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Original Article

Sleep problems in children with autism spectrum disorder: examining the contributions of sensory over-responsivity and anxiety

Micah O. Mazurek ^{a,*}, Gregory F. Petroski ^b

^a University of Missouri, Department of Health Psychology & Thompson Center for Autism and Neurodevelopmental Disorders, 205 Portland Street, Columbia, MO 65211, USA

^b University of Missouri, Office of Medical Research, Biostatistics and Research Design Unit, DC018, Columbia, MO 65212, USA

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ABSTRACT

Objectives: Children with autism spectrum disorder (ASD) are at high risk for sleep problems. Previous research suggests that sensory problems and anxiety may be related to the development and maintenance of sleep problems in children with ASD. However, the relationships among these co-occurring conditions have not been previously studied. The current study examined the interrelations of these symptoms in a large well-characterized sample of children and adolescents with ASD.

Methods: The current study examined the relationships among sleep problems, sensory over-responsivity, and anxiety in 1347 children enrolled in the Autism Speaks Autism Treatment Network. The primary measures included the Children's Sleep Habits Questionnaire, the Child Behavior Checklist, and the Short Sensory Profile.

Results: In bivariate correlations and multivariate path analyses, anxiety was associated with all types of sleep problems (ie, bedtime resistance, sleep-onset delay, sleep duration, sleep anxiety, and night wakings; $p < 0.01$ to $p < 0.001$; small to medium effect sizes). Sensory over-responsivity (SOR) was correlated with all sleep problems in bivariate analyses ($p < 0.01$ to $p < 0.001$; small effect sizes). In multivariate path models, SOR remained significantly associated with all sleep problems except night awakenings for older children, while SOR was no longer significantly associated with bedtime resistance or sleep anxiety for younger children.

Conclusions: Children with ASD who have anxiety and SOR may be particularly predisposed to sleep problems. These findings suggest that some children with ASD and sleep disturbance may have difficulties with hyperarousal. Future research using physiological measures of arousal and objective measures of sleep are needed.

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1. Introduction

Autism spectrum disorder (ASD) is a complex neurodevelopmental disorder that is characterized by difficulties with social communication and interaction and by restricted and repetitive behaviors and activities [1]. In addition to these primary symptoms, individuals with ASD also experience high rates of medical and behavioral comorbidities [2,3]. Among these, sleep problems are particularly common for children with ASD, with prevalence rates

ranging from 50% to 80% [4–7]. Most studies have found that difficulties falling asleep and night waking are the most common types of sleep problems in children with ASD, with additional evidence of disturbances in circadian rhythm [6,8]. For many children and families with ASD, sleep problems can contribute to significant distress and impairment over and above the effects of primary ASD symptoms. Sleep problems can have detrimental effects on learning and cognition [9], and they have been associated with an increased severity of stereotypic and challenging behaviors [10–12] and decreased quality of life [13] among children with ASD. Children's difficulties with sleep also affect the entire family, and they often result in increased parental stress and decreased well-being [14].

The etiology of sleep problems in children with ASD is thought to be multifactorial, including potential disruption in circadian rhythms and melatonin regulation and difficulties with sleep hygiene [6,15,16]. The majority of research and clinical practice guidelines for addressing sleep problems in children with ASD have focused on these factors. However, some researchers and clinicians have

Abbreviations: ASD, autism spectrum disorder; SOR, sensory over-responsivity; AS ATN, Autism Speaks Autism Treatment Network; ADOS, Autism Diagnostic Observation Schedule; MSEL, Mullen Scales of Early Learning; SSP, Short Sensory Profile; CBCL, Child Behavior Checklist; CSHQ, Children's Sleep Habits Questionnaire.

* Corresponding author. Department of Health Psychology, University of Missouri, Thompson Center for Autism and Neurodevelopmental Disorders, 205 Portland Street, Columbia MO 65211, USA. Tel.: +573 884 8502; fax: +573 884 6421.

E-mail address: mazurekm@missouri.edu (M.O. Mazurek).

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suggested that hyperarousal [17–19] and sensory reactivity [8] may also play a role in the etiology of sleep problems in children with ASD. Although there is evidence to support this from the typically developing (TD) population [20–22], similar research has not yet been conducted among children with ASD.

In TD individuals, insomnia has been found to be associated with hyperarousal, cortical excitability, and hypothalamic–pituitary–adrenal (HPA)-axis involvement (as evidenced by increased cortisol secretion) [20,21]. It is possible that hyperarousal may also underlie sleep difficulties for children with ASD, particularly given their increased risk for arousal-related difficulties. In fact, compared to other clinical and nonclinical groups, children with ASD are at high risk for both anxiety [23,24] and sensory over-responsivity [25,26]. Importantly, these separate sets of symptoms are also characterized by hyperarousal. However, research has only recently begun to examine the possibility that these difficulties may relate to sleep problems in children with ASD [27,28].

1.1. Sleep problems and anxiety

There is strong evidence of comorbidity of anxiety and sleep problems in the general population, with a markedly high prevalence of insomnia among individuals with anxiety disorders (70–90%) [29]. In addition, studies of both adolescents and adults have found that anxiety is a longitudinal predictor of insomnia, predating the onset of insomnia in the great majority of cases, while depression appears to occur subsequent to insomnia [30,31]. These results provide evidence of a specific directional association from anxiety to insomnia in the general population.

There is a growing body of evidence that anxiety is also associated with sleep problems in individuals with ASD. For example, anxiety-related nighttime behaviors were common in a sample of 69 children with autism and sleep disturbance [32], parent-rated sleep disturbance was correlated with anxiety in children with autism [11], and sleep-related fears were found to be more common among children with Asperger's syndrome than among TD children [33]. Anxiety was also associated with insomnia in studies of adults with Asperger's disorder [34,35]. More recently, a study of children with intellectual disability and/or ASD found that sleep problems were significantly correlated with anxiety across the entire sample. However, separate results for the ASD group were not reported [36]. A recent analysis of the Autism Speaks Autism Treatment Network (AS ATN) registry database also found that children with ASD who had sleep problems had higher internalizing symptoms than those without sleep problems. However, although anxiety comprises an aspect of the larger internalizing symptom domain, the specific relationship between anxiety and sleep problems was not reported [37]. Richdale and Baglin found that sleep problems were associated with both parent- and self-reported symptoms of anxiety in a sample of 17 children with high-functioning ASD [18]. More recently, Richdale and colleagues found that adolescents with high-functioning ASD experienced more presleep arousal than TD adolescents, and that self-reported anxiety and presleep arousal were both correlated with sleep problems in the ASD group [28].

1.2. Sleep problems and sensory problems

Sensory over-responsivity represents another symptom area that has theoretical relevance to both anxiety and sleep problems. Sensory over-responsivity is common among children with ASD, with estimates ranging from 56% to 70% [38,39], and it is characterized by negative responses (eg, distress, avoidance, or hypervigilance) to specific sensory stimuli, such as light, sound, and/or tactile experiences [40,41]. There is increasing evidence that sensory over-responsivity and anxiety represent closely related yet conceptually distinct phenomenon [42]. Previous studies have found significant relationships

between these variables in TD children [43,44], as well as children with ASD [45–47]. Similarly, there is some evidence that both conditions are characterized by increased HPA axis involvement [48]. This is not surprising given that the HPA axis regulates responses to stressful stimuli, and it is well connected to the amygdala, which is also activated by aversive stimuli from various sensory modalities [49].

Given that sensory over-responsivity, like anxiety, has been associated with hyperarousal, these particular symptoms may also be associated with sleep difficulties. In fact, there have been a few studies suggesting a link between sleep problems and sensory over-responsivity. Among TD children, sensory problems have been found to be associated with sleep problems [22]. Children with autism have also been found to have greater sensitivity to the sleep environment than children with other developmental problems [50]. More recently, a small study of 27 children with ASD found that sensory problems, particularly sensory avoiding, were correlated with sleep problems in children with ASD. Furthermore, physiological markers of stress, including salivary cortisol and galvanic skin response following the presentation of sensory stimuli, were highly related to sleep problems [27]. These preliminary findings indicate a need for further research on the relationships among sensory over-reactivity, anxiety, and sleep problems in children with ASD.

1.3. Current study

Evidence from previous studies provides a strong basis for predicting that sensory over-responsivity and anxiety may be highly related to the development and maintenance of sleep problems in children with ASD. The current study examined the possible inter-relatedness of this group of symptoms among a large well-characterized sample of children and adolescents with ASD. The following hypotheses were tested:

- 1) Sensory over-responsivity will be associated with increased anxiety in children with ASD.
- 2) Anxiety will be associated with increased sleep problems in children with ASD.
- 3) Sensory over-responsivity will be associated with increased sleep problems in children with ASD.
- 4) Sensory over-responsivity and anxiety will each be associated with sleep problems in children with ASD when included jointly within a multivariate model.

2. Methods

2.1. Participants

Participants in the current study included 1347 children and adolescents enrolled in the AS ATN who had complete data on the measures required for the analyses. The AS ATN is a multisite network of autism treatment and research centers located throughout the United States and Canada. The AS ATN supports a large clinical registry database, which includes a standard battery of medical and behavioral measures collected at enrollment and across time. The current study examined cross-sectional data collected at enrollment into the AS ATN clinical registry. The AS ATN registry study was approved by the institutional review board at each site, informed written consent was obtained from all parents, and children provided assent when applicable and appropriate. All participants were assessed by AS ATN clinicians using a standard diagnostic battery, including clinical interview, the Autism Diagnostic Observation Schedule (ADOS) [51], cognitive assessment, and adaptive behavior assessment (using Vineland Adaptive Behavior Scales – Second Edition [52]). To be eligible for enrollment, participants were required to meet DSM-IV-TR diagnostic criteria

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