Research in Developmental Disabilities 35 (2014) 1631–1638

Contents lists available at ScienceDirect

Research in Developmental Disabilities

Sleep patterns in children with and without autism spectrum disorders: Developmental comparisons

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ARTICLE INFO

Article history:
Received 9 October 2013
Received in revised form 17 March 2014
Accepted 17 March 2014
Available online 26 April 2014

Keywords:
Autism
Sleep
Melatonin
Development

ABSTRACT

The present study examined age-related changes in the sleep of children with autism spectrum disorders (ASD) compared to age-related changes in the sleep of typically developing (TD) children. Participants were 108 mothers of children with ASD and 108 mothers of TD children. Participants completed a questionnaire on children's overall sleep quality that also tapped specific sleep-domains (i.e., bedtime resistance, sleep onset delay, sleep duration, sleep anxiety, night wakings, parasomnias, disordered breathing, daytime sleepiness). Results confirm significantly poorer sleep quantity and quality in children with ASD, particularly children age 6–9 years. Unlike TD children, the sleep problems of children with ASD were unlikely to diminish with age. Our findings suggest that it is important to exam specific domains of sleep as well as overall sleep patterns. Finding of significant age-related interactions suggests that the practice of combining children from wide age-ranges into a single category obfuscates potentially important developmental differences.

Sleep problems are common in childhood, occurring in 25–40% of typically developing (TD) children (Ivanenko & Gururaj, 2009). Difficulties with sleep are particularly widespread in children with autism spectrum disorders (ASD), occurring in about two-thirds of this population (Johnson, 1996; Richdale & Schreck, 2009; Richdale, 2001; Stores & Wiggs, 1998). Although research in the area has increased in recent years (e.g., Goldman, Richdale, Clemons, & Mallow, 2012; Hodge, Hoffman, Sweeney, & Riggs, 2013; Hoffman, Sweeney, Gilliam, & Lopez-Wagner, 2006; Mayes & Calhoun, 2009; Sivertsen, Posserud, Gillberg, Lundervold, & Hysing, 2012), little is known about the exact nature of sleep problems in children with ASD. As noted by Richdale and Schreck (2009) in their biopsychosocial model, it is a mistake to assume that what is true for TD children will hold for children with ASD. It may be the case that factors contributing to sleep difficulties in children with ASD are a function of atypical, rather than typical, development.

Age-related, developmental changes in the sleep of children with ASD is a particularly understudied area. Although, sleep problems in TD children have been found to lessen with age (Gregory & O'Connor, 2002; Sivertsen et al., 2012), as noted by Richdale and Schreck (2009) it would be a mistake to assume this same developmental pattern holds for children with ASD. For instance, research indicates that autistic symptomology is linked to children's sleep problems (Hoffman et al., 2005;

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http://dx.doi.org/10.1016/j.ridd.2014.03.037
0891-4222/

Schreck, Milick, & Smith, 2004) and the symptomology of ASD may change over time (Seltzer, Shattuck, Abbeduto, & Greenberg, 2004). It is, therefore, possible that the sleep problems of children with ASD will fluctuate with age as their symptomology either increases or decreases. Nevertheless, few researchers have considered age-related changes in the sleep of children with ASD. In a recent review by Hollway and Aman (2011), 13 of 17 studies on sleep in children with ASD acknowledged the possibility of a relationship between age and sleep by either controlling for or matching participants on age; however, only three of these studies actually reported on age-related patterns in the sleep of children with ASD.

Complicating the understanding of age-related changes in the sleep of children with ASD is the fact that findings in the scant existing literature are mixed. Some studies on sleep in children with ASD report no significant differences across age groups (Goldman et al., 2012; Mayes & Calhoun, 2009; Patzold, Richdale & Tonge, 1998; Schreck & Mulick, 2000; Wiggs & Stores, 2004; Williams, Sears, & Allard, 2004). Others have found that older children with ASD have more sleep problems than younger children with ASD (Honomichl, Goodlin-Jones, Burnham, Hansen, & Anders, 2002; Inanuma, 1984; Sivertsen et al., 2012). Others still, report more sleep problems in younger children with ASD (Richdale & Prior, 1995). To address this inconsistency in the literature, the present investigation was designed to examine age-related changes in the sleep of children with ASD and to compare age-related changes in the sleep of children with ASD to the sleep of TD children.

One potential explanation for the discrepant findings in the existing literature relates to the way in which sleep problems are conceptualized. By examining the overall pattern of sleep (e.g., a generalized or generic sleep problem), important age-related changes related to specific aspects of sleep may be obscured. That is, children's sleep may improve in one or two sleep domains but worsen or remain the same in others, thereby, resulting in no apparently significant overall changes. For instance, Goldman et al. (2012) reported on 1859 children with ASD (ages 3–18) and found significant differences across age groups (i.e., age 7 and younger versus age 11 and older) on all subscales of the Children's Sleep Habits Questionnaire (CSHQ; Owens, Spirito, & McGuinn, 2000) except disordered breathing, but found no significant age-related differences overall. Older children, compared to younger children, were reported to have significantly fewer problems related to bedtime resistance, sleep anxiety, night waking and parasomnias (e.g., sleepwalking, sleep talking, night terrors, enuresis). However, older children in the study also exhibited significantly more problems than younger children for sleep onset, sleep duration, and daytime sleepiness. Thus, despite significant age-related differences on seven of the eight sleep domains examined, there were no developmental differences in total sleep disturbance scores. Other researchers have also noted age-related differences on one or two domains of sleep in the absence of age-related differences in overall sleep (e.g., Hoffman et al., 2006; Williams et al., 2004). These findings highlight the need to examine developmental changes in specific domains of sleep as well as in the overall pattern of sleep.

A second goal of this research was to clarify age-related changes in the sleep of children with ASD relative to age-related changes in the sleep of TD children. Some studies indicate that the development of sleep in children with and without ASD follows a similar pattern in terms of sleep timing (Schreck & Mulick, 2000), sleep quantity (Allik, Larsson, & Smedje, 2008; Schreck & Mulick, 2000), bedtime resistance and sleep anxiety (Hoffman et al., 2006). Other studies have found interactions across age and group type (i.e., ASD versus TD) which indicate that sleep problems in TD children decline with age and that age-related declines were not evidenced in children with ASD (Allik et al., 2008; Richdale & Prior, 1995). This is consistent with longitudinal research by Sivertsen et al. (2012), which concluded that sleep problems improved with age for TD children and were likely to persist in children with ASD.

The objectives of the present study were to identify age-related changes in multiple domains of the sleep of children with ASD and to compare these changes to those obtained for TD children. Three hypotheses were tested. Hypothesis One predicted differences across groups where children with ASD would have poorer sleep than TD children. Hypothesis Two predicted significant within group, age-related, changes in children's sleep. It was expected that the sleep of TD children would improve over time. Due to inconsistencies in the existing literature, no predictions were made with regard to overall sleep or the specific domains of sleep on which younger versus older children with ASD would differ. Hypothesis Three predicted that the sleep problems of children with ASD would be more likely to persist than would the sleep problems of TD children. That is, we predicted interactions such that the sleep of children with ASD would show less improvement over time compared to the sleep of TD children. No predictions were made with regard to the specific individual domains of sleep for which interactions might be found.

1. Method

1.1. Participants

Mother–child dyads were 108 mothers of children with ASD and 108 mothers of typically developing children. Mothers were selected from a dataset of families participating in a program of research on parent and child functioning at a university in inland southern California. Mothers of children with ASD were selected for inclusion if their children were between the ages of 3 and 18 years, had an ASD diagnosis (based on either a maternal, clinician, or physician report), and received a score of 85 or greater on the Autism Index (AI) of the Gilliam Autism Rating Scale-2 (GARS-2; Gilliam, 2005). According to Gilliam, an overall AI score of 85 or greater denotes a high probability of autism, thus supporting the report of an ASD diagnosis. AI scores for children with an ASD in this study ranged from 85 to 143 ($M = 102.25$, $SD = 12.07$). Mothers of TD children were eligible for inclusion if they reported that their child had no diagnosed conditions (e.g., ADHD, physical disability, mental retardation) and matched a child with ASD on age and gender.

Each group (i.e., ASD and TD) contained mothers of 90 boys and 18 girls. Children ranged in age from 3 to 17 years (for children with ASD, $M = 7.33$, $SD = 3.182$; for TD children, $M = 7.71$, $SD = 3.127$). To align our results with previous findings, we selected our youngest and oldest age-groups to be comparable with earlier studies (e.g., Goldman et al., 2012; Honomichl et al., 2002; Mayes & Calhoun, 2009; Sivertsen et al., 2012) This process allowed us to develop three age-groups representing early (age 2–5), middle (age 6–9), and late (age 10–17) childhood. Analyses demonstrate that, for children with ASD, AI scores did not differ significantly across age-groups.

Mothers of children with ASD ranged in age from 26 to 54 years ($M = 37.77$, $SD = 6.42$). The majority (43.5%) of their children were identified as Caucasian, 23.1% as Hispanic, 13.0% as African American, and 20.4% were identified as belonging to some other ethnic group. Mothers of TD children ranged in age from 23 to 70 years ($M = 33.97$, $SD = 7.53$). The majority (40.7%) of TD children were identified as Caucasian, 34.3% as Hispanic, 7.4% as African American, and 17.6% were identified as belonging to some other ethnic group. Seventy-four percent of mothers of children with ASD and seventy-eight percent of mothers of typically developing children were married or living with their significant other. Half (51%) the mothers of children with ASD and 45% of mothers of TD children had completed some college, but had not completed BA degrees.

1.2. Materials

Gilliam Autism Rating Scale – Second Edition (GARS-2; Gilliam, 2005). The GARS-2, which was derived from the criteria prescribed by the DSM-IV-TR (APA, 2000) and definition provided by the Autism Society of America (2003), was used to as a second indicator of the reported independent diagnosis of ASD. Based on maternal report, the measure assesses the severity of autism within three domains; Stereotyped Behavior, Communication, and Social Interaction. The combined scores from these subscales provide an Autism Index (AI) score; the AI is the total score and represents the degree of autistic symptomology. Higher scores on the GARS-2 denote more severe levels of autism. The GARS has been used previously to assess the presence of ASD (e.g., Hodge et al., 2013). The GARS-2 manual provides norming data from a nationwide sample of 1107 children and young adults (ages 3–22 years) diagnosed with autism. Internal reliability coefficients ranged from .84 to .94, with test-retest reliability for the AI score reported at .84. Content validity, based on discrimination coefficients, ranged from .35 to .64 (Gilliam, 2005).

Children's Sleep Habits Questionnaire (CSHQ; Owens et al., 2000). The quality of children's sleep was assessed using the CSHQ. Parents are asked how frequently their child experienced specific sleep-related behaviors during the preceding week. The majority of responses are made on a three-point Likert-type scale; *usually* (5–7 nights per week), *sometimes* (2–4 nights per week), or *rarely* (0–1 night per week). The CSHQ contains eight subscales: Bedtime Resistance, Sleep Onset Delay, Sleep Duration, Sleep Anxiety, Night Wakings, Parasomnias, Sleep Disordered Breathing, and Daytime Sleepiness. These subscales can be summed to obtain a Total score which is an overall measure of children's sleep quality, with higher scores indicating more disturbed sleep. Although the CSHQ was normed with children age 4–10 years, it has been used to assess sleep in preschoolers with ASD (Goodlin-Jones, Sitnick, Tang, Liu, & Anders, 2008; Goodlin-Jones, Tang, Liu, & Anders, 2008) and adolescents with ASD (Goldman et al., 2012).

Based on a sample of 495 elementary school children and 154 children from a pediatric sleep clinic, internal consistency coefficients for the entire scale are .68 for the community sample and .78 for the clinical sample (Owens, Fernando, McGuinn, 2005). The measure demonstrates adequate test-retest reliability, with coefficients ranging from .62 to .79 (Owens et al.). The CSHQ has been used to assess sleep in typically developing children (e.g., Miller, Palermo, Powers, Scher, & Hershey, 2003; Seifer, Sameroff, Dickstein, Hayden, & Schiller, 1996) and is the most commonly used parent-report measure in research on the sleep of children with ASD (Hodge, Parnell, Hoffman, & Sweeney, 2012).

2. Results

Our analytic strategy employed Chi-square analyses to explore differences in the rates of overall sleep problems across groups (i.e., ASD versus TD) and age-related changes within each group. Children were placed in age-groups to examine age-related change. For each group (ASD and TD) there were 25 children age 3–5 years, 59 children age 6–9 years, and 24 children age 10–17 years. *T*-tests were used to assess differences in the quantity of sleep in specific domains across groups. Finally, MANOVAs were employed to (1) test for differences across groups on specific domains of sleep, (2) test within groups for age-related differences on specific domains, and (3) test for age-related changes in sleep across groups (i.e., interactions for group by age-group).

2.1. Rates of sleep problems

It is recommended that a cutoff score of 41 on the CSHQ Total be used to identify the presence of sleep problems (Owens et al., 2000; Souders et al., 2009). The percentages of children from each group (i.e., ASD and TD), by age-group, to receive scores of 41 or greater on the CSHQ Total are presented in Table 1. Based on a 2×2 (sleep problem status by group type) Chi-square analyses, children with ASD were more likely to have overall sleep problems than were TD children, χ^2 (1, $N = 216$) = 23.76, $p < .01$. In order to examine age-related differences across groups, Chi-square analyses comparing children with ASD and TD children were conducted separately for the three age-groups (i.e., 3–5, 6–9, 10–17). Results indicate that, in the youngest age group, children with and without ASD did not differ significantly on sleep problem status. For the other two

Table 1
Percent of children in each group to receive CSHQ Total scores of 41 or above.

	ASD group (%)	TD group (%)
Overall ($N = 216$)	81.5	50
3–5 ($N = 50$)	84	72
6–9 ($N = 118$)	78	45.8
10–17 ($N = 48$)	87.5	37.5

Table 2
Comparisons on CSHQ overall and subscales across ASD and TD with ages combined.

	ASD ($n = 108$)	TD ($n = 102$)
Overall	48.83 (9.68)	42.80 (7.58)**
Bedtime Resistance	9.63 (3.05)	7.67 (2.21)**
Sleep Onset Delay	1.94 (0.74)	1.38 (0.60)**
Sleep Duration	4.96 (1.94)	3.87 (1.40)**
Sleep Anxiety	6.67 (2.24)	5.38 (1.78)**
Night Wakings	4.72 (1.77)	3.77 (1.23)**
Parasomnias	9.50 (2.48)	8.86 (2.04)
Sleep Disordered Breathing	3.87 (1.42)	3.42 (0.89)*
Daytime Sleepiness	10.88 (3.46)	10.99 (2.81)

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

age-groups, children with ASD were significantly more likely to receive scores of 41 or greater; for ages 6–9, χ^2 (1, $N = 118$) = 12.96, $p < 01$ and for ages 10–17, χ^2 (1, $N = 48$) = 12.80, $p < 01$.

To test for the age-related changes in sleep problems within each group, 2 × 3 (sleep problem status by age-group) Chi-square analyses were conducted for the ASD group and the TD groups separately. Analyses for the TD group showed age-related differences with significantly fewer TD children attaining scores of 41 or higher overtime, χ^2 (2, $N = 108$) = 6.76, $p < 01$. Conversely, the Chi-square analysis for children with ASD revealed no significant age-related differences in the proportion of children receiving scores of 41 or greater on the CSHQ Total.

2.2. Sleep quantity

T-tests were employed to examine sleep quantity, no significant differences were found for the bedtime of children with ASD ($M = 8{:}59$ PM, $SD = 70$ min) and TD children ($M = 8{:}49$ PM, $SD = 47$ min). Likewise, no significant differences were found for morning wake time between the ASD group ($M = 6{:}36$ AM, $SD = 81$ min), and the TD group ($M = 6{:}37$ AM, $SD = 50$ min). However, children with ASD were reported to have had significantly less overall sleep ($M = 8$ h 47 min, $SD = 93$ min) than TD children ($M = 9$ h 22 min, $SD = 76$ min), $t(206) = 2.93$, $p < .01$ and significantly more minutes of waking after sleep onset ($M = 23.06$, $SD = 49.28$) than TD children ($M = 7.02$, $SD = 9.24$), $t(183) = 3.053$, $p < .01$.

2.3. Sleep quality

To compare sleep quality between children with and without ASD a group MANOVA, was conducted with the CSHQ subscales as dependent measures. The results of this analysis can be seen in Table 2. Multivariate tests indicated a significant effect of group (i.e., ASD versus TD) overall on the CSHQ subscales, $F(8, 203) = 5.01$, $p < .01$, and on the specific subscales of Bedtime Resistance, $F(1, 210) = 14.95$, $p < .01$, Sleep Onset Delay, $F(1, 210) = 23.88$, $p < .01$, Sleep Duration, $F(1, 210) = 13.50$, $p < .01$, Sleep Anxiety, $F(1, 210) = 1{,}12.47$, $p < .01$, Night Wakings, $F(1, 210) = 11.83$, $p < .01$, and Sleep Disordered Breathing, $F(1, 210) = 6.29$, $p < .05$. As indicated in Table 2, in each instance more specific sleep problems were reported for the ASD group than for the TD group. No significant differences were found across groups on the subscales of Parasomnias or Daytime Sleepiness.

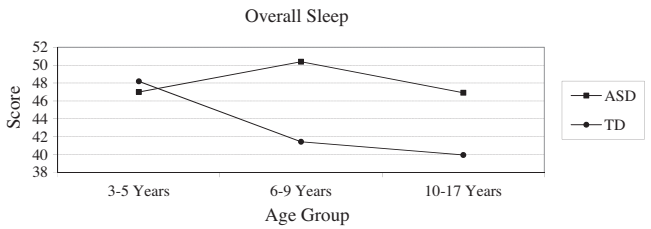
2.4. Age-related changes in sleep

To examine within-group, developmental, patterns in the sleep of children with and without ASD, MANOVAs, were run separately for the ASD and TD groups. Analyses for the ASD group were conducted first and are illustrated in Table 3. Multivariate tests indicated a significant effect of age on the subscales of Bedtime Resistance, $F(2, 105) = 3.35$, $p < .05$, and Sleep Anxiety, $F(2, 105) = 3.62$, $p < .05$. Findings from the MANCOVA for TD children are also presented in Table 3 immediately below the findings for children with ASD. This analysis on TD children revealed significant overall age differences on the CSHQ, $F(16, 196) = 2.10$, $p < 01$ and on the subscales of Bedtime Resistance, $F(2, 105) = 5.56$, $p < .01$, Sleep Onset Delay, $F(2, 105) = 3.40$, $p < .05$, Sleep Anxiety, $F(2, 105) = 6.19$, $p < .01$, Night Wakings, $F(2, 105) = 5.80$, $p < .01$, Parasomnias, $F(2, 105) = 8.06$, $p < .01$, and Daytime Sleepiness, $F(2, 105) = 4.64$, $p < .05$.

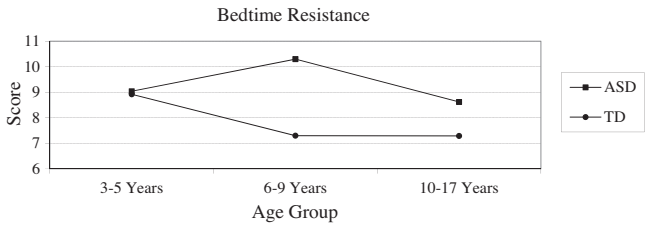
Table 3
Comparison on overall sleep scores and subscales across age-groups for ASD and TD separately.

CSHQ	Ages 3–5 ($n = 49$)	Ages 6–9 ($n = 113$)	Ages 10–17 ($n = 48$)
Overall			
ASD group	47.00 (9.30)	50.38 (10.47)	46.91 (7.45)
TD group	48.00 (9.64)	41.75 (6.25)	39.95 (5.52)*
Bedtime Resistance			
ASD group	9.04 (3.22)	10.30 (3.06)	8.62 (2.48)**
TD group	8.83 (3.08)	7.38 (1.94)	7.29 (1.36)*
Sleep Onset Delay			
ASD group	2.00 (0.76)	1.96 (0.74)	1.83 (0.76)
TD group	1.62 (0.71)	1.24 (0.51)	1.41 (0.58)**
Sleep Duration			
ASD group	4.80 (2.21)	5.11 (2.02)	4.75 (1.51)
TD group	4.20 (1.61)	3.68 (1.19)	3.91 (1.52)
Sleep Anxiety			
ASD group	5.80 (1.80)	7.15 (2.22)	6.41 (2.37)**
TD group	6.29 (2.23)	5.27 (1.69)	4.70 (1.12)*
Night Wakings			
ASD group	4.40 (1.77)	4.93 (1.77)	4.54 (1.74)
TD group	4.50 (1.69)	3.64 (1.08)	3.50 (0.83)*
Parasomnias			
ASD group	9.88 (2.48)	9.76 (2.71)	8.45 (1.47)
TD group	10.16 (2.69)	8.61 (1.68)	8.25 (1.53)*
Sleep Disordered Breathing			
ASD group	3.84 (1.57)	3.84 (1.36)	3.95 (1.45)
TD group	3.50 (1.02)	3.38 (0.87)	3.42 (0.91)
Daytime Sleepiness			
ASD group	10.12 (2.81)	10.98 (3.87)	11.45 (2.97)
TD group	12.12 (3.39)	11.16 (2.46)	9.75 (2.54)**

Note:
* $p < 01$.
** $p < 05$.



Graph 1. Significant interaction on CSHQ Total scores for group-type by age-group.

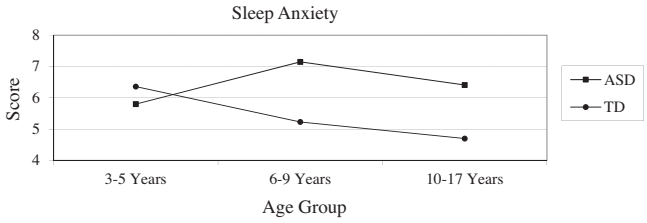


Graph 2. Significant interaction on Bedtime Resistance for group-type by age-group.

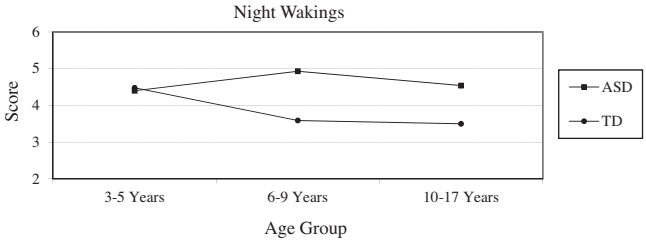
A 2 × 3 (group-type by age group) MANOVA, revealed significant interactions for the CSHQ overall score, $F(16, 406) = 2.10$, $p < .01$, and the subscales of Bedtime Resistance, $F(2, 210) = 5.86$, $p < .01$, Sleep Anxiety, $F(2, 210) = 7.39$, $p < .01$, Night Wakings, $F(2, 210) = 3.93$, $p < .05$, and Daytime Sleepiness, $F(2, 210) = 4.34$, $p < .05$. These relationships are presented in Graphs 1–5.

3. Discussion

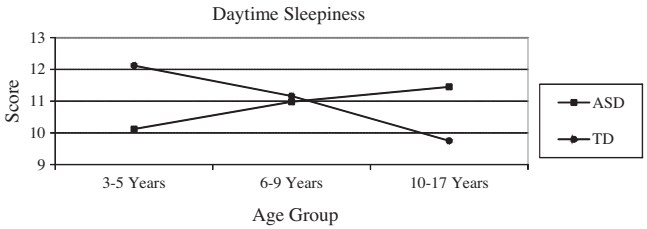
Hypothesis One, that mothers would report poorer sleep for children with ASD than for TD children was confirmed in terms of both quantity and quality of sleep. Although children with and without ASD had similar bedtimes and wake times,



Graph 3. Significant interaction on Sleep Anxiety for group-type by age-group.



Graph 4. Significant interaction on Night Wakings for group-type by age-group.



Graph 5. Significant interaction on Daytime Sleepiness for group-type by age-group.

children with ASD were reported to sleep significantly less, probably a result of their significantly longer waking periods during the night. The youngest and oldest participants with ASD were significantly more likely than their TD counterparts to have sleep difficulties as assessed by the CSHQ Total score cutoff of 41. Additionally, qualitative differences in the sleep of children with and without ASD were demonstrated by significant group differences on six of the eight CSHQ subscales. With age-groups combined, children with ASD differed significantly from TD children in terms of mothers' reports of higher levels for Bedtime Resistance, longer Sleep Onset Delay, more problems with Sleep Duration, greater Sleep Anxiety, more Night Wakings, and more Sleep Disordered Breathing. Mothers' reports of the sleep problems of children with and without ASD did not differ on the Parasomnias or Daytime Sleepiness domains of the CSHQ.

Hypotheses Two, that there were would be within group, age-related, changes in children's sleep was also supported. Children with ASD improved significantly with age on the Bedtime Resistance subscale and worsened significantly with age on the Sleep Anxiety subscale. In both instances problems were reported to peak for the middle age-group (i.e., ages 6–9). For TD children, significant age-related differences overall on the CSHQ and on the subscales of Bedtime Resistance, Sleep Onset Delay, Sleep Anxiety, Night Waking, Parasomnias, and Daytime Sleepiness indicated that with age, sleep improved significantly.

Hypothesis Three, that the sleep problems of children with ASD, compared to TD children, would be more likely to persist as they aged, was confirmed via two methods. When comparing the youngest group of TD children to the oldest group of TD children, the rate of mother-reported sleep difficulties dropped significantly from 72% to 37.5%. Comparing the youngest children with ASD to the oldest children with ASD, the rates of sleep difficulties increased marginally from 84% to 87.5%. Additional evidence for the persistence of sleep problems in children with ASD was found in interactions by age and group membership. Significant age by group interactions were identified for Total sleep scores, as well as for Bedtime Resistance, Sleep Anxiety, Night Waking, and Daytime Sleepiness domains. Elevated scores for children with ASD in the middle age-group (i.e., age 6–9) accounted for four of these five interactions (i.e., Total sleep score, Bedtime Resistance, Night Wakings, Sleep Anxiety). Notably, for the Daytime Sleepiness subscale, when age groups were combined, there was no significant difference between children with and without ASD. Yet, when age was considered, the trajectories for groups moved in opposite directions. That is, TD children were reported to evidence significantly less daytime sleepiness with age and children with ASD were reported to exhibit markedly more daytime sleepiness with age. This finding supports our assertion

that examining differences between children with ASD and TD children without considering age-related changes obfuscates potentially important differences in the way that sleep changes for children with and without ASD.

As noted, in four of the five areas of sleep for which we identified significant group by age interactions, the sleep problems were most evident in children with ASD who were between the ages of 6 and 9 years. This worsening of problems for the middle age-group may be attributable to differences in children's production of the hormone melatonin. Melatonin has been implicated as a contributor to the sleep–wake dysregulation evidenced in children with ASD (Tordjman, Anderson, Pichard, Charbuy, & Touitou, 2005; Rossignol & Frye, 2011). Melatonin is responsible for the synchronization of body rhythms and the regulation of sleep (Arendt, 1995; Didden & Sigafoos, 2001; Hering, Epstein, Elroy, Se Iancu, & Zelnik, 1999; Richdale & Prior, 1995). Serotonin, a precursor to melatonin, is also believed to play an important role in the regulation of sleep. Differences in melatonin and serotonin production, perhaps associated with ASD, may make it difficult for individuals with ASD to establish a 24-h sleep–wake cycle (Arendt, 2005; Nir et al., 1995). This suggestion is in line with research identifying abnormally low levels of melatonin in children with ASD (Kulman et al., 2000; Nir et al., 1995; Tordjman et al., 2005) and of serotonin in young adults with ASD (Nir et al., 1995). Significantly, in terms of our findings, Tordjman et al. (2005) found that excretion rates for 6-sulphatoxymelatonin, a metabolite of melatonin, were particularly low in prepubescent (i.e., under the age of 10) children with ASD. Our findings of more disrupted sleep among children with ASD who were between the ages of 6 and 9 years, is consistent with the interpretation that dysregulations in melatonin may be contributing, at least in some measure, to the sleep difficulties indicated for prepubescent children with ASD. This contention is bolstered by a proposed relationship between atypical melatonin and difficulties related to sleep onset and sleep maintenance (Richdale, 2001) and our finding of greater bedtime resistance and night waking in children with ASD between the ages of 6 and 9 compared to older or younger children with ASD.

This study benefited from a large sample of children with ASD who were matched to typically developing children and their mothers. The study was further strengthened by the use of two indicators of ASD and by employing a widely used, standardized, measure of children's sleep. Additionally, because our data were part of a larger study addressing overall functioning in families of typical children and children with developmental disabilities, we avoided potential selection biases. However, this study also has methodological limitations. Several researchers have noted the shortcomings associated with parental reports of children's sleep (e.g., Arbelle & Ben-Zion, 2001; Johnson, 1996; Richdale, 2001; Schreck & Mulick, 2000). We acknowledge this limitation, however, cognitive and language difficulties make obtaining self-reported information from children with ASD impractical and children with ASD are frequently unable to tolerate the application of sensors required for objective data collection (Hodge et al., 2012). Additionally, the validity of the CSHQ for assessing some aspects of children's sleep has been objectively confirmed (Hodge et al.) and the Total score cutoff of 41, has shown excellent agreement with an objective measure of children's overall sleep quality (Souders et al., 2009). The cross-sectional nature of this study represents an additional limitation. It is therefore necessary to interpret the findings with some caution. The best means by which to understand the continuity or discontinuity of children's sleep over time would be to employ longitudinal designs. To date there is a paucity of longitudinal research on sleep in children with ASD, with only a handful of studies examining the sleep of children with ASD over several months to a few years (e.g., Allik et al., 2008; Goodlin-Jones, Schwichtenberg, Iosif, Tang, & Liu, 2009; Sivertsen et al., 2012).

This study contributes to the growing body of evidence indicating that the sleep of children with ASD is more problematic than the sleep of TD children and that children with ASD appear to be less likely to outgrow their sleep problems. Whereas TD children displayed a pattern of improvement in sleep at each successive age group, children with ASD in our middle age-group often evidenced a peak in CSHQ scores relative to their younger and older counterparts. Moreover, our findings indicate that when assessing sleep as a global characteristic (e.g., overall sleep scores, the presence of a generic sleep problem), researchers may be missing important developmental differences related to specific domains of children's sleep. Finally, our finding of significant age-related interactions, across groups, in the absence of overall group differences when ages were combined, suggests that the practice of combining children from wide age-ranges into a single category should be avoided.

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