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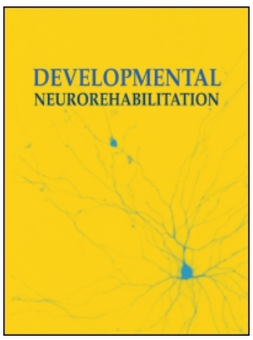

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Attention-Deficit/Hyperactivity Disorder Symptoms, Gastrointestinal Symptoms, Sleep Problems, Challenging Behavior, Adaptive Behavior, and Quality of Life in Children and Adolescents with Autism Spectrum Disorder

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ABSTRACT

This study investigated the relationship between sleep, gastrointestinal symptoms, challenging behavior, adaptive behavior, and quality of life between children and adolescents with autism spectrum disorder (ASD), with and without attention-deficit/hyperactivity disorder (AD/HD) symptoms. Parents of 118 children and adolescents with ASD completed the Conners Early Childhood Rating Scale–Parent Short Form or the Conners 3–Parent Short Form, Children's Sleep Habits Questionnaire, Gastrointestinal Symptom Inventory, Behavior Problems Inventory–Short Form, Pediatric Quality of Life Inventory and the Vineland Adaptive Behavior Scales, Second Edition. The ASD group and the ASD with AD/HD groups differed significantly in sleep problems, gastrointestinal symptoms, and quality of life. Regressions indicated that AD/HD symptoms accounted for a small proportion of the variance for the differences in sleep problems and quality of life. AD/HD symptoms contribute to the complex needs of individuals with ASD. Research is necessary to investigate how these symptoms exacerbate comorbidities.

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Introduction

Autism Spectrum Disorder (ASD) and Attention-Deficit/ Hyperactivity Disorder (AD/HD)

Autism Spectrum Disorder (ASD) is characterized by deficits in social interaction and communication as well as restrictive and repetitive patterns of behavior.[1,2] In addition to the primary symptoms of ASD, individuals with this disorder often present with a range of related medical and behavioral challenges.[3] Recent estimates suggest that over 70% of children diagnosed with ASD will meet the criteria for at least one other comorbid disorder.[4] These co-occurring disorders can include sleep problems,[5] gastrointestinal (GI) symptoms,[6] toileting problems,[7] epilepsy,[8] behavior problems,[9,10] mood disorders,[11] fears and phobias,[12] anxiety disorders,[13] and Attention-Deficit/Hyperactivity Disorder (AD/HD).[14] Among co-occurring challenges, individuals with ASD very often present with a range of inattentive and hyperactive behavior.[15] Individuals with ASD often present with other neurodevelopmental disorders. A neurodevelopmental disorder is a lifelong condition that affects the development of the nervous system, which can result in atypical brain function and can impact psychological function.[16]

AD/HD is a neurodevelopmental disorder characterized by difficulties sustaining attention (i.e., inattentive) as well as inhibiting impulsive behavior and includes primarily inattentive, primarily hyperactive, and combined subtypes, including hyperactivity and inattentive behavior.[1,17] Research has only recently begun studying AD/HD comorbidity in individuals with ASD and other conditions.[18] Previous research has found that 89% of children with ASD have AD/HD symptoms and estimates suggest that 30–50% of children with ASD display one or more symptoms consistent with AD/HD.[19,20] Despite the research highlighting the repeated co-occurrence of ASD and AD/HD, the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision (DSM-IV-TR)[21] did not acknowledge or permit a co-morbid diagnosis. However, with the introduction of the DSM-5, an individual can, for the first time, be clinically diagnosed with comorbid ASD and AD/HD. Due to the constraints of the DSM-IV-TR, the study of ASD and AD/HD has not received adequate research attention.

ASD, AD/HD, and Gastrointestinal (GI) Symptoms

GI symptoms are among the most common concerns for individuals diagnosed with ASD.[22–24] Recent estimates suggest that up to 80% of individuals diagnosed with ASD will experience some level of GI symptoms[5] while severe GI symptoms have been reported among 40.5% of those with ASD.[25] Wasilewska and Klukowski have proposed that the comorbidity of ASD and GI symptoms is due to a clinical endophenotype and that it should be regarded as an overlap syndrome.[26] They argue that the use of this concept should alert clinicians to the possibility of GI tract disease if an individual with ASD presents with agitation, anxiety, aggression/destructive behavior, or with other symptoms that are worsening for unexplained

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reasons. Among these co-occurring challenges, diarrhea, constipation, and abdominal discomfort are often the most frequently endorsed difficulties.[6] Regarding the relationship between AD/HD and GI symptoms, the available literature has suggested that individuals diagnosed with AD/HD also experience comorbid GI symptoms.[27–29] Additionally, pharmacological treatments for AD/HD have been found to exacerbate GI symptoms, as children receiving the stimulant methylphenidate often endorse higher rates of abdominal discomfort and diarrhea, reduced appetite, and weight loss.[30,31]

ASD, AD/HD, and Challenging Behavior

Recent estimates have suggested that over eighty percent of individuals diagnosed with ASD will demonstrate some level of challenging behavior.[32] As such, challenging behavior is among the most commonly endorsed concerns for children and adolescents with ASD.[10] Consistent with ASD, challenging behavior has also been found to co-occur with AD/HD.[29] Research found that children with AD/HD often presented with challenging behavior and that the presence of both ASD and AD/HD symptoms produced greater levels of impairment than the presence of ASD alone.[33] Mayes et al. found that irritability, oppositional behavior, inattention, hyperactivity, impulsivity, and tantrums were significant problems for most children with ASD and children with the AD/HD subtype that included both hyperactivity and inattentive behavior (AD/HD combined).[19] In terms of the frequency of psychiatric neurodevelopmental and somatic symptoms, children with ASD and combined AD/HD combined, were found to have similar profiles.[34] Indeed, children with ASD and AD/HD combined were found to be more impaired than children neurotypical children, and other children with AD/HD, in all areas, except regarding inattention in comparison to children with the AD/HD inattention subtype.[34] Recent research found that children with ASD and AD/HD and ASD alone had higher social impairment than those with AD/HD alone.[35] Dellapiazza et al.[35] also found that for people with ASD and AD/HD, externalized behavioral problems were related to the AD/HD severity whereas internalized behaviors problems were related to ASD severity. The combined AD/HD and ASD presentation has been found to increase risks for other types of disorders as well. Previous research found that the presence of both ASD and AD/HD exacerbated many other psychiatric symptoms, such as depressed mood, resistance, and misconduct.[36]

ASD, AD/HD, and Sleep Problems

Children and adolescents with ASD often present with difficulties related to sleep. Recent estimates have suggested that as much as 80.9% of children and adolescents diagnosed with ASD have problems related to sleep and these problems persist over time.[5,37] Early research has indicated that children with ASD are reported as having more difficulty falling asleep when compared to typically developing controls along with a higher prevalence of dysomnias and parasomnias in children with ASD.[38,39] Additional research has found that these difficulties often persist from childhood and throughout adulthood for individuals with ASD.[40–42] These children with both ASD and comorbid sleep problems often demonstrate higher levels of challenging behavior, hyperactivity, stereotypy, and other forms of undesired behavior.[34,43] Recent comparative research has found that sleep problems are almost twice as prevalent in children with ASD in contrast to typically developing children.[44,45] Behavioral sleep problems have been found to negatively impact social, emotional and academic functioning not only in children with ASD but also in typically developing samples.[46] This relationship is supported by early research which indicated that the presence of sleep problems increased the ratings of challenging behavior among children and adolescents with ASD.[47] Indeed, the connections between specific sleep problems and the patterns of daytime behavior need to understand and identified, through profiling, because the relationships between problems and symptoms for children with ASD can be unique to individuals and complex.[48]

Children with AD/HD often present with sleep problems, and tiredness associated with their AD/HD symptoms.[29] Furthermore, children with AD/HD and ASD have been shown to experience similar levels of behavioral sleep problems as children with AD/HD alone.[49] Further, behavioral symptoms of AD/HD among children with ASD – without a formal diagnosis of AD/HD – have been shown to be associated with sleep problems.[50] These findings are consistent with earlier research which found that sleep problem severity did not differ between children with AD/HD and ASD when compared to children with ASD alone.[49,51] Elevated rates of sleep problems in AD/HD are likely compounded by additional factors as well. For example, children with AD/HD treated with stimulant medication often demonstrate greater difficulties with sleep than individuals with ASD, who are not taking stimulant medication.[52] Research has indicated that behavioral sleep interventions resulted in improvements to sleep and psychosocial quality of life along with a reduction in AD/HD symptom severity.[53]

ASD, AD/HD, and Adaptive Behavior

Adaptive functioning represents an individual's capacity to perform behavior essential to everyday life.[54] Among various areas related to everyday functioning, adaptive behavior represents the ability to communicate, socialize, problem-solve, and perform daily living skills.[54] While adaptive behavior is correlated with an individual's overall cognitive functioning, individuals with ASD generally achieve adaptive skills 1–2 deviations below their same-aged peers.[55] This difference from neurotypical peers is correlated with the presence and severity of the symptoms of ASD.[56,57] Recent research has found that this difference is further compounded by the presence of other symptoms. Research compared levels of adaptive functioning in individuals with ASD and AD/HD, and ASD alone.[56] They found that the combination of these two disorders resulted in significantly lower levels of adaptive functioning. These results and others further highlight the impact of hyperactive and inattentive symptoms in children and adolescents with ASD.

ASD, AD/HD, and Quality of Life

Health-related Quality of Life (HRQoL) is often used as an outcome measure for several types of treatments. While useful

as an overall outcome measure, HRQoL has been used less often in treatments for individuals with ASD.[58–60] Consistent with trends observed in adaptive behavior, measures of HRQoL are often substantially lower in individuals with ASD than same-aged peers without ASD.[59–61] Research has found that quality of life is further impaired when additional disorders are present. Research compared levels of adaptive functioning between individuals with ASD alone to individuals with ASD and AD/HD. These researchers found that ASD with comorbid AD/HD symptoms resulted in significantly lower levels of HRQoL than found in ASD alone. The results of this study further highlight the impact that AD/HD symptoms can have on the overall quality of life for individuals with ASD.

Current Study

Research suggests that individuals with ASD present with a broad range of complex, often co-occurring needs. Regarding hyperactive and inattentive behavior, the current literature suggests that the presence of symptoms consistent with AD/HD contributes to significantly greater impairment in multiple domains.[35,57,59,60] These findings highlight the complex and often overlapping symptoms that present with ASD. Difficulties with inattention and hyperactivity can influence and are likely influenced by, a range of factors that include GI symptoms, challenging behavior, sleep problems, adaptive behavior, and quality of life. Given the range and scope of the factors involved, an investigation of relevant variables was indicated. The present study was designed to extend the existing literature by investigating the relationship between AD/HD symptoms in a sample of children and adolescents with ASD. This research examined the relationship between AD/HD symptoms and sleep problems, GI symptoms, challenging behavior, quality of life and adaptive functioning. The present study also investigated the association between AH/HD symptoms and ID, gender, medication usage and GI symptoms, and educational intervention. In addition, to elicit knowledge that might facilitate future clinical decision-making, the study investigated potential predictors of sleep problems and quality of life. Guided by the literature, and their relevance to guide clinical practice, the following potential predictors of sleep problems were investigated: age, gender, medication usage, AD/HD symptoms, GI symptoms. Whereas age, gender, ID, or AD/HD symptoms were investigated as predictors of life quality.

Method

Participants

A total of 118 children and adolescents with a diagnosis of ASD participated in the study. Over half of participants had an existing diagnosis of AD/HD prior to participation (n = 67; 56.8%), while the remaining 43.2% (n = 51) had a diagnosis of ASD alone. There were no exclusion criteria and individuals with a diagnosis of epilepsy were not excluded from this study. Diagnoses were provided by a licensed psychologist or pediatrician independent of the study. The participants received their diagnoses using a formal diagnostic protocol that employed multiple diagnostic measures. Caregiver information was obtained on professional diagnosis, using the DSM-5 criteria,[1] the diagnostic setting/organization, and professional-(s) who made the diagnosis. The diagnosis of AD/HD was made under a year before the study in 23% of participants; 1–2 years previously for 18% of participants; 3–5 years previously for 26% participants and more than 5 years previously in 33% of participants. Mean age of study participants was 9.55 years (SD = 3.74; Range = 3–17) and most study participants were male (n = 92; 78% male). Individuals having both ASD and AD/HD were also predominantly male (n = 52; 77.6%). Rates and levels of intellectual disability (ID) ranged considerably, with 41.5% of caregivers endorsing some varying level of ID (n = 49). Individual levels of ID were as follows: Mild (n = 20, 40.82%), Moderate (n = 22, 44.90%) and Severe (n = 7, 14.28%).

Procedure and Informants

Parents and guardians were made aware of the study through parent support groups and special schools. If parents wished to participate in the study, they were provided with a participant information sheet and a consent form to complete. Once consent was obtained, the informants were provided with the battery of the questionnaires below to complete in their own time. Informants were parents of children and adolescents diagnosed with ASD. Rating scales were completed by parents independently according to the instructions printed on top of the questionnaires. Ethical approval was granted by the School of Psychology Research Ethics Committee at the National University of Ireland, Galway.

Measures

Demographic Questionnaires

A self-constructed demographic information questionnaire provided information on participant age, gender, diagnosis (i.e., ASD, AD/HD), presence and level of ID, presence and type of anxiety disorder, and the treatment approaches currently being undertaken (i.e., therapies, medications). Data were collected on current diagnoses, as well as age at diagnosis. A summary of demographic information is presented in Table 1.

Conners Early Childhood Rating Scale – Parent Short Form

The Conners Early Childhood Rating Scale (Conners EC) is a questionnaire designed to measure symptoms of AD/HD in children aged between 2 and 6 years of age.[62] The Conners EC yields six distinct subscales: Inattention/Hyperactivity, Social Functioning/Atypical Behavior, Anxiety, Mood/Affect, Physical Symptoms, and Sleep Problems. Responses are rated on a 4-point Likert scale from 0 = not true at all (never, seldom), 1 = Just a little true (occasionally), 2 = Pretty much true (often, quite a bit), 3 = very much true (very often, very frequently). Internal consistency and Test-retest reliability of the Conners EC has been found to be satisfactory,[62] and the scale has been successfully administered to ASD samples.[63] For this study, the Inattention/Hyperactivity subscale of the Conners EC was used as the primary indicator of AD/HD

Table 1. Summary of demographic information.

	M	*SD*
Age of diagnosis (in years)		
ASD	5.77	3.23
AD/HD	6.31	2.86
	n	%
Educational Intervention	116	98.30
Mainstream approaches	77	65.30
Applied Behavior Analysis	11	9.30
Eclectic approaches	1	0.80
Other	27	22.90
Medication	77	65.30
Melatonin	38	32.20
Methylphenidate	18	14.29
Risperidone	10	7.94
Atomoxetine	10	7.94
Fluoxetine	6	4.76
Clonidine	6	4.76
Anxiety disorder	22	18.60
Generalized Anxiety Disorder	16	72.70
Separation Anxiety Disorder	4	18.30
Selective mutism	1	4.50
Obsessive-Compulsive Disorder (OCD)	1	4.5%

symptoms for participants in the early childhood range. T scores were used to calculate AD/HD symptom severity. In the present study, the Conners EC demonstrated good internal consistency (Cronbach's α = .82).

Conners 3 – Parent Short Form

The Conners 3 – Parent Short Form (Conners 3) is a rating scale designed to measure the symptoms of AD/HD in children aged between 6 and 18 years of age.[64] The Conners 3 yields six subscales: Inattention, Hyperactivity/Impulsivity, Executive Functioning, Learning Problems, Defiance/Aggression, and Peer/Family Relations Responses are rated on a 4-point Likert scale from 0 = not true at all (never, seldom), 1 = Just a little true (occasionally), 2 = Pretty much true (often, quite a bit), 3 = very much true (very often, very frequently). This measure has been found to have good test-retest reliability and internal consistency,[64] and the scale has been previously used to examine ASD populations.[65,66] This study used the average of both the Inattention and Hyperactivity/Impulsivity subscales as the primary indicator of AD/HD symptoms for participants in the later childhood range. T scores were used to calculate AD/HD symptom severity. In the present study, the Conners 3 demonstrated good internal consistency (Cronbach's α = .81).

Children's Sleep Habits Questionnaire

The Children's Sleep Habits Questionnaire (CSHQ) is a rating scale designed to assess sleeping habits in typically developing children.[67] In order to calculate the subscale and total scores, 33 items are used. The CSHQ provides eight individual subscales: Bedtime Resistance, Sleep Onset Delay, Sleep Duration, Sleep Anxiety, Night Wakings, Parasomnias, Daytime Sleepiness, and Sleep Disordered Breathing. Individual subscales were added to calculate a total CSHQ score, and a cutoff of 41 was used as the clinical cutoff for determining possible sleep problems.[67] It has been reported to have good test-retest reliability of between .62 and .79 and internal consistency, which ranges from .68 to .78.[68] In the present study, the CSHQ demonstrated acceptable internal consistency (Cronbach's α = .75).

Gastrointestinal Symptom Inventory

The Gastrointestinal Symptom Inventory[69] is a measure designed to collect information relevant to GI symptoms. This instrument measures symptoms including abdominal pain, nausea, bloating, diarrhea, and other GI symptoms. The inventory is scored dichotomously; specifically, whether the child possesses any GI symptoms. Individual items were added to calculate a total GI score. The GI has been used previously to assess the GI symptoms in children and adolescents with ASD,[70] but it has not to date been psychometrically validated. In the present study, the GI Symptom Inventory demonstrated moderate internal consistency (Cronbach's α = .65).

Behavior Problems Inventory – Short Form

The Behavior Problems Inventory – Short Form (BPI-S)[71] is an abbreviated version of the Behavior Problems Inventory (BPI-01).[72] The BPI-S is an instrument created to detect both the frequency and severity of undesirable behavior. The BPI-S yields the following subscales: Self-injurious behavior (SIB), Aggressive/Destructive behavior and Stereotyped behavior. Each item on the Self-injurious behavior and Aggressive/Destructive behavior subscales are rated on a frequency scale, and a severity scale, while the Stereotyped behavior subscale is rated on a frequency scale only. This measure has satisfactory levels of reliability and validity, with internal consistency ranging from fair (self-injurious behavior) to good (aggressive/destructive and stereotyped behavior).[73] In the present study, the BPI-S demonstrated good internal consistency (Cronbach's α = .84). Subscales were treated as separate constructs for the purpose of analysis, and T scores were not implemented.

Pediatric Quality of Life Inventory

The Pediatric Quality of Life Inventory (PedsQL) is a measure of health-related quality of life (HRQoL). The PedsQL was designed for use with children and adolescents between the ages of 2 and 18 years.[74] The PedsQL yields four quality of life subscales: Physical, Emotional, Social and School Functioning. Items are reverse scored and transformed to a 0–100 scale. Items answered in the Emotional, Social and School functioning scales are computed to create the Psychological Health Summary Score. The Physical Health Summary Score is taken as the same as the Physical Functioning Scale Score. The total score is computed as a sum of all items over the number of items answered on all scales. This measure has satisfactory reliability and validity[75] and has been used to assess HRQoL for both clinical and non-clinical groups.[76] In the present study, the PedsQL demonstrated acceptable internal consistency (Cronbach's α = .75).

Vineland Adaptive Behavior Scales, Second Edition

The Vineland Adaptive Behavior Scales – Second Edition (VABS-II) is a behavior rating scale that measures the adaptive functioning of children or adults. It can be used to assess the overall adaptive skills of a child and adults, with ages ranging

from 0 to 90 years.[77] The VABS-II provides four subscales: Communication, Daily Living Skill, Socialization and Motor skills. This measure has good reliability and validity and is often used as both a diagnostic and progress monitoring tool for children and adults with developmental disorders.[77] Composite scores were used to calculate an overall adaptive behavior score. In the present study, the VABS-II demonstrated excellent internal consistency (Cronbach's α = .90).

Results

Analyses

Statistical analyses were performed using the IBM SPSS Statistics Software – Version 21. Independent samples *t*-tests were performed to investigate the relationship between the presence of AD/HD symptoms and sleep problems, total GI symptoms, challenging behavior, quality of life, and adaptive functioning. A MANOVA was performed to compare means between individual subscales of the VABS-II. Additional independent-samples *t*-tests were performed to compare individual subscales of the CSHQ, and Bonferroni Corrections were conducted to reduce the chances of obtaining Type I errors in all *t*-tests, which is increased when multiple comparisons are conducted simultaneously on the same dependent variables.[78] Bonferroni adjustment was chosen because it is regarded as a statistically conservative approach.[79] The alpha level was adjusted to .004 on the basis of the 14 analyses conducted. Chi-Squares were performed to examine associations between AD/HD symptoms and ID, gender, medication, presence of GI symptoms, abdominal pain, nausea, bloating, constipation, diarrhea, other GI symptoms, treatment of GI symptoms, and educational intervention. Mann-Whitney *U* tests were performed to determine potential differences in physical health and bedtime resistance between groups. Two multiple regressions were conducted to determine if age, gender, medication usage, AD/HD symptoms, or total GI symptoms were predictive of total sleep problems, and to determine if age, gender, ID, or AD/HD symptoms were predictive of quality of life.

Specific subscales of the Conners EC and the Conners 3 and were used to analyze AD/HD symptoms. The Inattention/Hyperactivity subscale and Inattention and Hyperactivity subscales were analyzed from the Conners EC and Conners 3, respectively. The sample of 118 participants was grouped into AD/HD and no AD/HD groups dependent on the amount of presenting AD/HD symptoms. Nearly ninety percent of participants presented with some level of AD/HD symptoms as indicated by scores ranging from "very elevated" to "high average" on the symptom metric (n = 105, 89.8%). Only eleven percent of participants presenting with no AD/HD symptoms (n = 13, 11%). Levels of AD/HD symptoms were as follows: Very elevated (T-score ≥ 70, n = 95, 80.5%), elevated (T = 65–69, n = 5, 4.2%), high-average (T = 60–64, n = 6, 5.1%), and average (T = 45–59, n = 12, 10.2%). Participant symptom levels by gender were as follows: Very elevated (male: n = 73, 77%; female: n = 22, 23%), elevated (male: n = 4, 80%; female: n = 1, 20%), high-average (male: n = 5, 83%; female: n = 1, 17%), and average (male: n = 10, 83%; female: n = 2, 17%). The clinical cutoff point for the AD/HD was a T score of 45 from the Connors' questionnaire. This cutoff point was used to form the ASD with AD/HD groups in the present study. No study participants were rated as having T-scores below 40. An independent-samples t-test was conducted to compare the groups created from the Conners EC and Connors 3 questionnaires to whether individuals had a preexisting AD/HD diagnosis. There was a significant difference between those who did not have an AD/HD diagnosis (M = 73.82, SD = 11.85) and those with an AD/HD diagnosis (M = 83.20, SD = 8.33) conditions; t (91) = −4.478, p < .001). . Further details of how the groups were similar and different regarding the variables under investigation are reported below in sections 3.2 to 3.9.

Demographics

Demographic information is presented in Table 1. An independent samples *t*-test indicated that there was not a significant difference in the ages of the ASD only (M = 8.91, SD = 4.21) and ASD with AD/HD groups, (M = 9.63, SD = 3.69), t (116) = −0.65, p = .516). A small effect size was observed (d = 0.18), indicating that participants with ASD and AD/HD were on average 0.18 standard deviations above the mean age of those with ASD. The results of a Pearson Chi-Square test revealed a significant difference in medication use between ASD only and ASD with AD/HD groups (χ^2 = 6.39, p < .05). Rates of medication use were 23.1% and 60% for the ASD only group and the ASD with AD/HD group, respectively. Pearson Chi-Square tests did not find a significant difference in either gender (χ^2 = .38, p = .731, φ = .06), presence of ID (χ^2 = 2.05, p = .233, φ =,13), or presence of educational intervention (χ^2 = 7.78, p = .051, φ =.26) for the ASD only and ASD with AD/HD groups. A Pearson Correlation matrix for measured variables can be found in Table 2.

AD/HD Symptoms

Children aged 7–12 scored higher on the Hyperactivity/Impulsivity scale (M = 83.15, SD = 9.48), than children aged 13–18 (M =78.04, SD = 15.60). Children aged 7–12 (M = 77.23, SD = 12.55) also scored higher on the Inattention than did children aged 13–18 (M 76.70 SD 12.91).

GI Symptoms

The majority of participants were reported as having one or more GI symptoms within the previous three months (n = 95, 80.5%). A summary of the frequency of caregiver-reported GI symptoms is presented in Table 3. An independent samples *t*-test indicated that there was not a significant difference in total GI symptoms between ASD only (M = 1.77, SD = 1.17) and ASD with AD/HD (M = 1.88, SD = 1.28) groups, t (116) = −0.29, p = .775. A very small effect size was observed (d = 0.09). A Pearson Chi-Square test revealed a significant difference in the rates of constipation between ASD only (30.8%) and ASD with AD/HD (48.6%) groups, χ^2 = 11.22, p < .01, φ = .31. Pearson Chi-Square tests revealed no significant differences in abdominal pain (χ^2 = .51, p = .773, φ =.07), nausea (χ^2 = 4.24, p = .12, φ =.19), bloating (χ^2 = .33, p = .850, φ =.05), diarrhea (χ^2 = 1.44, p = .487, φ =.11), or other GI symptoms (χ^2 = .78, p = .676, φ = .08) between these groups.

Table 2. Pearson Correlation Coefficient matrix for measured variables.

	1.	2.	3.	4.	5.	6.	7.	8.
1. Age								
2. Age at AD/HD diagnosis	.42**							
3. Sleep problems	-.17	.01						
4. GI symptoms	-.23*	-.19*	.37**					
5. SIB severity	-.02	-.06	.27**	.20*				
6. Aggression severity	-.09	.10	.33**	.10	.29**			
7. Quality of Life	-.07	-.01	-.41**	-.33**	-.49**	-.29**		
8. Adaptive Behavior	-.36**	-.22*	-.03	.14	-.41**	-.04	.26**	
9. Inattention/ Hyperactivity (age 2-6 years)	-.27	.41*	.41*	-.03	.36	.32	-.62**	-.46*
10. Inattention (age 6-16 years)	.05	.35**	.11	-.04	.17	.07	-.24*	-.30**
11. Hyperactivity/ Impulsivity (age 6-16 years)	-.16	.23*	.25*	.05	.21*	.32**	-.22*	-.16

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

Table 3. Summary of caregiver-reported GI symptoms within the previous six months.

	n	%
One or more symptom	95	80.50
One symptom	22	18.60
Two symptoms	32	27.10
Three symptoms	31	26.30
Four symptoms	9	7.60
Five symptoms	1	0.80
Abdominal Pain	62	52.50
Constipation	55	46.60
Diarrhea	46	39.00
Nausea	36	30.50
Bloating	18	15.30
Other symptoms	5	4.20

Roughly one third of study participants were receiving treatment for GI symptoms (n = 42, 35.6%). Caregiver-reported rates of treatment for individual GI symptoms were as follows: Constipation (n = 31, 26.3%), abdominal pain (n = 13, 11%), nausea (n = 3, 2.5%), diarrhea (n = 3, 2.5%), other GI symptoms (n = 2, 1.7%), and bloating (n = 1, 0.8%). A Pearson Chi-Square test revealed no significant difference in whether treatments were received for GI symptoms between ASD only (30.8%) and ASD with AD/HD (36.2%) groups, $\chi^2 = .15$, $p = .769$, $\varphi = .04$.

Medication Use and Constipation

In overall medication usage, the overall rates of caregiver-reported administration of pharmacological treatments were 47% and 45.5% for children and adolescents with ASD-only and ASD with AD/HD, respectively. A Pearson Chi-Square test was performed to examine the association between medication administration and the presence of caregiver-reported constipation. The results of this test indicated that there was not a significant association, $\chi^2 = .008$, $p = .996$, $\varphi = 8.23$.

Sleep Problems

Over ninety percent of study participants (n = 108, 91.5%) presented with sleep problems on the CSHQ (M = 54.54, SD = 10.51). Daytime sleepiness was the highest reported sleep problem in 3–6 years (M = 12.12, SD = 3.23), 7–12 (M = 13.47, SD = 3.21) and in 13–18 years (M =14.26, SD = 3.80). The results of an independent samples t-test indicated a significant difference in CSHQ total scores between the ASD only (M = 46.62, SD = 8.46) and ASD with AD/HD (M = 55.52, SD = 10.36) groups, t (116) = −2.98, $p < .01$. A medium effect size was observed (d = −0.55, r = .27), indicating that participants with ASD only had less sleep problems than those with ASD and AD/HD. Additional independent samples t-tests found no significant differences between groups in either sleep onset, t (116) = −.99, p = .324, sleep duration, t (116) = −1.45, p = .149, disordered breathing, t (116) = −1.09, p = .278, or daytime sleepiness specifically, t (116) = −1.52, p = .133. Levene's test for equality of variances indicated that the assumption of homogeneity of variance had been violated for bedtime resistance (F = 17.57, p <.001), therefore the non-parametric equivalent test was used. A Mann-Whitney U test indicated a significant difference in bedtime resistance between ASD only (M = 6.41) and ASD with AD/HD (M = 9.44) groups, U = 267.00, $p < .006$. An additional Mann-Whitney U test found no significant differences in sleep anxiety between ASD only (M = 5.75) and ASD with AD/HD (M = 7.26) groups, U = 460.00, p = .053.

Challenging Behavior

The majority of participants presented with at least one form of challenging behavior on the BPI-S (n = 117, 99.2%). The types of challenging behavior included: Stereotyped behavior (n = 114, 96%), Aggressive/destructive behavior (n = 109, 92%), and SIB (n = 96, 81%). Ranges of behavior endorsed by caregivers on the BPI-S varied, with 5.9% (n = 7) endorsing one elevated subscale, 16.9% (n = 20) endorsing two elevated subscales and 76.3% (n = 90) endorsing elevated scores on all three subscales. Stereotyped behavior was the highest reported challenging behavior in 3–6 years, 7–12 years and in 13–18 years. An independent samples t-test found a significant difference in stereotyped behavior frequency between ASD only (M = 11.31, SD = 10.59) and ASD with AD/HD (M = 19.80, SD = 12.04) groups, t (116) = −2.43, $p < .05$. A large effect size was observed (d = 0.75). Independent samples t-tests revealed no significant differences in SIB frequency, t (116) = −1.422, p = .16, SIB severity, t (116) = −1.60, p = .111, aggressive/

destructive behavior frequency, t (116) = −1.26, p = .209, or aggressive/destructive behavior severity, t (116) = −1.42, p = .159.

Adaptive Functioning

Over eighty percent of study participants were scored as having some impairment in adaptive functioning (n = 96, 81.4%). Daily living skill was the highest reported subscale in 3–6 years) while Communication was the highest reported subscale in 7–12 years and in 13–18 years the overall Adaptive Behavior Composite of the VABS-II was 70.84 (SD = 17.07) for the study sample. Levels of adaptive function standard scores (SS) endorsed by caregivers ranged considerably, as follows: low (SS ≤ 70, n = 61, 51.7%), moderately-low (SS = 71–85, n = 35, 29.7%), adequate (SS = 86–114, n = 20, 16.9%), and high (SS ≥ 130, n = 2, 1.7%). No participants were rated as having a moderately high adaptive level (SS = 115–129) or above. A one-way multivariate analysis of variance (MANOVA) was conducted to examine differences in individual subscales on the VABS-II. Box's Test of Equality of covariance matrices was not significant ($F_{(10,\ 351.049)}$ = 1.84, p = .052), therefore ensuring there was equality of covariance matrices. The MANOVA found no significant differences between the ASD with AD/HD and ASD only groups on subscale measures (Wilk's Λ = .94, $F_{(4.\ 29)}$ = .69, p = .608, ηp^2 = .08).

Quality of Life

The results of caregiver-completed PedsQL indicated that the average HRQoL total score was 48.85 (SD = 16.60). The results of an independent samples t-test indicated a significant difference between ASD only (M = 65.06, SD = 12.06) and ASD with AD/HD (M = 46.84, SD = 16) groups for PedsQL Total, t (116) = 3.96, p < .001. A medium effect size was observed (d = 0.76, r = .35), indicating that participants with ASD only had higher overall HRQoL than those with both ASD and AD/HD. The results of an independent samples t-test indicated a significant difference in psychosocial health between ASD only (M = 58.41, SD = 14.45) and ASD with AD/HD (M = 41.74, SD = 15.26) groups, t (116) = 3.74, p < .001. A medium effect size was observed (d = 0.69, r = .33), indicating that participants with ASD only had higher ratings of psychosocial health than those with ASD and AD/HD. Levene's test for equality of variances indicated that the assumption of homogeneity of variance had been violated for physical health (F =4.23, p =.042), therefore the non-parametric equivalent test was used. The results of a Mann-Whitney U test revealed a significant difference in physical health between ASD only (M = 88.19) and ASD with AD/HD (M = 55.95) groups, U = 309.50, p < .05. Table 4. Summarizes the ASD and ASD+AD/HD groups by the study variables.

Table 4. Summary of the ASD and ASD+ADHD Groups by the Study Variables

	ASD	*ASD+AH/HD*	*Difference between Groups*
Age of Participant	M =8.91, SD =4.21	M =9.63, SD =.69	t (116) = -0.65, p = .516).
Total GI Symptoms	M =1.77, SD =1.17	M =1.88, SD =1.28	t (116) = -0.29, p = .775.
Constipation	30.8%	48.6%	*χ^2 =11.22, p < .01, φ =.31
Treatments for GI	30.8%	36.2%	χ^2 = .15, p = .769, φ = .04.
Total Sleep Problems	M =46.62, SD=8.46	M =55.52, SD=10.36	* t (116) = -2.98, p < .01.
Bedtime resistance	M = 6.41	M = 9.44	* U = 267.00, p < .006.
Sleep anxiety	M = 5.75	M = 7.26	U = 460.00, p = .053.
Stereotyped Behavior frequency	M =11.31, D=10.59	M =19.80, SD=12.04	* t (116) = -2.43, p < .05
Quality of Life	M =65.06, D=12.06	M =46.84, SD =16	*t (116) = 3.96, p < .001
Psychosocial health	M=58.41, SD=14.45	M =41.74, SD=15.26	*t (116) = 3.74, p < .001.
Physical Health	M = 88.19	M = 55.95	*U = 309.50, p < .05.
Rate of Medication Use	23.1%	60%	* χ^2 = 6.39, p < .05

*= Significant difference

Regressions

The predictor variables to determine if age, gender, medication usage, AD/HD symptoms or total GI symptoms, were predictive of sleep problems were entered into the model using the enter method. Multicollinearity was not present in the data. Pearson's Correlation statistics for predictor variables were less than .7 (see Table 5). The variance inflation factor (VIF) scores were less than 10 (range 1.01–1.2) and tolerance scores were greater than .1 (range .82-.99).

The results of the multiple regression analysis (see Table 6) show that the overall model was significant accounting for 20% of the variance in total sleep problems ($F_{(5,112)}$ = 6.88, p < .001, R^2 = .24, $Adj.\ R^2$ = .20). Examination of beta coefficients revealed that GI symptoms (β = −.35, p < .001) and AD/HD symptoms (β = −.22, p = .014) significantly contributed to the model. Age (β = −.15, p = .108), gender (β = −.04, p = .635) and medication use (β = .16, p = .075) were not significant contributors to the model.

The predictor variables to determine if age, gender, ID, or AD/HD symptoms were predictive of HRQoL, were entered into the model using the enter method. Multicollinearity was not present in the data. Pearson's Correlation statistics for predictor variables were less than .7 (see Table 5). The variance inflation factor (VIF) scores were less than 10 (range 1.01-.105) and tolerance scores were greater than .1 (range .95-.99).

– -Insert Table 5 about here – -

The results of the multiple regression analysis (see Table 6) revealed that the overall model was significant, accounting for 11% of the variance of HRQoL ($F_{(4,113)}$ = 3.92, p = .002, R^2 = .14, $Adj.\ R^2$ = .11). Examination of beta coefficients revealed that AD/HD symptoms was the only significant contributor (β = .36, p < .001). The predictor variables of age (β = −.07, p = .433), gender (β = −.02, p = .848) and ID (β = .10, p = .281) were not significant contributors.

Discussion

The current study examined the relationships between AD/HD symptoms and sleep problems, adaptive functioning, behavior

Table 5. Pearson's Correlation statistics for predictor and criterion variables.

Variable	1	2	3	4	5
1. Total Sleep Problems					
2. Total GI Symptoms	.36**				
3. AD/HD Symptoms	-.26*	.02			
4. Age	-.17*	-.23*	-.03		
5. Gender	-.04	-.04	-.06	.07	
6. Medication Use	.16*	-.08	-.31**	.30***	.06
Variable	1	2	3		
1. HRQoL					
2. AD/HD Symptoms	.35***				
3. Level of ID	.02	-.18*			
4. Age	-.07	-.03	.10		

*$p < .05$, **$p < .01$, $p < .001$

Table 6. Summary of hierarchical multiple regression analysis for variables predicting Total Sleep Problems and Health-related Quality of Life (HRQoL).

Predictor	*B*	*SE*	*β*	*p*	*F*	R^2	*Adj.* R^2
Sleep Problems (Total CSHQ)					6.88	0.24	0.20
Total GI symptoms	2.88	0.71	0.35**	.001**			
AD/HD symptoms	-2.34	0.93	-0.22*	.014*			
Age	-.41	0.25	-0.15	.108			
Gender	-0.99	2.01	-0.04	.635			
Medication Use							
Quality of Life (Total PedsQL)							
AD/HD Symptoms	6.14	1.50	0.36***	.001***			
Gender	-.68	3.52	-0.02	.848			
Presence of ID	1.67	1.54	0.10	.281			
Age	-.31	0.39	-0.07	.433			

*$p < .05$, **$p < .01$, $p < .001$

problems, GI symptoms, and overall quality of life of children and adolescents with ASD. This study found that while 56.8% of participants had a formal diagnosis of AD/HD, almost 90% of participants demonstrated symptoms consistent with that of AD/HD. Additionally, the presence of these elevated AD/HD symptoms was often accompanied by increased levels of impairment across multiple domains. The results of this study highlighted the impact of AD/HD symptoms, on the needs of children and adolescents with ASD. Consistent with the existing literature, this study found that participants with both ASD and AD/HD had significantly higher levels of impairment in the areas of sleep problems, GI symptoms, and overall quality of life.

It was found that that 91.5% of participants presented with a sleep problem. This finding is higher than previous findings that found that 80.9% of children and adolescents with ASD had sleep problems.[31] Furthermore, the study found that participants with ASD and AD/HD symptoms had significantly more sleep problems than those with ASD only, particularly in relation to bedtime resistance. AD/HD symptoms were found to predict sleep problems in children and adolescents with ASD. GI symptoms also predicted sleep problems, which is a finding which is in line with prior data, such as by Hollway and colleagues, who identified that GI symptoms predicted total scores on the CSHQ,[80] the same measure employed in the current study.

Findings that increased levels of AD/HD symptoms were related to poorer sleep outcomes is not altogether surprising. Sleep and sleep-related challenges often co-occur with AD/HD symptoms, often independent of stimulant medication usage.[81] Hyperactive and inattentive symptoms often manifest in a range of sleep-related difficulties that contribute to difficulties for the individual and their families.[80,82] As such, the presence of hyperactive and inattentive symptoms in children and adolescents diagnosed with ASD may warrant additional investigation into, as well as intervention for, potential sleep disturbances. It is recommended that sleep problems should be considered a high priority for intervention by clinicians, as they may interfere with the success of other interventions.[59] Furthermore, in order to accurately access the progression of sleep disorders in children and adolescents with ASD and AD/HD symptoms, it may be beneficial for future work to conduct longitudinal research.

In addition to increased impairments in sleep, the combination of ASD and AD/HD symptoms was related to significantly higher rates of GI symptoms. Consistent with the available literature on comorbid GI symptoms,[5] over 80% of the participants in this study were endorsed as having at least one type of GI symptom. Concurrent to the established literature, diarrhea, constipation, and abdominal pain were among the most frequently cited concerns in the current study.[83] Also, consistent with findings of previous research,[27,28] the current study found that children and adolescents with ASD showing symptoms of AD/HD experienced higher levels of GI symptoms, such as constipation.

However, it is notable that a subset of GI symptoms reported by children with an AD/HD diagnosis may be in part due to the side effects of medication.[33] Regarding constipation, however, in a review of 102 studies in 12 meta-analyses,[84] the overall prevalence of constipation among children and adolescents with AD/HD prescribed methylphenidate was just 7.60%. As such, additional investigation of GI symptoms in children and adolescents with ASD with and without a medication regimen may be necessary to further clarify this observation. The high prevalence of GI symptoms among the children and adolescents with ASD in the current study makes it pertinent to further explore and develop effective interventions and treatments. Effective treatments and interventions are important for alleviating GI symptoms among children with ASD as GI symptoms are often found to significantly predict the development of sleep problems, feeding problems, challenging behaviors, and rigid compulsive behaviors.[85]

Challenging behavior was found to be present among 99.2% of the participants in the study. This rate is considerably higher than previous research that has identified 82% of participants as having some form of challenging behavior.[33] Although it is assumed that the characteristics of AD/HD may exacerbate challenging behavior, in contrast to the findings of Dellapiazza et al.,[35] there was no significant difference in the current study regarding challenging behavior, that involved SIB or aggressive destructive behavior, between participants with ASD only and participants with ASD and AD/HD symptoms.[35] This finding may be impacted through almost all participants exhibiting challenging behavior. Previous research has found tantrum behaviors to be more common in children with ASD and AD/HD.[33] However, considering that almost all of the participants in the current study presented with challenging behavior, it is recommended that treatment plans, individualized for children,[35] are developed to decrease the level of SIB, aggressive/destructive behavior, and

stereotyped behavior in children and adolescents with ASD.[41] Indeed, effective treatment is vital as individuals displaying challenging behavior can be at an increased risk of abuse, bullying, neglect, and isolation.[86]

With respect to overall adaptive skills, over 80% of the participants in this study were endorsed as having impaired levels of adaptive functioning. Existing research has found an interaction between AD/HD and ASD symptoms that have negatively impacted overall adaptive functioning.[57] However, the results of the current study did not find any significant differences in overall adaptive functioning between the ASD alone and the ASD with AD/HD groups. One possible explanation for this finding is that since adaptive functioning was impaired in most of the sample, it was difficult to make clear comparisons across groups. Therefore, future studies should include participants with a variety of levels of adaptive functioning, such as those involved in assisted education initiatives. Indeed, it would be helpful to examine samples of individuals with AD/HD and typically functioning individuals, to understand the impact of specific AD/HD symptoms (e.g., hyperactivity, inattention) on these co-occurring conditions, as well as how those specific symptoms impact functioning among adaptive skills. The main limitation of the current study is that parental report was used to obtain data. It is recommended that objective measures should be employed in future studies to measure comorbid conditions. This would include examining stool samples to measure GI symptoms and using actigraphy or polysomnography to examine if sleep problems are present in individuals. However, these approaches are often considered to be invasive for some individuals, especially children and adolescents with ASD that may have particular sensory issues.[87] Although parental report was used in the current study, previous research suggests that there is a large percentage of agreement between parental report and clinical observation. For example, research revealed a high level of concordance (92.1%) between parental report and gastroenterologist evaluations for the presence of GI dysfunction.[88] Some GI symptoms such as nausea and abdominal pain are more difficult for parents to observe, especially in children and adolescents with ASD that have impaired social and communication skills or are non-verbal. Considering this, research should focus on developing objective measures that are suitable and effective for children and adolescents with neurodevelopmental disorders. Other limitations were that the current study examined, with a small sample size, a large age range of children and adolescents that contained relatively few children with ASD alone. In addition, while it was found that age and gender did not significantly differ between the two comparison groups in this study, future studies should consider entering these variables as covariates in their statistical analyses. Finally, it should be noted that using a Bonferroni adjustment during the analysis with simultaneous t-tests, reduced the potential of type 1 error but doing so also increased the likelihood of a type 2 error occurring.[89] Therefore, it is theoretically possible that some significant differences between groups were not revealed during the current analysis. The study findings should be interpreted in light of these limitations and future research could focus on specific age groups, and ensure more evenly balanced comparison groups, to strengthen the validity of findings.

The findings of the current study have several clinical implications, specifically for the treatment of AD/HD symptoms in children and adolescents with ASD. The current study found that individuals presenting with ASD and AD/HD symptoms were rated as having significantly lower HRQoL than individuals with ASD alone. These findings are consistent with earlier research, suggesting that AD/HD symptoms contribute to an overall lower HRQoL for both children and adolescents with ASD.[57] It is possible that, by reducing AD/HD symptoms in children and adolescents with ASD, in addition to treating core symptoms, their quality of life may be improved considerably.

The current study has successfully added to the under researched area of comorbidity in children and adolescents with ASD. It has shown that the presence of AD/HD symptoms create a more complex clinical picture for children and adolescents with ASD. Children and adolescents with ASD and AD/HD symptoms presented with significantly more sleep problems, constipation, increased stereotyped behavior, and they had a lower quality of life. The results of this study extend the existing literature by further clarifying the impact of hyperactive and inattentive (i.e., AD/HD) symptoms for children and adolescents with ASD. Future research is needed to investigate how these symptoms exacerbate comorbidities. This research should use larger samples of participants and collect data using objective measurements of behavior.

Disclosure statement

All the authors of this article declare that they have no conflict of interest.

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Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of National University of Ireland Galway and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent

Informed consent was obtained from all individual participants included in the study.

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