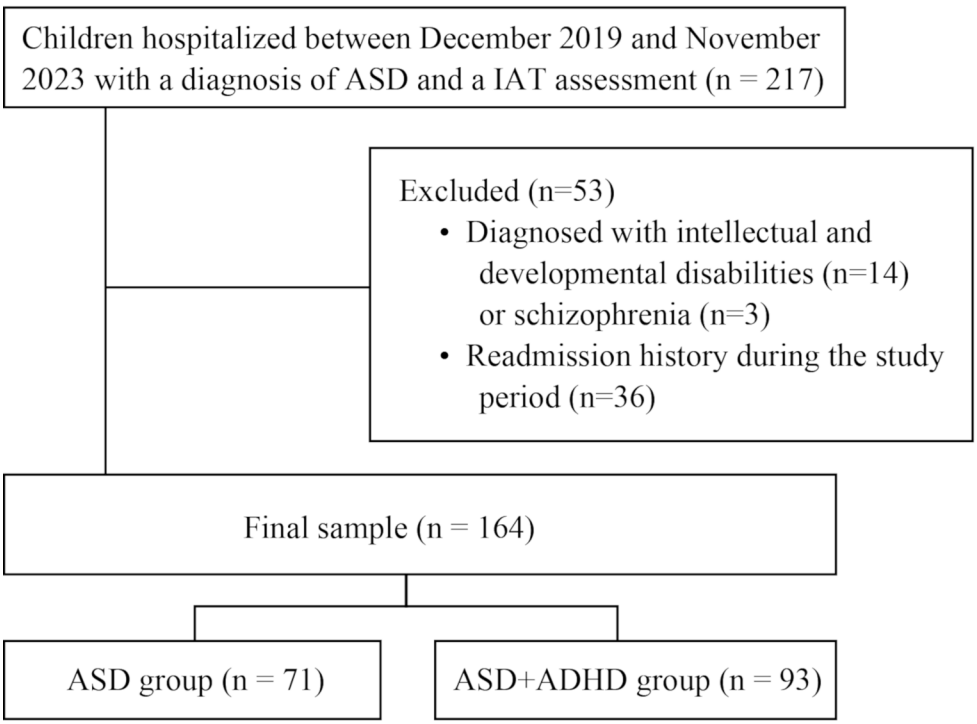

Fig. 1 Flowchart of the inclusion/exclusion criteria

Diagnosis

ASD or ADHD was diagnosed by a pediatrician or child and adolescent psychiatrist using the DSM-5 (American Psychiatric Association, 2022) before hospitalization. We set the ASD (without ADHD) group as a control group to determine the impact of ASD + ADHD coexistence on the severity of IA symptoms. Participants diagnosed with ASD but not ADHD were allocated to the ASD group and participants diagnosed with ASD and ADHD were allocated to the ASD + ADHD group, resulting in 71 participants in the ASD group and 93 in the ASD + ADHD group.

Adverse Childhood Experiences

Information on adverse childhood experiences (ACEs) was obtained as a family-related factor. The ACEs questionnaire comprised 11 items: physical, psychological, and sexual abuse, physical and psychological neglect, single parenting, parental psychiatric history, parental incarceration, parental substance abuse, parental domestic violence, and bullying victimization (Finkelhor et al., 2013). To examine the effects of bullying victimization, which often occurs at school, and the effects of adversity experiences at home, we used 10 items, except for an item on bullying victimization as a family factor, and bullying victimization was treated as an independent factor (Gao et al., 2022). The caregiver responded with a "yes" or "no" as to whether the child experienced each ACE. Total scores for the 10 ACEs were summed and treated as a continuous variable. Bullying victimization was treated as a binary variable. However, the validity of treating this item separately has not been tested, so the results should be interpreted with caution.

Socioeconomic Status

Socioeconomic Status (SES) was included as another family-related factor and evaluated using the Brief Rating Scale of Socioeconomic Status (Navarro-Carrillo et al., 2020). This scale categorized parental education into seven levels, from elementary school graduation to graduate school completion. Either parent's highest education level was used as the score, and treated as a continuous variable.

School Attendance

The percentage of school attendance was included as a school-related factor. Parents reported their child's school attendance in the last three months in quartiles, which was categorized as $\geq 75\%$ or $< 75\%$.

Medication

Medication status upon admission for ASD and/or ADHD, which included mood stabilizer (e.g., lithium carbonate, valproic acid), sleep medication (e.g., Lemborexant, zolpidem tartrate), or other psychoactive drugs (e.g., fluvoxamine, clomipramine), was obtained from the medical records. Because the medication type, number, and dosage varied widely, medication was categorized into binary values based on whether children took any medication.

Demographic Variables

Demographic variables, such as the child's sex and age and parents' ages, were included as covariates.

Statistical Analysis

Data were analyzed using STATA version 15. Differences between the ASD and ASD + ADHD groups were assessed via a chi-squared (χ^2) test performed on the binary data (sex, medication, school attendance, bullying). Furthermore, Wilcoxon rank-sum tests were performed on non-normally distributed continuous data (age of child, IAT score, ACEs, SES). Student's t-test was performed on normally distributed continuous data (age of parents).

Associations between IA severity and other variables were examined using generalized linear models (GLM). Data were assumed to follow a gamma distribution, and a log-link function was used. In the first step, associations between IA severity and each variable were separately examined using a simple regression model. Subsequently, a multiple regression analysis that included all the variables was performed. Marginal effects are calculated as effect sizes, representing the change in the predicted probability for a unit change in the predictor. Marginal effect is an important way of translating the results of non-linear models into intuitive and useful quantities (Long & Freese, 2014).

To examine sex differences in the associations between IA symptoms' severity and diagnostic groups, an interaction term of diagnostic group by sex was included in the regression model. Subgroup analyses examined the sex-specific impact of factors of interest, including family- and school-related factors, on IA symptoms. Multiple regression analyses, the same as those above, were performed separately for males and females.

Missingness

IAT is administered to all inpatients with few exclusions due to missing IAT scores. In the multivariate analysis, eight subjects were excluded due to missing data. Missing in each

variable were the ACE score, $n=1$; father's age, $n=5$ subjects; and mother's age, $n=2$.

Results

Participants' Characteristics

Table 1 presents the participants' demographic characteristics. For categorical variables, numbers and percentages of participants in each group are shown, medians and interquartile ranges (IQRs) for continuous variables that are not normally distributed and means and standard deviations for continuous variables that follow a normal distribution. Proportions of participants' sex varied between the groups ($\chi^2(2)=7.19$, $p=.007$), with more males in the ASD+ADHD group. Group differences were also observed in school attendance; more children in the ASD+ADHD group had ≥75% school attendance ($\chi^2(2)=4.15$, $p=.04$). Results of the Wilcoxon rank-sum test revealed that the ACE score, which excluded bullying victimization, was significantly higher in the ASD+ADHD group compared with the ASD group ($z=-2.89$, $p=.001$). Furthermore, SES was significantly higher in the ASD group compared with the ASD+ADHD group ($z=2.01$, $p=.01$). No significant differences were observed in IAT scores, bullying victimization, medication, or age of the child and parents between the ASD and ASD+ADHD groups. Figure 2 illustrates the distribution of the IAT scores according to diagnosis and sex.

Factors that May Contribute To the IAT Scores

Table 2 presents the results of the GLM for IA symptom severity. No significant association was observed between the diagnosis group and IAT score in either the simple or multiple regression analyses. Only school attendance was negatively associated with IAT scores in both the simple and multiple regression analyses (coefficient=-0.163, 95% confidence interval [CI]: -0.288, -0.038; coefficient=-0.150, 95% CI: -0.289, -0.010, respectively). Children with ≥75% school attendance had lower levels of IA symptom severity than those with <75% school attendance.

A diagnostic group by sex interaction was statistically insignificant in the multiple regression model (coefficient=0.221, 95% CI: -0.032, 0.475, $p=.087$). Table 3 presents the results of the subgroup analysis according to sex. Among males ($n=109$), no significant association was observed between the diagnosis group and IAT score. Males with ≥75% school attendance had lower IAT scores than those with <75% school attendance (coefficient=-0.186, 95% CI: -0.329, -0.043). Furthermore, a higher SES was associated with lower IAT scores (coefficient=-0.073, 95% CI: -0.114,

Table 1 Participants' demographics

	ASD group		ASD+ADHD group		Total	
	$n=71$		$n=93$		$n=164$	
	n	%	*n*	%	*n*	%
Sex[1)*]						
Males	42	59.1	73	78.5	115	70.1
Females	29	40.9	20	21.5	49	29.9
Medication[1)]						
Yes	57	80.3	79	84.9	136	82.9
No	14	19.7	14	15.1	28	17.1
School attendance[1)*]						
<75%	60	84.5	66	70.9	126	76.8
≥75%	11	15.5	27	29.1	38	23.2
ACEs (bullying victimization)[1)]						
Yes	25	35.7	40	43	65	39.9
No	46	64.3	53	57	99	60.1
	Median	IQR	Median	IQR	Median	IQR
Age of the child[2)]	13.1	11.8–14.2	12.4	10.8–14.0	12.8	11.3–14.1
IAT score[2)]	43	30–54	43	33–56	43	32–55.5
ACEs (familial factors)[2)*]	1	0–1	2	1–4	2	1–3
SES[2)*]	5	4–6	5	4–6	5	4–6
	Mean	SD	Mean	SD	Mean	SD
Age of the mother[3)]	34.1	5.6	32.9	5.9	33.4	5.9
Age of the father[3)]	31.8	5.2	31.1	5.4	31.4	5.3

Note. IAT: Internet Addiction Test; ACEs: adverse childhood experiences; SES: socioeconomic status; IQR: interquartile range; SD: standard deviation

[(1)] χ^2 test; [(2)] Wilcoxon rank-sum test; [(3)] Student's t-test; [*] $p<.05$

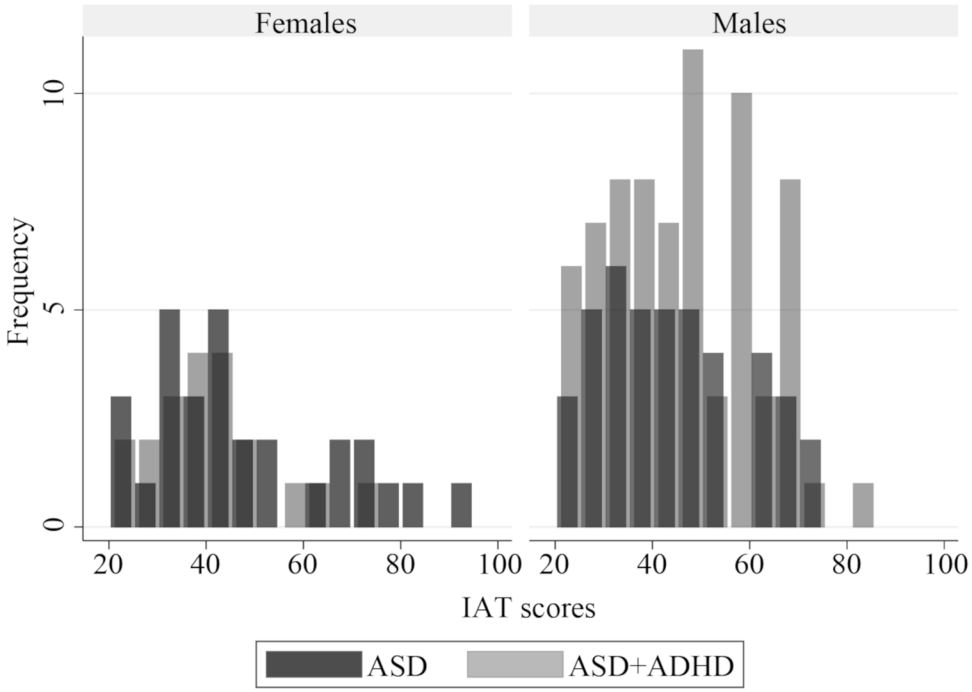

Fig. 2 IAT scores according to sex for the ASD and ASD+ADHD groups

-0.009). Among females (n=47), the ASD+ADHD group had lower IAT scores compared with the ASD group (coefficient=-0.281, 95% CI: -0.522, -0.041). In addition, those on medication had lower IAT scores compared with those not on medication (coefficient=-0.304, 95% CI: -0.570, -0.038). Furthermore, females who had experienced bullying victimization had higher IAT scores compared with females who had not (coefficient=0.245, 95% CI: 0.011, 0.479).

Discussion

This study aimed to investigate the impact of ADHD coexistence on IA symptoms in children with ASD, considering family- and school-related factors. We hypothesized that ASD+ADHD coexistence would increase IA symptoms. Contrary to our hypothesis, no differences in self-reported IA symptoms were found between the ASD and ASD+ADHD groups. However, among females, the ASD group had higher IA symptoms than the ASD+ADHD group. In addition, the included family- and school-related factors did not demonstrate any confounding in the association between ASD+ADHD coexistence and IA symptoms. Independent of ASD+ADHD coexistence, school attendance of ≥75% was associated with reduced IA symptoms for participants overall and for males. Furthermore, being on medication was associated with lower IA symptoms, and the experience of bullying victimization was associated with higher IA symptoms for females. For males, higher school attendance and lower SES were associated with lower and higher IA symptoms, respectively. Considering sex differences and the influence of family- and school-related factors is important when assessing and treating IA symptoms in individuals with ASD.

In the entire target population, self-reported IA symptoms were similar between the ASD and ASD+ADHD groups, which was consistent with previous results in clinical groups (Kawabe et al., 2022; So et al., 2017); however, this finding differed from our hypothesis. The association remained similar when family- and school-related factors were considered. A possible interpretation was that ASD+ADHD coexistence may not be a mere overlap of the two prevalent neurodevelopmental disorders (Hours et al., 2022; Watanabe & Watanabe, 2023). Watanabe and Watanabe (2023) reported that the autistic social symptoms of individuals with ASD+ADHD were based on the same neural mechanisms as those of individuals with only ASD, whereas their ADHD-like symptoms, such as inattention and hyperactivity, were attributable to the unique brain dynamics not related to any symptoms in individuals with only ADHD. Assuming that the coexistence of ASD and ADHD was not simply a combination of their symptoms and biological mechanisms, their coexistence may not have an additive effect on IA symptoms.

By contrast, subgroup analysis for females revealed that the ASD+ADHD group had lower IA symptoms than the ASD group, which we did not observe in the whole group analysis. For males, the ASD and ASD+ADHD groups had mostly similar score distributions; however, among females,

Table 2 Possible contributing factors to the IAT score

	Simple Regression Models				Multiple Regression Model			
	Coefficient	95% CI	Marginal effect	95% CI	Coefficient	95% CI	Marginal effect	95% CI
Diagnosis (ASD+ADHD)	-0.017	-0.126, 0.091	-0.766	-5.593, 4.061	-0.015	-0.136, 0.106	-0.673	-6.071, 4.725
Age of the child	0.028	-0.006, 0.062	1.238	-0.287, 2.763	0.024	-0.014, 0.062	1.084	-0.624, 2.792
Sex (male)	0.013	-0.104, 0.131	0.597	-4.598, 5.792	0.092	-0.038, 0.223	4.054	-1.582, 9.690
Medication	-0.115	-0.258, 0.027	-5.328	-12.154, 1.498	-0.088	-0.237, 0.061	-4.023	-11.046, 3.000
School attendance (≥75%)	-0.163*	-0.288, -0.038	-6.942	-12.045, -1.840	-0.150*	-0.289, -0.010	-6.422	-12.181, -0.663
ACEs (familial factor)	-0.013	-0.042, 0.015	-0.595	-1.870, 0.678	-0.018	-0.050, 0.014	-0.807	-2.253, 0.640
ACEs (bullying)	0.065	-0.044, 0.173	2.905	-2.003, 7.812	0.057	-0.060, 0.174	2.543	-2.703, 7.790
SES	0.004	-0.042, 0.050	0.180	-1.869, 2.228	-0.025	-0.079, 0.029	-1.125	-3.549, 1.299
Age of father	-0.002	-0.011, 0.008	-0.679	-0.496, 0.361	-0.007	-0.020, 0.006	-0.303	-0.875, 0.268
Age of mother	0.006	-0.005, 0.016	0.245	-0.212, 0.702	0.004	-0.010, 0.019	0.185	-0.467, 0.836

Note. *$p<.05$, 95% CI: 95% confidence interval; IAT: Internet addiction test; ACEs: adverse childhood experiences; SES: socioeconomic status

the ASD group had a higher IAT score distribution than the ASD+ADHD group (Fig. 1). Therefore, it was not considered to be an effect of extreme scores such as outliers. To the best of our knowledge, no studies have examined sex differences in the association among IA symptoms, ASD, and ASD+ADHD coexistence. Females' Internet use is related to maintaining social relationships and emotionally stressful issues (Beranuy et al., 2009). Adolescent females with ASD exhibit difficulties with friendships due to their communication and social nature compared to males (Kopp & Gillberg, 2011). Females with ASD are less likely to exhibit externalizing behaviors such as hyperactivity/impulsivity and behavior problems, but more likely to exhibit internalizing problems such as anxiety and depression (Hukke 2013; Mandy et al., 2012). Female with ASD may be increasing their use of the Internet as a way to cope with interpersonal problems. However, the sex differences in the prevalence, severity, and behavioral phenotypes in ASD+ADHD coexistence are largely unexplored. These sex differences may also be associated with sex differences in IA symptoms and need to be further explored with larger sample sizes.

In this study, school attendance was associated with IA symptoms independently of ADHD coexistence, and children with ≥75% attendance had lower IA symptoms than those with <75% attendance. Both problematic Internet use and school refusal behaviors were avoidance behaviors for distressing emotions (Cerniglia et al., 2017). Therefore, IA symptoms and low school attendance may have been associated in this study. Since this was a cross-sectional study, a causal relationship could not be established. However, low school attendance could have contributed to increased IA symptoms. These findings could be explained by a compensatory Internet use model (Kardefelt-Winther, 2014) in which people used the Internet to mitigate negative emotions. An increase in IA symptoms could also have contributed to low school attendance. Husarova et al. (2018) reported that the more time spent on digital devices during leisure time, the more problems in school, and that this association was mediated by poor sleep quality (Husarova et al., 2018). Presumably, a bidirectional relationship existed between IA symptoms and low school attendance.

Subgroup analyses of males revealed that, similar to the overall results, school attendance of ≥75% was associated with lower IA symptoms. However, this association was not observed in females. Since the participants in this study were predominantly males, the association between school attendance and IA symptoms observed in the entire sample may have reflected the results for males. Studies have reported sex differences in medium and content in Internet use (Dufour et al., 2016; Kawabe et al., 2016) and an association between family relationships, friendships, and Internet use (Liu et al., 2011). These differences may affect the

Table 3 Possible contributing factors to the IAT score (Subgroup Analysis)

	Males				Females			
	$n=109$				$n=47$			
	Coefficient	95% CI	Marginal effect	95% CI	Coefficient	95% CI	Marginal effect	95% CI
Diagnosis (ASD+ADHD)	0.021	-0.119, 0.160	0.926	-5.294, 7.147	-0.281*	-0.522, -0.041	-12.084	-22.361, -1.807
Age of the child	0.02	-0.022, 0.061	0.888	-0.971, 2.746	0.06	-0.018, 0.138	2.631	-0.827, 6.088
Medication	-0.042	-0.221, 0.137	-1.924	-10.200, 6.353	-0.304*	-0.570, -0.038	-14.563	-28.645, -0.480
School attendance (≥75%)	-0.186*	-0.329, -0.043	-8.014	-13.981, -2.048	0.154	-0.237, 0.546	7.232	-12.393, 26.857
ACEs (familial factor)	-0.016	-0.056, 0.023	-0.739	-2.528, 1.050	-0.01	-0.061, 0.040	-0.459	-2.692, 1.775
ACEs (bullying)	-0.022	-0.154, 0.111	-0.972	-6.922, 4.979	0.245 *	0.011, 0.479	10.763	0.296, 21.230
SES	-0.073*	-0.137, -0.009	-3.271	-6.176, -0.366	0.063	-0.028, 0.154	2.791	-1.241, 6.822
Age of father	-0.009	-0.024, 0.006	-0.409	-1.083, 0.264	-0.004	-0.026, 0.018	-0.181	-1.157, 0.794
Age of mother	0.014	-0.003, 0.031	0.610	-0.155, 1.375	-0.014	-0.041, 0.012	-0.633	-1.802, 0.536

Note. *$p<.05$, 95% CI: 95% confidence interval; IAT: Internet addiction test; ACEs: adverse childhood experiences; SES: socioeconomic status

sex differences in the association between school attendance problems and IA symptoms. Such sex differences require further examination, including the media and content used, in a sample with an equal number of males and females.

While the overall results revealed no significant association between family-related factors and IA symptoms, results of the subgroup analyses revealed different trends in males and females. In males, lower parental SES was associated with increased IA symptoms. Some studies reported that low SES increased the risk of IA, for example through the risk of behavioral problems (Yang et al., 2020). However, others reported that high SES increased the risk of IA (Koc & Tamer, 2011) due to high amount of access to the Internet at home. Our results for males were consistent with the former. High SES is reported to effectively reduce the risk of dependence on children's Internet use, based on parents' Internet knowledge (Alvarez et al., 2013). Intervention programs aimed at improving health in the context of poverty are reported to be often disproportionately beneficial for males compared to females (Campbell et al., 2014; Conti et al., 2016). Together, males were more effective in the intervention than females, and higher parental SES may have reinforced this effect. Subgroup analyses of females revealed that IA symptoms were lower with medication than without. A previous study reported that medications, such as methylphenidate and atomoxetine, were effective for IA symptoms (Kuss & Lopez-Fernandez, 2016; Zajac et al., 2020). However, no studies have examined sex differences in the effects of medications. In addition, the effects of specific medications or their doses were not tested in this study. Furthermore, medication may be a potential confounder, a proxy for symptom severity, or treatment engagement. The effects of medications on IA symptoms and their sex differences in individuals with ASD remain a topic for future investigation. Another result of the subgroup analyses of females was that IA symptoms were higher in those with bullying victimization than in those without. Adolescents may use cyberspace to cope with the distress caused by bullying victimization, and consequently, may exhibit IA symptoms (Boniel-Nissim & Sasson, 2018; Gámez-Guadix et al., 2013). However, whether similar trends existed in females and males remains unknown and requires further investigation in future large-scale studies.

The strength of this study is that it examined differences in IA symptoms between children with ASD alone and children with ASD+ADHD coexistence in a relatively large sample. Our results provide new insights into the influence of family- and school-related factors and sex differences.

We also need to note that this study has several limitations. First, not all possible risk factors for IA symptoms could be considered in the study. In particular, symptom severity of ASD and ADHD and comorbidities other than

ADHD were not considered. These may influence IA symptoms. Therefore, future studies are needed, considering various risk factors, including severity and comorbidities, compared with the control group. Second, the study population comprised of inpatients, who included those with severe symptoms and difficulties in the family environment. Therefore, the results of this study cannot be applied to all individuals with ASD and ASD+ADHD coexistence, and generalizability should be noted. However, focusing on cases of severe difficulties that require hospitalization is important because they were often excluded from previous studies. Third, in the subgroup analysis, the number of females was minimal, which could be a type II error due to a lack of statistical power. Fourth, the threshold of school attendance rate is not line with the standards set by the Japanese government. In Japan, absences of 30 days (about 15%) or more per year are defined as long-term absenteeism. Of these absences, those not due to economic reasons or illness are considered *'futoukou'* (school refusal). Classifying absences according to these standards or treating absences as a continuous quantity would be desirable. Finally, IA symptoms were assessed using IAT, but it was designed for general Internet use, not specific to gaming, social media, or content types. Sex differences in content types have been reported; therefore, the use of IAT may have influenced the results of sex differences in this study. In addition, IAT is a questionnaire targeted at typically developing groups and has not been validated for ASD/ADHD. The survey was based on a self-administered questionnaire, and whether it was answered accurately by children in the clinical group with challenges regarding social communication and self-awareness remains unknown. To overcome this limitation, the accuracy of the responses was ensured by asking a medical staff to accompany the children when they responded, but the presence of staff may have influenced responses.

To conclude, females in the ASD group had more IA symptoms than those in the ASD+ADHD group, although IA symptoms were similar between the ASD and ASD+ADHD groups in the entire target population. These findings suggest that coexisting ADHD in children with ASD does not necessarily confer an increased risk for IA symptoms. Individualized assessment of IA symptoms would be warranted, regardless of diagnosis. In terms of the impact on IA symptoms, it also suggests the need to reconceptualize ASD+ADHD as a distinct profile, not just a combination of the two, and to develop distinct treatment strategies. Sex differences were also demonstrated in the effects of family- and school-related factors on IA symptoms. These results suggest sex differences in the mechanisms underlying IA symptoms and the need for sex-sensitive interventions. School attendance may be key, especially for males. In addition, psychosocial factors such as bullying victimization and SES may also be important in considering tailored interventions. However, caution should be exercised in generalizing the results, as this study included children with ASD who were hospitalized. Future research on the impact of coexistence on IA symptoms, including its biological basis, sex differences, and effects of family- and school-related factors, is warranted.

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Declarations

Conflicts of Interest There are no conflicts of interest to declare.

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Ethical Approval This study was approved by the Institutional Review Boards of Tenryu Hospital (reference No:2023-19) and Hamamatsu University School of Medicine (reference No:23–231).

Consent To Participate The participants were not required to obtain written or verbal consent, since this study utilized existing medical record information, and no new materials or information were acquired. Instead, information regarding the study was posted, and participants could refuse to be part of the research.

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