Sleep Problems in Children with Autism Spectrum Disorder and Attention-Deficit/Hyperactivity Disorder: A Comparative Study and Effects on Communication Skills

RUNNING TITLE: Sleep problems and communication skills

Carmen Berenguer, Inmaculada Baixauli*, Eva Rosa, Simona De Stasio

(*) Corresponding Author: inmaculada.baixauli@ucv.es

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Lay Summary

Few studies have delved into the impact of sleep problems on the communication skills of children with neurodevelopmental disorders, such as ASD and ADHD. We found that sleep problems partially mediate the relationship between symptoms and communication skills. Our work emphasizes the need of considering sleep disorders when assessing structural and pragmatic language in ASD and ADHD, given its indirect influence in these domains.

Abstract

Sleep disturbances are highly prevalent among children with neurodevelopmental disorders, like Autism Spectrum Disorder (ASD) and Attention-Deficit/Hiperactivity Disorder (ADHD). The first objective of this study is to examine the differences in sleep problems between a group of children with ASD without intellectual disabilities, a group with ADHD and a typically developing (TD) group. A second objective is aimed at analyzing the effects of sleep problems and symptom severity on their

communication skills. Participants were 122 children between 7 and 12 years old distributed in three groups: 32 TD children, 47 children with ASD and 43 children with ADHD, matched on age and intelligence. Parents completed different questionnaires that measured sleep disturbances and communication skills. Findings show significant differences between the clinical groups and the TD group in most types of sleep disorders. Moreover, the group with ADHD showed significantly more sleep breathing disorders and hyperhidrosis in comparison with ASD and TD, as well as more total sleep problems. In contrast to ASD, the predictive power of sleep problems on communication difficulties was greater in the group with ADHD. The results of the mediation analysis indicate that in both groups, sleep problems partially mediate the relationship between symptoms and communication. This investigation highlights the need of considering sleep disorders when assessing communication skills in ASD and ADHD, given its indirect influence in this domain. Understanding the sleep dysfunctions of both conditions and their repercussions is crucial to develop adjusted interventions.

Keywords: Autism spectrum disorder; ADHD; sleep problems; structural communication skills; pragmatics; symptoms severity

Introduction

Sleep has been identified as a modulator of general neurodevelopment by playing a crucial role in brain restoration, cognitive functioning and learning (Lamônica et al., 2021). It impacts cognitive functions such as attention, declarative learning and memory consolidation (Köse et al., 2017), which are key processes involved in language acquisition. Sleep supports the consolidation of different linguistic processes including speech perception (Molfese et al., 2013), derivation of abstract grammatical patterns (Gómez et al., 2006), and vocabulary (Henderson et al., 2012). In fact, a systematic review by McGregor and Alper (2015) concluded that sleep disorders in infancy may pose a risk to language learning, and longitudinal studies demonstrate that increasing sleepiness is associated with less growth in verbal comprehension (Bub et al., 2011). Moreover, the relationships between language and sleep might be considered bidirectional since language difficulties, such as understanding and following bedtime

routines or communicating needs accurately, might interfere with the adequate development of sleep habits.

Sleep problems in neurodevelopmental disorders: ASD and ADHD

Sleep problems are highly prevalent among children with neurodevelopmental disorders (Al Lihabi, 2023). Specifically, they are reported in 50% to 80% of children with Autism Spectrum Disorder (ASD) (Lamônica et al., 2021), which are substantially higher rates than those found in children with typical development (TD; 20-40%) (Sadeh et al.,2014). Studies using subjective measures have revealed significantly lower total sleep time, increased sleep onset latency, worse sleep efficiency, greater bedtime resistance, sleep anxiety, sleep-disordered breathing, parasomnias and higher daytime sleepiness (Díaz-Román et al., 2018).

Understanding the complex causes of sleep problems in ASD involves recognizing the interplay between sleep and several contributing factors like biological abnormalities in melatonin secretion timing (Melke et al., 2008) or genetic mutations in circadian relevant-genes (Yang et al., 2016). Behavioral factors also play an important role, including dysfunctional bedtime routines, poor sleep hygiene, bedtime stalling, refusal behaviors, communication challenges and over-responsiveness to environmental stimuli (Souders et al., 2017). Additionally, medical issues such as seizures and digestive problems may impact sleep efficiency (Klukowski et al., 2015).

Sleep disturbances are also frequent in Attention-Deficit/Hyperactivity Disorder (ADHD) (Cortese et al., 2013), a condition with similarities to the ASD neurocognitive profile (Schachar et al., 2022), and with prevalence rates ranging from 70% to 85% (Yürümez, E. & Kiliç, 2016). Children diagnosed with ADHD exhibit increased levels of daytime sleepiness, heightened sleep-related movements, and elevated apnea-hypopnea indices (Cortese et al., 2006). These problems can stem from different causes like unfavorable sleep habits, the presence of electronic devices in the bedroom, and late-night exposure to bright computer screens, among others. Additionally, they may also be due to co-occurring conditions or as an unintended consequence of stimulant medication (Lundsford-Avery, 2016).

Relationships between sleep problems and language in ADHD and ASD

Despite the previously described influence of sleep patterns on language development, there are hardly any investigations dedicated to exploring this intricate relationship further in populations that present difficulties in language acquisition. Thus, to the best of our knowledge, there are no studies to date that have looked at this association among children with ADHD. Nevertheless, parent-reported sleep disturbances have been significantly related to deficits in their attention and executive control skills (Schneider et al., 2016), which have also been linked to language performance in this population (Ygual et al., 2010). Therefore, it seems reasonable to consider an indirect relation between sleep and language problems in individuals with ADHD.

In contrast to ADHD, the impact of sleep disturbances has been explored a little more in ASD, and they have even been considered a possible predictor of intensified symptoms of the disorder (Schreck et al., 2004). In fact, research has shown an association between sleep problems and challenging behavior in ASD (Cohen et al., 2014), as well as with social and affective functioning (Veatch et al., 2017). Regarding language, the study by Botting and Baraka (2018) provided support for a direct association between everyday sleep and language ability not only in children with ASD but also in individuals with a language disorder. Specifically, sleep behaviors predicted expressive, receptive and social-language difficulties in both groups, and were related to processes like attention and listening, according to parents' perceptions. Moreover, sleep-onset latency was found to be associated with syntax and semantic/pragmatic abilities measured through the Children's Communication Checklist (CCC) (Bishop, 1998). These findings have been recently corroborated in children with language disorders, as an association has also been demonstrated between linguistic ability described by the CCC-2 and sleep behaviors such as sleep duration, sleep anxiety, night wakings and parasomnias (Knowland et al., 2021). In contrast, when using direct observation of communication, no correlations have been found between scores on communicative behavior and sleep disorders in preschoolers with ASD (Lamônica et al., 2021).

In addition to general communication skills, the learning of phonology may also be influenced by sleep patterns in children with ASD. Thus, nocturnal sleep parameters have been related to improvements in the consolidation process of new phonological information (Knowland et al., 2019). Likewise, longitudinal studies also suggest a strong association between sleep problems and developmental trajectories in autism. Specifically, young children with ASD who suffer from sleep disorders have exhibited significantly lower linguistic growth compared to their typically-developing peers. This

slowed growth has been observed in combinatorial receptive language and expressive language indexes at different time points over a three-year period (Levin et al., 2022). From these considerations, and based on the scientific evidence that stablishes connections between sleep disorders and language, this study aims to extend the knowledge on this topic in children with neurodevelopmental disorders, specifically, ADHD and ASD, as literature recognizes an overlap between both disorders in terms of genetic, clinical and neuropsychological aspects (Mulas & Roca, 2018). Moreover, DSM-5 allows for a dual diagnosis of ADHD and ASD. Given this overlap, more research is needed to further understand the relationship between these two conditions.

As previously reviewed, there are hardly any studies on the topic in the ASD population, and none in children with ADHD. The characterization of sleep problems in both groups and their relationship to the difficulties they experience in language and communication skills is important, given that many of the negative consequences of sleep disturbances may be reversed with appropriate interventions. In particular, this investigation aims to address the following specific objectives:

a) To examine the differences in sleep problems between children with ASD without intellectual disabilities, children with ADHD, and TD children
b) To analyze the effects of sleep problems and symptom severity on communication skills (structural and pragmatic communication indexes) in children with ASD without intellectual disabilities and children with ADHD

Our hypotheses are that sleep problems and symptom severity would be related to reduced communication skills in children with ASD and children with ADHD, and both groups would experience more sleep problems compared to TD children.

2. Materials and methods

2.1. Participants

Participants in this study were 122 children between 7 and 12 years old, 83.1% of whom were boys. They had an intelligence quotient (IQ) equal to or above 80, measured by the K-BIT (Kaufman & Kaufman 2000), and were distributed in three groups matched on

age and IQ: 32 children with TD, 47 children with ASD (severity level 1, according to the Diagnostic and Statistical Manual of Mental Disorders- Fifth Edition, DSM-5, APA, 2013), and 43 children with ADHD. The general language level was evaluated by the vocabulary subtest of the Wechsler Intelligence Scale for Children – Fourth Edition (WISC-IV) (Wechsler, 2003), which revealed significant differences between the groups analyzed (see Table 1).

The clinical sample was recruited from Unidades Especializadas de Orientación educativa (UEOs [specialized psychoeducational care centers]) in Spain (Valencia and Alicante). Inclusion criteria of participants with ASD and ADHD were those corresponding to the diagnoses of these disorders in the DSM-5. The diagnosis of ASD was confirmed through the Autism Diagnostic Interview-Revised (ADI-R; Rutter et al., 2006), and/or the Autism Diagnostic Observation Schedule (ADOS-2; Lord et al., 2001). All autistic participants in the present sample had no ADHD comorbidity. The ADHD diagnosis was verified with parents and teachers according to the clinical criteria for ADHD from the DSM-5 (APA, 2013). The prevalence of sleep problems in the participants were: TD (n=7, 21,8%), ASD (n=32, 68,1%) and ADHD group (n=33, 76,7%). To calculate the prevalence of sleep problems, it was considered the total sleep problem score at 39 points (>39 sleep indicates sleep difficulties as suggested by Bruni et al., 1996).

The children with TD were selected form 8 primary schools in the same locations where the clinical sample was recruited. None of them presented a history of psychopathologies or criteria for ASD or ADHD diagnosis according to DSM-5.

The exclusion criteria for all groups were having an IQ of less than 80, motor or sensorial deficits, mental or neurological diseases.

-Table 1-

2.2. Measures

2.2.1. *Sleep problems*

The Sleep Disturbance Scale for Children (SDSC; Bruni et al., 1996) is a 26-item parent-reported questionnaire that assesses the occurrence of sleep problems during the last 6 months in children aged 6–16 years. The 26 items are rated on a 5-point scale (never to always), yielding a continuous variable ranging from 26 to 130 with higher values reflecting a greater severity of symptoms. The first two questions measure the

total sleep time and latency to sleep onset. The remaining items, assess the frequency of sleep-related behaviours between conditions on six subscales: disorders of initiating and maintaining sleep (DIMS); sleep breathing disorders (SBD); disorders of arousal (sleepwalking, sleep terrors) (DA); sleep–wake transition disorders (SWTD); disorders of excessive somnolence (DOES); and sleep hyperhydrosis (falling asleep sweating and night sweating) (SHY). A total sleep problem score (TSP) was obtained by summing all subscale scores. The internal consistency was $\alpha = 0.79$ and test–retest reliability $r = 0.71$ over a 6-month interval (Bruni et al., 1996). For this study we use the Spanish version form Pagerols et al. (2023) with good psychometric properties ($\alpha = 0.82$).

2.2.2. *Communication Skills*

Communication skills were assessed using The Children's Communication Checklist second edition (CCC-2; Bishop, 2004) that was completed by the parents. This checklist provides information on communication characteristics in children from 4 to 11 years The CCC-2 contains 70 items grouped in 10 subscales that measures different aspects of communication: the structure of language (speech, syntax, semantics, coherence), pragmatics (inappropriate initiation, stereotyped language, use of context, and non-verbal communication), and behaviors that are found to be impaired in children with ASD (social relationships and interests). The frequency of the behaviours described in each item included in the CCC-2 is rated on a 4-point scale; a high score indicates greater communication problems. This study used the structural and pragmatic communication index. The structural communication index is formed by adding together the raw scores on the speech, syntax, semantics, and coherence. The pragmatic communication index is obtained by adding the raw scores on the coherence, inappropriate initiation, stereotyped language, use of context, and non-verbal communication subscales. This specific grouping, although not contemplated in the CCC-2, has been used in other research studies (Helland et al., 2014). The CCC-2 presents good internal consistency, with alphas values ranging from 0.73 to 0.89, and test-retest reliability ranging from 0.44 to 0.76 (Bishop, 2004). Spanish translation has obtained a Cronbach's alpha of 0.92 (Mendoza & Garzon, 2012).

2.2.3. Symptom Severity

Autism Severity

The Autism Diagnostic Interview-Revised (ADI-R; Rutter & Lord, 2006), was used in this study. ADI-R is a clinician-administered interview for evaluating autistic symptomatology. Parents report information about their child Scores are classified into four categories: Reciprocal Social Interaction, Communication (verbal, non-verbal), Restricted Repetitive and Stereotyped Behaviors, and Abnormal Development. The sum of the ADI-R four subscale scores was selected to measure of the severity of ASD.

ADHD Severity

For the dimensional evaluation of the ADHD symptoms, a clinical psychologist held an interview with the parents, who reported on the diagnostic criteria of the ADHD included in the DSM-5 (APA, 2013). The first domain referred to symptoms of inattention with nine items. The second domain referred to hyperactivity and impulsivity with nine items. The parents evaluated the severity of each criterion from 0 to 3, where 0 represents “almost never”, 1 “sometimes”, 2 “often”, and 3 “many times”. The reliability of the questionnaire was high for our sample (Cronbach's alpha of 0.82)

2.3. Procedure

The study was approved by the Ethics Committee of the Universitat de València in accordance with the principles of Helsinki Declaration (World Medical Association, 2013) (UV-INV_ETICA-1905517). The tests were applied by psychologists who were familiar with the use of the different instruments. The parents provided their written informed consent, in addition to the oral consent of all the children who participated.

2.4. Data analysis

The statistical analyses were performed with the Statistical Package for the Social Science (SPSS) software, version 26.00 (SPSS Inc., Chicago, IL USA). The distribution of the variables was analyzed, as well as their fit to the normal distribution curve, by applying histograms and Kolmogorof-Smirnov tests. First, to analyze the differences between ASD, ADHD and TD groups in sleep problems, a multivariate analysis of covariance (MANCOVA) was carried out using vocabulary and medication as covariate. The differences on the entire test were verified through additional covariate analyses of variance (ANCOVAs). For the additional ANCOVAs, the level of significance was set at $p < .008$, after applying the Bonferroni correction, and the value of η^2_p was calculated to test the strength of the association. Partial correlation analyses

were also performed in the clinical groups (ASD and ADHD), including vocabulary and medication as covariates, to study the relationships between sleep problems, symptom severity and communication skills (structural and pragmatic). Multiple linear regression analyses were conducted to study the impact of sleep problems and symptom severity (independent variables) on structural and pragmatic communication (dependent variables) in ASD and ADHD groups. The assumption of independent errors was tested using the Durbin–Watson test, with multicollinearity tested, using variance inflation factor and tolerance diagnostics (Field, 2013). VIF <7 and tolerance >.20 indicated the absence of multicollinearity problems. All results were considered statistically significant if $p < .05$. Finally, simple mediation analysis were carried out using the PROCESS program of mediation, moderation, and conditional analysis (Hayes, 2013), to examine the possible mediation of the variable sleep problems in the relationship between autism or ADHD symptom severity and structural and pragmatic communication. Vocabulary and medication were included as covariates in the Process macro. The present study used the bootstrapping procedure with 10,000 repetitions to verify the mediator effect of the sleep problems with a confidence interval of 95%. When the indirect effect of the mediators is significantly different from zero, it is considered significant (Preacher & Hayes, 2004).

3. Results

3.1. Differences in sleep problems between children with ASD, ADHD and TD

A multivariate analysis of covariance was performed to test for differences in sleep problems between the ASD, ADHD and TD, including medication and vocabulary as covariates. Results showed a significant main effect of group for SDSC scores [Wilk's Lambda (Λ) = .62, $F(12,214) = 4.76$, $p < .001$, $\eta 2p = .21$], but not for the covariates medication [Wilk's Lambda (Λ) = .96, $F(6,107) = .71$, $p = .637$, $\eta 2p = .04$], and vocabulary [Wilk's Lambda (Λ) = .95, $F(6,107) = .89$, $p = .50$, $\eta 2p = .05$]. The confirmation ANCOVAs showed significant differences between children with TD, ASD and ADHD on all sleep domains (see Table 2).

Post hoc analyses revealed significant differences between the TD group and the clinical groups (ASD and ADHD) on all the SDSC dimensions, except on sleep breathing disorders (SBD) and sleep hyperhidrosis (CHY). Specifically, the SBD variable scores were significantly higher for the ADHD group than for the ASD and TD groups. Regarding CHY scores, significant differences were only found between the TD and

ADHD groups, being greater for the latter. Finally, as Table 2 shows, SDSC total scores were significantly higher for the clinical groups than for the TD group, and also higher for ADHD than for ASD.

-Table 2-

3.2. The effects of sleep problems and symptom severity on communication skills (structural and pragmatic communication index) in children with ASD without intellectual disabilities and children with ADHD

Correlations between sleep and language variables are summarized in Table 3. For the group of children with ASD, deficits in structural communication skills correlated positively with total sleep problems and two of its dimensions, DA and SHY (r between .32 and .35). Furthermore, impairments in pragmatic communications skills correlated positively with total sleep problems ($r = .47$, $p < .001$) and three of its subscales, SBD ($r = .44$, $p = .002$), DA ($r = .34$, $p = .017$), and SHY ($r = .41$, $p = .004$). Similarly, severity of ASD symptoms correlated significantly with SBD, DA and total sleep problems (r between .38 and .32). For the group of children with ADHD, deficits in structural communication skills correlated positively with total sleep problems and five of its dimensions, DIMS, SBD, DA, SWTD, and SHY(r between .40 and .61), whereas impairments in pragmatic communications skills correlated positively with all the sleep problems variables (r between .55 and .32). ADHD severity symptoms correlated significantly with DIMS, DA, CHY, and total sleep problems (r between .47 and .35).

-Table 3-

As can be seen in Table 4, results from multiple regression analyzes in the group of children with ASD indicated that sleep problems and symptom severity jointly explained 22% of the variance in structural communication dysfunctions and 49% of the variance in pragmatic communication dysfunctions. In the pragmatic language model the coefficients of both predictors were significant, while in the structural language model only the symptom severity coefficient was significant.

Regarding the group with ADHD, sleep problems and symptom severity jointly explained 44% of the variance in structural language and 35% of the variance in

pragmatic language. In this case, the coefficients of both predictors, sleep problems and symptom severity, were significant in the structural language model, while only the sleep problems coefficient was significant in the pragmatic language model (see Table 4).

-Table 4-

The results of the correlation and regression analyzes supported the feasibility of a simple mediation analysis to explore the effect of sleep problems on the relationship between symptom severity and pragmatic communication skills in the group of children with ASD, and the effect of sleep problems on the relationship between symptom severity and structural communication skills in the group of children with ADHD.
As Figure 1 shows, in the model constructed for the group of children with ASD using *bootstrapping* procedure for a sample of 10,000 and a confidence interval (CI) of 95%, the *path* c´ was statistically significant (p=.045) when controlling for medication and vocabulary. This suggest that ASD symptoms not only directly affected the pragmatic communication skills, but also indirectly through the mediating effects of sleep problems. Specifically, the indirect effect obtained with the mediator of sleep problems, using *bootstrapping* procedure for a sample of 10,000 and a confidence interval (CI) of 95%, was statistically significant on the *path* between the ASD symptoms and pragmatic communication, CI [.025, .277]. Similar results were found in the ADHD group. Results show that the *path* c´ was statistically significant (p=.046). The indirect effect obtained with the mediator of sleep problems in the relationship between ADHD symptoms and structural communication was significant CI [.21, .92]. As zero was not contained in the confidence interval, the findings suggest that the indirect effects were significant ($p < .05$). The analysis of the covariates in both models indicated that neither medication ($\beta = 2.07$, $p = .68$), nor vocabulary ($\beta = .27$, $p = .56$) had a significant role.

-Figure 1-

4. Discussion

This study aimed to delve into the knowledge about sleep disturbances and their relationships with communication abilities in two neurodevelopmental disorders: ADHD and ASD. The first objective was to examine the differences in sleep problems between children with ASD without intellectual disabilities, children with ADHD and children with TD. The results showed significant differences between the clinical groups and the TD group in most of the types of sleep difficulties, such as initiating and maintaining sleep, disorders of arousal, sleep-wake transition disorders and excessive somnolence. These findings are consistent with the higher prevalence of sleep problems in children with neurodevelopmental conditions, particularly ASD (Lamônica et al., 2021) and ADHD (Cortese et al., 2013; Yürümez & Kiliç, 2016), compared to children with TD (Al Lihabi, 2023).

These data also align with the results of a recent meta-analysis comparing sleep problems in adults with ADHD and ASD, which found a similar sleep-impaired profile in both disorders, characterized by higher sleep onset latency, poorer sleep efficiency and a greater number of awakenings compared to healthy controls (Lugo et al., 2020). However, in our study, the group with ADHD showed significantly more sleep breathing disorders and hyperhidrosis compared to ASD and TD, as well as more total sleep problems. This is consistent with the data provided by Thus, Khan, Taneja and Bhatia (2022), who found that children with ADHD had the most severe impact of sleep problems and a higher propensity for them compared to children with ASD, intellectual disabilities and cerebral palsy. It is also congruent with the findings of a meta-analysis that specifically associates sleep breathing disorders with ADHD (Sedky et al., 2014). Furthermore, it is important to note that ADHD is associated with emotional and behavioral problems such as anxiety and hyperactivity, which have been related to sleep problems like delay in bedtime (Zerón et al., 2021). Moreover, the majority of participants with ADHD had been diagnosed with the combined subtype, which has been associated with the highest scores in sleep questionnaires (Wagner & Schlarb, 2012).

An additional factor to consider when interpreting these results is that our participants with ASD did not have intellectual disabilities, which usually corresponds to level 1 of support according to DSM-5 (APA, 2013) and therefore, represents the mildest presentation of autism, which has been associated with less severe sleep problems (Schreck et al., 2004). Although the DSM-5 allows for the dual diagnosis of ASD+ADHD, only a small percentage of our participants with ASD showed this comorbidity and therefore, the hyperactivity symptoms of ADHD that might significantly affect children's sleep were not present in the majority of the ASD group.

Our study is unique in that we examined the effects of sleep problems and symptom severity on communication skills in both children with ASD and children with ADHD. In this sense, the results of the second objective showed that regarding the group with ASD, sleep disorders mainly predicted pragmatic impairments, with a notably high percentage of variance. These difficulties were positively associated with sleep breathing disturbances, hyperhidrosis and total sleep problems. Furthermore, linguistic structural impairments were positively linked to disorders of arousal and, again, with sleep hyperhidrosis. These results align with findings reported by Botting and Baraka (2018) and Levin et al. (2022) and suggest that insufficient rest during sleep is an important variable to consider when dealing with communication disorders in individuals with ASD. These difficulties are especially evident during everyday communication and may affect attention and response to the pragmatic cues and rules that are necessary to navigate adequately through the social world. Moreover, in comparison with ASD, the predictive power of sleep problems on communication difficulties was greater in the group with ADHD, as these problems were able to predict not only pragmatic but also structural difficulties. Along with pragmatic difficulties, structural language difficulties have also been reported in ASD (Reindal et al., 2023). However, in our study, participants with ADHD obtained lower scores in this domain compared to ASD. Therefore, it emerged as a more vulnerable domain in the language skills of children with ADHD and, therefore, more susceptible to be affected by sleep disturbances.

The results of the mediation analysis indicate that in both groups, sleep problems mediate the relationship between symptoms and communication skills, so sleep difficulties have an indirect and partial effect on the communication challenges that these children experience. In other words, the findings suggest that sleep problems intensify communication challenges. However, it is important to note that there may be more variables that may affect the communication process, which will need to be addressed in future research.

This profile of disturbances might be explained by considering the differential and common characteristics of both disorders, and keeping in mind that the relationhips between sleep, language and other domains are intricate and complex. Thus, both disorders share deficits in executive functions (EF) (Craig et al., 2016) and in both cases EF have been related to sleep problems. Specifically, sleep quantity and instability have been directly linked to increased executive dysfunctions in ADHD (Gagnon et al., 2021; Moreau et al., 2013), which, in turn, have been related to linguistic deficits in this population (Ygual et al., 2010). Similarly, sleep quantity and quality have been related to deficits in EF involved in behavioral regulation in ASD (Tesfaye et al., 2021), which have also been linked to pragmatic impairments within these children (Razavi et al., 2019). Nevertheless, some studies report that executive dysfunction is not a statistically significant predictor of pragmatic language abilities in children with ASD (Berenguer et al., 2018; Cardillo et al., 2021) and other deficits, such as social cognition difficulties, seem to play a more prominent role in the social communication deficits described in this group (Roselló et al., 2020). Consequently, these sociocognitive impairments will also have to be considered when analyzing communication skills deficits in ADHD (Çiray et al., 2022). Future investigations will have to shed light on the relative weight that each construct has in the communication challenges experienced by these children.

Our study has several strengths. It is the first comparative study of sleep patterns in children with ADHD and children with ASD, and the impact they have on communication problems. This investigation focuses on a variable that may be overlooked in the language and communication assessment of children with neurodevelopmental disorders which partially influences their performance in this domain. Sleep problems can have effects on mood, attention and general cognitive functioning, which can affect a child's ability to communicate effectively. Moreover, they can also impact a child's ability to participate in social and communication activities, which can have a negative influence on his or her pragmatic development.

The findings of this study must be considered within the framework of its limitations. One limitation refers to the small sample size and characteristics, as the majority of participants were male without cognitive disabilities, and therefore the results may not be generalized to other profiles. The second limitation relates to the instruments used to assess both sleep patterns and communication skills, which solely relied on parents' perceptions. In future research, it will be necessary to employ other complementary evaluation procedures such as standardized tests or qualitative analysis of spontaneous communication to provide a more comprehensive profile of the children's structural and pragmatic abilities. Likewise, the use of objective methods for recording sleep parameters, such as actigraphy or polysomnography, will be relevant to obtain a more precise pattern of the sleep disturbances that these children experience.

In subsequent studies, it will also be important to identify the variables that may minimize the negative consequences of sleep problems in children with ASD and ADHD. Understanding the sleep dysfunctions that occur in both conditions and their repercussion in other areas such as communication is crucial for developing tailored interventions that reduce the adverse consequences of sleep disturbances. More research is needed in ordr to clarify the complex relationships between sleep and language in children with ADHD and ASD and to develop effective management strategies.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with the research, authorship, and/or publication of this article.

Credit autorship contribution statement

Conceptualization and study design: CB, IB; Formal analysis and interpretation of the data: ER, SDS; Assessment and supervision of data collection: CB, ER. All authors contributed to reviewing the analysis and editing the manuscript prior to submission.

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Table 1

Sociodemographic characteristics

	TD (n=32) Mean (SD)	ASD (n=47) Mean (SD)	ADHD (n=43) Mean (SD)	$F_{(2,119)}$	χ^2	*p*
Age (years)	8.75(1.22)	9.37 (1.75)	9.29 (1.38)	1.75	-	.177
IQ	100.4 (8.22)	98.37 (10.92)	98.94 (6.91)	.49	-	.612
Sex (% boys)	65.6%	89.3%	90.7%		10.26	.006*
Vocabulary Level	13.91 (2.75)	11.41 (3.24)	10.01 (2.38)	8.31	-	.000*
P.Educational Level	3.27 (.95)	3.05 (1.09)	1.88 (1.40)	0.57	-	.564
No education	3,1%	8,5%	2,3%			
Primary Education	6,3%	14,9%	14,0%			
Lower Secundary Ed	28,1%	21,3%	25,6%			
Higher Secundary Ed	6,3%	12,8%	14,0%			
University Education	56,3%	42,6%	44,2%			
Medication (% yes)	0.0%	41.7%	79.4%		42.02	.000*
ASD Symptoms	-	28.3 (5.7)	-			
ADHDSymptoms	-	24.6 (10.7)	41.0 (9.1)			
ADHD Inna		14.6 (8.7)	23.79 (6.2)			
ADHD H/I		10.0 (3.4)	17.21 (3.3)			
Structural C.	5.2 (3.6)	31.42 (17.4)	33.60 (18.4)			
Pragmatic C.	7.09 (4.9)	43.54 (13.4)	35.5 (16.9)			

Note. P. Education (Parental education); Parental education measured as highest level of mother or father (0=No education, 1 = Primary Education, 2 = Lower Secundary Education, 3 = Higher Secundary Education, 4= University Education, C. (Communication), ASD Symptoms (ADI-R), ADHD Symptoms (Total score DSM-V parents report); ADHD Inna (Inattention); ADHD H/I (Hyperactivity/Impulsivity)
* $p < .05$

Table 2

Differences between children with TD, ASD and ADHD on Sleep problems (ANCOVAs)

	TD (n=32)		ASD (n=47)		ADHD (n=43)				
	M	SD	M	SD	M	SD	$F_{(2,119)}$	η^2_P	Group differences
DIMS	6.78	2.15	14.60	5.61	16.63	7.39	24.26*	.30	ASD,ADHD>TD
SBD	3.50	0.84	4.38	1.73	5.77	3.79	6.71*	.11	ADHD>ASD,TD
DA	3.28	0.81	5.45	2.41	5.93	2.81	12.47*	.18	ASD,ADHD>TD
SWTD	8.06	2.26	11.98	4.41	14.40	6.37	11.79*	.17	ASD,ADHD>TD
DOES	7.03	3.21	9.47	3.72	10.12	4.05	3.73*	.06	ASD,ADHD>TD
CHY	3.13	1.60	3.62	1.82	4.53	2.70	5.06*	.08	ADHD>TD
T. Sleep p	31.78	4.07	49.49	12.81	57.37	20.30	22.96*	.29	ASD,ADHD>TD; ADHD>ASD

Note. DIMS (Disorders of initiating and maintaining sleep), SBD (sleep breathing disorders), DA (disorders of arousal), SWTD (sleep-wake transition disorders), DOES (disorders of excessive somnolence), SHY (sleep hyperhidrosis), T. Sleep p (total sleep problem score)
$p < .007$ (Bonferroni correction)

Table 3

Associations between sleep problems, communication skills and symptom severity in children with ASD and children with ADHD

		1	2	3	4	5	6	7	8	9
ASD	1.DIMS	-								
	2.SBD	.27								
	3.DA	.33*	.17							
	4.SWTD	.36*	.11	.38**						
	5.DOES	.28	.26	.37*	.12					
	6.CHY	.24	.44**	.26	.21	.45**				
	7.T. Sleep Problems	.76**	.46**	.63**	.64**	.62**	.56**			
	8.Structural C.	.21	.20	.32*	.17	.15	.35*	.33*		
	9.Pragmatic C.	.28	.44**	.34*	.25	.27	.41**	.47**	.63**	
	10.ASD Symptoms	.12	.38**	.35*	.12	.24	.27	.32*	.42**	.56**
ADHD	1.DIMS	-								
	2.SBD	.48**								
	3.DA	.59**	.44**							
	4.SWTD	.51**	.64**	.50**						
	5.DOES	.15	.20	.21	.36*					
	6.CHY	.55**	.68**	.54**	.66**	.26				
	7.T. Sleep Problems	.80**	.76**	.71**	.85**	.47**	.79**			
	8.Structural C.	.46**	.60**	.40**	.55**	.25	.42**	.61**		
	9.Pragmatic C.	.51**	.38*	.47**	.37*	.32*	.35*	.55**	.80**	
	10. ADHD Symptom	.47**	.21	.35*	.29	.09	.38*	.42**	.48**	.42**

Note. DIMS (Disorders of initiating and maintaining sleep), SBD (sleep breathing disorders), DA (disorders of arousal), SWTD (sleep-wake transition disorders), DOES (disorders of excessive somnolence), SHY (sleep hyperhidrosis), C. (Communication), ASD Symptoms (ADI-R), ADHD Symptoms (Total score DSM-V parents report)

*$p \leq .05$. **$p \leq .01$.

Table 4

Multiple linear regression analyses for sleep problems and symptoms severity predicting communication skills (Structural and Pragmatic communication) in children with ASD and children with ADHD

ASD					
Structural C.	Beta	t	p	R^2	F
				.22	6.12*
T. Sleep Problems	.22	1.56	.124		
ASD Symptoms	.34	2.45	.018*		
Pragmatic C.	Beta	t	p	R^2	F
				.49	22.1**
T. Sleep Problems	.21	2.9	.005*		
ASD Symptoms	.43	6.01	<.001**		
ADHD					
Structural C.	Beta	t	p	R^2	F
				.44	15.7*
T. Sleep Problems	.50	3.87	<.001**		
ADHD Symptoms	.27	2.05	.046*		
Pragmatic C.	Beta	t	p	R^2	F
				.35	10.77**
T. Sleep Problems	.46	3.27	.002*		
ADHD Symptoms	.23	1.59	.118		

Note. C. (Communication), ASD Symptoms (ADI-R), ADHD Symptoms (Total score DSM-V parents report)
*$p \leq .05$. **$p \leq .01$.

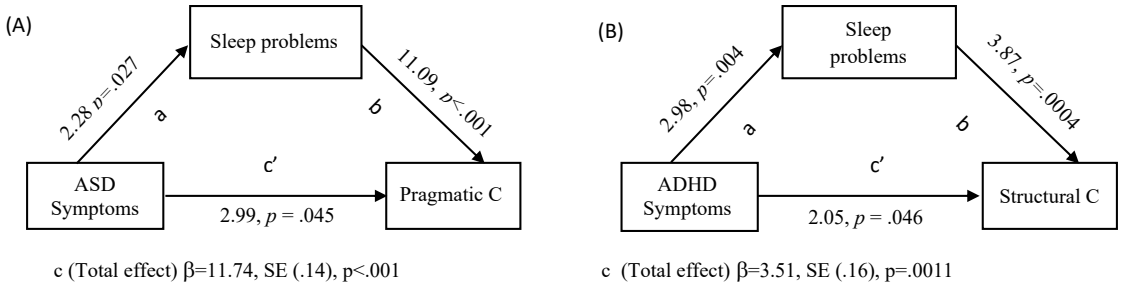

Fig. 1 (A) (B) Simple Mediation Analysis of Sleep problems on the relationship between symptom severity and pragmatic communication skills in the group of children with ASD (Fig. 1 (A)) and on the relationship between symptom severity and structural language skills in the group of children with ADHD (Fig. 1 (B)).