

# The Relationship Between Sleep Problems and Daytime Behavior in Children of Different Ages With Autism Spectrum Disorders

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## KEY WORDS

autism spectrum disorders, sleep problems, behavior problems, adaptive skills

## ABBREVIATIONS

ASD—autism spectrum disorder  
 ATN—Autism Treatment Network  
 CBCL—Child Behavior Checklist  
 CSHQ—Children's Sleep Habits Questionnaire  
 DLS—Daily Living Skills  
 HRQoL—health-related quality of life  
 MANOVA—Multiple analysis of covariance  
 VABS-II—Vineland Adaptive Behavior Scales, Survey Interview Form, Second Edition

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## abstract

**BACKGROUND:** The purpose of the current study was to evaluate the relationships among sleep problems and daytime behaviors in a large, well-defined cohort of children with autism spectrum disorder (ASD).

**METHODS:** Out of a registry population of 3452 children with ASDs, a subset of 1193 children aged 4 to 10 years of age from 14 centers across the country was used to evaluate the relationship between varying levels of sleep problems and daytime behavior. Measures included Children's Sleep Habits Questionnaire, Vineland Adaptive Behavior Scales, Survey Interview Form, Second Edition, and Child Behavior Checklist. Multiple analysis of covariance was used to assess the association between sleep and behavior.

**RESULTS:** Results suggest that sleep problems, as identified by parent report by use of the Children's Sleep Habits Questionnaire, have a negative relationship with daytime behavior. More specifically, children with ASDs and sleep problems had more internalizing and externalizing behavior problems, as measured by the Child Behavior Checklist, and poorer adaptive skill development, as measured by the Vineland Adaptive Behavior Scales, than children with ASDs and no sleep problems. Children with moderate to severe sleep problems had greater behavior difficulties, but not necessarily poorer adaptive functioning, than children with mild to moderate sleep problems. Both preschool- and school-aged children demonstrated a negative relationship between behavior and sleep, whereas the relationship between sleep and adaptive functioning was much more variable.

**CONCLUSIONS:** These results suggest that, although sleep has a negative relationship with internalizing and externalizing behavior, it may have a different relationship with the acquisition of adaptive skills. *Pediatrics* 2012;130:S83–S90

Autism spectrum disorders (ASDs) are a group of neurodevelopmental disorders defined by impairments in the areas of communication and socialization, as well as patterns of restricted or repetitive behaviors.<sup>1</sup> Recently, attention has shifted to treating medical conditions found in children with ASDs with the goal of improving overall function and health-related quality of life (HRQoL). One such comorbid condition is sleep disturbance.

Studies indicate that 50% to 80% of children with ASDs have sleep problems.<sup>2–4</sup> Sleep-onset and maintenance insomnia are the primary sleep problems reported by parents of children with ASDs.<sup>4–6</sup> Additionally, children with ASDs experience irregular sleep-wake patterns, early morning awakenings, and poor sleep routines.<sup>7–10</sup> Attempts have been made to control for the confounding variable of intellectual deficits when evaluating sleep problems in ASD, and it appears that ASD is an independent risk factor for sleep problems.<sup>4,11</sup>

Parents of typically developing children with sleep problems report a number of negative consequences during the day. These include behavior difficulties, affective problems, and cognitive dysfunction.<sup>12–17</sup> In children with developmental disabilities, poor sleep habits have been related to negative mood, irritability, self-injury, and aggression.<sup>18,19</sup> Several additional studies have emphasized the negative impact of childhood sleep disorders on the HRQoL for the child and family.<sup>20–22</sup>

Although the relationship between sleep and daytime functioning is established in heterogeneous groups of children with developmental disabilities, fewer studies have looked at this relationship in children with ASDs. Mayes and Calhoun<sup>23</sup> reported that children with ASDs and sleep problems had more severe autistic symptoms, hyperactivity, mood variability, and aggression, than children with no sleep problems. Malow and

colleagues<sup>24–26</sup> found associations among sleep problems and inattention, hyperactivity, ritualistic behavior, self-injury, and affective problems. Because behavior symptoms and sleep habits in children with ASDs change with age,<sup>27</sup> it becomes important to look at the relationship between sleep problems and daytime functioning in children with ASDs at different ages.

The purpose of the current study was to further evaluate the relationship between sleep problems and daytime behavior by using a large, well-defined cohort of children with ASDs and stratify the sample by age. We chose to evaluate not only problem behavior, but also adaptive behavior, which has not been the focus of previous studies. It was hypothesized that (1) participants with sleep problems would have more behavior problems and poorer adaptive functioning than those with no sleep problems, (2) participants with moderate to severe sleep problems would have more behavior problems and poorer adaptive functioning than those with mild sleep problems, and (3) sleep problems would have weaker relationships to daytime behavior in older versus younger children.

## METHODS

### Recruitment and Sample Description

This research was conducted as part of the activities of the Autism Treatment Network (ATN), a registry collecting data on children ages 2 to 17 with ASDs across 14 sites in the United States and Canada. All ATN participants completed a multidisciplinary evaluation that included diagnostic, cognitive, behavioral, and physical assessments, including assessment of sleep. Parents or legal guardians of all participants provided consent for participation, and an institutional review board at each participating ATN site reviewed and approved the study.

Participants in the current study met the following inclusion criteria: (1) age 4 to 10 years; (2) a clinical ASD diagnosis according to one or more diagnostic measures: Autism Diagnostic Observation Schedule, Autism Diagnostic Interview-Revised, or *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* symptom checklist; (3) planned or ongoing care at an established ATN site that allowed for completion of the research testing; and (4) parent/caregiver fluent in written and spoken English, and English spoken in the home with the child at least 75% of the time.

## Measures

### Sleep

Children's Sleep Habits Questionnaire (CSHQ).<sup>28</sup> Parents completed the CSHQ, a survey used to screen for sleep problems, consisting of 45 sleep-related questions. Parents are asked to recall children's sleep behaviors over a "typical" recent week. Items are rated on a 3-point scale: "usually" (behavior occurred 5–7 times per week); "sometimes" (2–4 times per week); and "rarely" (0–1 time per week). Parents are asked to endorse whether each sleep behavior item is considered problematic (yes/no). Ratings on 33 of the 45 items are summed to generate a single total score; higher scores indicate more severe sleep difficulties.

The CSHQ had satisfactory psychometric properties in a large sample of 4- to 10-year-old children<sup>28</sup> and was found to be clinically useful for screening sleep problems in typically developing children ages 2 to 5.5 years.<sup>29</sup> A total CSHQ score of >41 has been reported to be a sensitive cutoff for clinically significant sleep problems.<sup>30</sup>

Participants were grouped based on scores on the CSHQ: those with scores <41 (good sleepers) or scores ≥41 (poor sleepers). Poor sleepers were further divided into those with mild

sleep problems and those with moderate to severe sleep problems, as previously reported by Krakowiak et al<sup>6</sup> using a different sleep measure. They found that sleep problem severity was associated with increased medication use and health problems. They did not explore the relationship between sleep problem severity and daytime behavior, which may be important clinically in terms of when to address reported sleep concerns. Groupings for the current study were determined based on calculating the CSHQ score at the 75th percentile (fourth quartile) for our participant population (a score of 56).<sup>31</sup> Participants with CSHQ scores of 41 to 55 fell in the mild sleep problem group, whereas participants with scores of 56 and above fell in the moderate to severe sleep problem group.

### *Adaptive Functioning*

Vineland Adaptive Behavior Scales, Survey Interview Form, Second Edition (VABS-II).<sup>32</sup> Parents were interviewed to complete the VABS-II, a semistructured caregiver interview of a child's everyday living skills. Open-ended questions are used to determine if the child "usually," "sometimes or partially," or "never" performs various behaviors within the domains of: Communication, Daily Living Skills (DLS), Socialization, and Motor Skills. Interviews were conducted and protocols scored by trained clinicians at each of the participating ATN sites. VABS-II standard scores have a mean of 100 and SD of 15. Scores between 85 and 115 are considered to be within normal limits, whereas scores of <70 are considered to be within the impaired range of ability (lower scores = greater impairment). The VABS-II has adequate reliability and validity<sup>33</sup> and has been widely used for years as a measure of adaptive skills in individuals with a wide variety of developmental and chronic health conditions. Standard scores for the Adaptive Behavior Composite and Communication,

DLS, and Socialization domains were used in the current study.

### *Behavioral Functioning*

Child Behavior Checklist (CBCL).<sup>34</sup> The CBCL is a caregiver-completed measure of a variety of childhood behavior problems; it consists of 2 separate forms: one for children between the ages of 1.5 and 5 years, and the other for children between the ages of 6 and 18 years. Both versions assess specific internalizing and externalizing problematic behaviors. Caregivers are asked to rate the frequency of each behavior on a 3-point Likert scale (0 = Not True, 1 = Somewhat or Sometimes True, 2 = Very True or Often True). Scores are summed and converted to T scores (M = 50, SD = 10) on factor analytically derived syndrome scales, with higher scores suggesting greater behavior problems. Syndrome scales are combined to form an Internalizing Problems, Externalizing Problems, and Total Problems composite score. A composite scale T score of <60 is considered "average," whereas a T score of >65 is generally considered "clinically significant." The manual for the CBCL reports adequate reliability and validity for scale scores. Researchers have used the CBCL specifically to examine the relationship between sleep problems and daytime behavior in children. For example, Stein et al<sup>35</sup> studied children aged 4 to 12 and found strong associations between sleep problems and the externalizing and internalizing scores on the CBCL. In the current study, parents completed the version of the CBCL appropriate to their child's age, and composite scores were used in the analyses.

The CBCL manual<sup>34</sup> reports that the assignment of T scores at T = 50 were truncated and notes that raw scores "can reflect greater differentiation than T scores among children who obtain low scores on these scales." We

followed recommendations outlined in the CBCL manual and converted our sample's raw scores to z scores separately for each age range and gender with the sample. In this way, we were able to obtain a common metric for all children in the sample. Thus, each participant's CBCL score reflects his or her standing relative to other children of the same age and gender in our sample.

Age stratification was based on the 2 different versions of the CBCL (for ages 1.5–5 or ages 6–18). The preschool-aged group included participants ages 4 to 5, whereas the school-aged group included participants ages 6 to 10.

### *Cognitive Functioning*

Cognitive scores were used in this study only as covariates in the multivariate analyses. Participants were individually administered a cognitive instrument based on their age and ability to participate in standardized testing. Either the early learning composite from the Mullen Scales of Early Learning<sup>36</sup> or the Abbreviated IQ from the Stanford Binet Intelligence Scale, fifth edition,<sup>33</sup> was used as a global indicator of cognitive functioning.

### **Procedure**

All data collected as part of a participant's initial, multidisciplinary evaluation at one of the ATN sites were deidentified and entered into a single data repository. The following data were extracted from the repository for analysis as part of the current study: age, gender, diagnostic classification, global indicator of cognitive functioning, and scores from the CSHQ, VABS-II, and CBCL, as described above.

### **Data Analysis**

Multiple analysis of covariance (MANOVA), with the use of the sleep groups as described above as a between-subject variable, was used to

assess the association between sleep as measured by the CSHQ and behavior as measured by the CBCL and the VABS-II. MANOVA is an extension of the analysis of variance model and used when there are 2 or more related dependent variables. MANOVA takes into consideration the pattern of covariation among the related dependent measures while controlling the overall  $\alpha$ -level. In the current study, the MANOVA tested whether mean differences among the sleep groups (independent variable) on a combination of dependent variables (CBCL total, internalizing and externalizing subscales, or VABS-II domains) were likely to have occurred by chance. This is achieved by creating a single dependent measure from a combination of all dependent measures that maximizes the between-group differences. MANOVA determines whether there are statistically reliable mean differences among groups, after adjusting the newly created dependent measure on 1 or more covariates. Race, cognitive functioning, and diagnosis were designated as covariates. If the overall MANOVA F test showed the centroid of means (vectors of mean values of the dependent variables in the

model) of the sleep group effect was not the same for all groups, post hoc univariate F tests of group differences were used to determine which sleep group means differ significantly from others. Because of multiple comparisons, we used a  $P$  value of .01 to reduce type 1 error. All analyses were conducted by using SAS Version 9.1.

## RESULTS

Of 3452 children enrolled in the ATN at the time of database closure for these analyses (January 31, 2011), 1193 were eligible for participation in the current study. Those children excluded from the current study were outside the specified age range or were missing 1 or more of the measures described below. Demographic characteristics of the sample are reported in Table 1.

### Relationship Between Sleep Problems and Behavior Problems

Z scores from the CBCL were compared across sleep groups for both preschool- and school-aged children. We found that the sleep groups differed on the CBCL total score as well as the internalizing and externalizing compos-

ite scores. The MANOVA revealed an effect of sleep group (Wilks  $\lambda = 0.82$ ,  $P < .0001$ ). The good sleep group scored significantly lower on the 3 composite scores than the sleep problem group ( $P < .0001$ ). Within the sleep problem group, participants with mild sleep problems scored lower than participants with moderate to severe sleep problems. The MANOVA revealed an effect of being in the mild sleep problem group versus moderate to severe sleep problem group for both age groups (Wilks  $\lambda = 0.77$  and  $0.83$ ;  $P < .0001$ , respectively). Results are summarized in Table 2.

### Relationship Between Sleep Problems and Adaptive Functioning

Scores from the VABS-II were compared across sleep groups for both age groups. The MANOVA revealed an effect of sleep group overall and for both age groups (Wilks  $\lambda = 0.97$ ,  $0.96$ , and  $0.96$ ;  $P < .0001$ ,  $.003$ , and  $.005$ , respectively). For the sample as a whole, we found that all groups differed from each other on the composite score, with the moderate to severe sleep problem group having the lowest score of the 3 groups ( $P < .0001$ ). For the

**TABLE 1** Demographic Information for Each Sleep Group and Entire Participant Group

| Characteristic           | Good Sleepers<br>(CSHQ <41) (n = 340) | Mild Sleep Problems<br>(CSHQ 41–55) (n = 638) | Moderate-Severe Sleep Problems<br>(CSHQ >55) (n = 215) | Total       | $\chi^2$<br>(P Value) |
|--------------------------|---------------------------------------|---|--|-------------|-----------------------|
| Age (N = 1193)           |                                       |   |  |             |                       |
| 4–5 y                    | 157 (46.2)                            | 288 (45.1)                                    | 113 (52.6)   | 558 (46.8)  | 3.62 (0.16)           |
| 6–10 y                   | 183 (53.8)                            | 350 (54.9)                                    | 102 (47.4)   | 635 (53.2)  | —                     |
| Gender (N = 1193)        |                                       |   |  |             |                       |
| Male                     | 291 (85.6)                            | 541 (84.8)                                    | 182 (84.7)   | 1014 (85.0) | 0.13 (0.93)           |
| Female                   | 49 (14.4)                             | 97 (15.2)                                     | 33 (15.3)  | 179 (15.0)  | —                     |
| Race (N = 1193)          |                                       |   |  |             |                       |
| White                    | 279 (82.1)                            | 500 (78.4)                                    | 165 (76.7)   | 944 (79.1)  | 2.73 (0.25)           |
| Nonwhite                 | 61 (17.9)                             | 138 (21.6)                                    | 50 (23.3)  | 249 (20.9)  | —                     |
| ASD diagnosis (N = 1193) |                                       |   |  |             |                       |
| Autism                   | 208 (61.2)                            | 402 (63.0)                                    | 132 (61.4)   | 742 (62.2)  | 4.20 (0.38)           |
| Asperger's               | 33 (9.7)                              | 72 (11.3)                                     | 31 (14.4)  | 136 (11.4)  | —                     |
| PDD/NOS                  | 99 (29.1)                             | 164 (25.7)                                    | 52 (24.2)  | 315 (26.4)  | —                     |
| IQ group (N = 1193)      |                                       |   |  |             |                       |
| >100                     | 78 (22.9)                             | 141 (22.1)                                    | 50 (23.3)  | 269 (22.5)  | 6.08 (0.64)           |
| 85–100                   | 87 (25.6)                             | 168 (26.3)                                    | 46 (21.4)  | 301 (25.2)  | —                     |
| 70–85                    | 64 (18.8)                             | 115 (18.0)                                    | 46 (21.4)  | 225 (18.9)  | —                     |
| 55–70                    | 53 (15.6)                             | 89 (14.0)                                     | 25 (11.6)  | 167 (14.0)  | —                     |
| <55                      | 58 (17.1)                             | 125 (19.6)                                    | 48 (22.3)  | 231 (19.4)  | —                     |

PDD/NOS, pervasive developmental disorder not otherwise specified—only one comparison value per characteristic. indicates that there were no differences among the groups.

**TABLE 2** Z Scores From the CBCL (Mean = 0; SD = 1) by Sleep Group and Analysis Results

| CBCL          | Age Category | Good Sleepers (CSHQ <41), Mean (SE) | Mild Sleep Problems (CSHQ = 41–55), Mean (SE) | Moderate-Severe Sleep Problems (CSHQ > 55), Mean (SE) | P      |
|---------------|--------------|-------------------------------------|---|---|--------|
| Total CBCL    | Overall      | −0.50 (0.06)                        | 0.02 (0.05) <sup>a</sup>                      | 0.70 (0.07) <sup>a,b</sup>                            | <.0001 |
|               | Age 4–5      | −0.53 (0.10)                        | 0.05 (0.08) <sup>a</sup>                      | 0.64 (0.11) <sup>a,b</sup>                            | <.0001 |
|               | Age 6–10     | −0.47 (0.09)                        | −0.01 (0.07) <sup>a</sup>                     | 0.76 (0.10) <sup>a,b</sup>                            | <.0001 |
| Internalizing | Overall      | −0.42 (0.07)                        | −0.01 (0.05) <sup>a</sup>                     | 0.57 (0.07) <sup>a,b</sup>                            | <.0001 |
|               | Age 4–5      | −0.50 (0.10)                        | −0.01 (0.09) <sup>a</sup>                     | 0.49 (0.11) <sup>a,b</sup>                            | <.0001 |
|               | Age 6–10     | −0.36 (0.09)                        | −0.02 (0.07) <sup>a</sup>                     | 0.62 (0.10) <sup>a,b</sup>                            | <.0001 |
| Externalizing | Overall      | −0.34 (0.07)                        | 0.03 (0.06) <sup>a</sup>                      | 0.56 (0.08) <sup>a,b</sup>                            | <.0001 |
|               | Age 4–5      | −0.29 (0.10)                        | 0.10 (0.09) <sup>a</sup>                      | 0.49 (0.12) <sup>a,b</sup>                            | <.0001 |
|               | Age 6–10     | −0.37 (0.09)                        | −0.03 (0.07) <sup>a</sup>                     | 0.67 (0.10) <sup>a,b</sup>                            | <.0001 |

The overall models were adjusted to all covariates including age. The age specific models were covariate adjusted (separate/stratified models by age).

<sup>a</sup> P value < .01 (good compared with either mild or moderate to severe).

<sup>b</sup> P value < .01 (mild compared with moderate to severe).

Communication domain, the good sleep group scored significantly lower than both the mild and moderate to severe sleep problem groups for the preschool-aged children but only significantly lower than the moderate to severe sleep problem group for the school-aged children. There was no significant difference in scores between the mild and moderate to severe sleep problem groups. For the DLS domain, there were no differences in scores between the good sleep and mild sleep problem groups for both preschool- and school-aged children, but there were differences in scores between the good sleep group and the moderate to severe sleep group for preschool-aged children ( $P = .0052$ ). In the Socialization domain, there were

no differences in scores across groups for the preschool-aged children, but there were differences in scores between the good sleep group and the sleep problem groups for children 6 to 10 years old. There were no differences between the mild and moderate to severe sleep problem groups for any domain at any age. Results are summarized in Table 3.

### DISCUSSION

Results from the current study support our first hypothesis. Children with ASDs and sleep problems had higher scores on the CBCL (more behavior problems) and lower scores on the VABS-II (poorer adaptive functioning) than children with ASDs and no sleep problems. These

findings confirm previous studies looking at the relationship between sleep problems and daytime behavior of children with ASDs.<sup>9,23–26</sup> DeVincent et al<sup>37</sup> reported that externalizing behaviors were greater in children with ASDs and poor sleep in comparison with children with ASDs and typical sleep habits. In the current study, not only were externalizing problems related to sleep quality, but also internalizing problems, such as emotional reactivity and anxiety. Internalizing behaviors are often problematic for children with ASDs, and it is relevant to document that they are also related to a child's sleep habits.

The relationship between sleep and adaptive behavior was less robust. For

**TABLE 3** Standard Scores From the VABS-II (Mean = 100; SD = 15) by Sleep Group and Analysis Results

| Vineland                          | Age Category | Good Sleepers (CSHQ <41), Mean (SE) | Mild Sleep Problems (CSHQ = 41–55), Mean (SE) | Moderate-Severe Sleep Problems (CSHQ >55), Mean (SE) | P      |
|-----------------------------------|--------------|-------------------------------------|---|--|--------|
| Communication                     | Overall      | 81.47 (0.81)                        | 78.56 (0.67) <sup>a</sup>                     | 76.84 (0.90) <sup>a</sup>                            | <.0001 |
|                                   | Age 4–5      | 83.09 (1.29)                        | 79.08 (1.09) <sup>a</sup>                     | 77.60 (1.41) <sup>a</sup>                            | .0003  |
|                                   | Age 6–10     | 80.12 (1.01)                        | 78.04 (0.84)                                  | 76.27 (1.16) <sup>a</sup>                            | .0092  |
| Daily living skills               | Overall      | 80.71 (0.86)                        | 79.50 (0.71)                                  | 76.45 (0.96) <sup>a,b</sup>                          | .0002  |
|                                   | Age 4–5      | 81.77 (1.36)                        | 79.69 (1.14)                                  | 76.82 (1.48) <sup>a</sup>                            | .0058  |
|                                   | Age 6–10     | 79.85 (1.13)                        | 79.29 (0.93)                                  | 76.24 (1.29)   | .0343  |
| Socialization                     | Overall      | 74.40 (0.75)                        | 72.45 (0.62) <sup>a</sup>                     | 71.01 (0.83) <sup>a</sup>                            | .0007  |
|                                   | Age 4–5      | 74.25 (1.17)                        | 72.84 (0.99)                                  | 72.58 (1.27)   | .3397  |
|                                   | Age 6–10     | 74.51 (0.99)                        | 71.96 (0.82) <sup>a</sup>                     | 69.26 (1.153) <sup>a</sup>                           | .0002  |
| Adaptive behavior composite score | Overall      | 77.04 (0.66)                        | 75.17 (0.55) <sup>a</sup>                     | 73.12 (0.74) <sup>a,b</sup>                          | <.0001 |
|                                   | Age 4–5      | 77.80 (1.09)                        | 75.61 (0.92)                                  | 73.87 (1.19) <sup>a</sup>                            | .0056  |
|                                   | Age 6–10     | 76.45 (0.82)                        | 74.73 (0.68)                                  | 72.50 (0.94) <sup>a</sup>                            | .0009  |

The overall models were adjusted to all covariates including age.

<sup>a</sup> P value < .01 (good compared with either mild or moderate to severe).

<sup>b</sup> P value < .01 (mild compared with moderate to severe).



the participant group as a whole, sleep problems were related to poorer communication and socialization skills, regardless of the degree of sleep problems. In contrast, they were related to DLS only when sleep problems became moderate to severe. One possible explanation for these results is differences in the VABS-II domains. The Communication and Socialization domains, in general, reflect core ASD symptoms, whereas the DLS domain more often reflects specific skill sets. Parent values and priorities often influence whether DLS are taught and which skills are emphasized. Children who are taught skills such as teeth brushing or taking a bath will score higher on the DLS domain than children who are not taught these skills. Mild sleep problems may not force parents to turn their focus away from teaching DLS. Only when sleep problems become more severe might a parent's focus shift away from teaching DLS to treating sleep problems. In contrast, because Communication and Socialization skills are core ASD symptoms, any sleep problems, even mild ones, may be negatively related to skill development in these areas. Other researchers have found similar results. In a study looking at children with ASDs who were characterized by their parents as good and bad sleepers, children characterized as good sleepers were only reported to have problems in language, attention, and social interaction, whereas bad sleepers were reported to have problems with attention, social interaction, language, hyperactivity, sensory issues, anxiety, eating behaviors, and self-stimulatory behavior.<sup>38</sup>

Results also support our second hypothesis that children with moderate to severe sleep problems have more daytime behavior problems than children with mild sleep problems. CBCL scores were statistically significantly higher for children with moderate to

severe sleep problems in comparison with children with mild sleep problems. These differences suggest a relationship between sleep and behavior problems such that children with greater sleep disturbance have greater behavior disturbance. Although all 3 CBCL scores evidenced these differences, VABS-II scores did not. Only the Adaptive Behavior Composite and DLS scores differed between the mild and moderate to severe sleep groups. A possible reason for this difference is the impact that both sleep and problem behaviors have on parenting stress. Behavior and sleep problems have been found to have a stronger negative relationship with parenting stress than autistic symptom severity in children with ASDs.<sup>25</sup> As suggested above, when sleep problems increase and parents become more stressed, they may become less available to teach their children DLS.

Results did not support our third hypothesis, that sleep problems would have a weaker relationship to daytime behavior in older versus younger children. Although this finding was true for DLS domain scores, the opposite was true for Communication domain scores. On the CBCL, a relationship between sleep and behavior was significant for both older and younger children. Therefore, our results indicate that age may not be an important factor in looking at the relationship between sleep and behavior in children ages 4 to 10. There is, however, research that indicates that sleep problems in early childhood persist through adolescence but that the nature of an individual's sleep difficulties may change.<sup>39</sup>

Whereas results of the current study are important in determining the relationship between sleep problems and daytime functioning, it is necessary to look also at clinical implications of the data presented. With a few exceptions, clinically significant scores were only

evident in the moderate to severe sleep problem group. None of the scores reached clinical significance for the no or mild sleep problem groups. Although our results further support the relationship between sleep and behavior problems, they also suggest that behavior problems may only reach clinical significance, where direct intervention is warranted, in children with moderate to severe sleep problems. Therefore, by bringing moderate to severe sleep problems down to the mild range of severity, parents may experience improved daytime functioning in their children with ASDs. However, this finding also supports the possible bidirectionality of the sleep-behavior relationship. It may be that, by improving some aspects of daytime functioning, such as decreasing anxiety and emotional reactivity, children may have an easier time falling and staying asleep.

There are limitations to the current study. First, although groups evidenced statistically significant differences, few differences would reach the level of clinical significance. Despite the lack of clinically significant differences, findings strongly support a relationship between sleep problems and daytime functioning, particularly because significance was set at a *P* value of .01 rather than .05. Second, information about both sleep and daytime behavior was gathered via parent report. Although parent report is generally used as a proxy for self-report of children, Wiggs and Stores<sup>40</sup> suggested that parents are accurate in their report of sleep problems only when children make them aware of them (ie, wake them up). Therefore, future research should use more objective measures of behavior and sleep. Third, the use of quartile scores as the cutoff between mild and moderate to severe sleep problems may not be valid. Although this statistical method is often used to define groups,<sup>31</sup> it has not been

determined that higher scores (>41) on the CSHQ are correlated with more meaningful impairment. However, the fact that there were differences between the sleep problem groups on many measures suggests that higher scores may mean more impairment.

Finally, although this study emphasizes the bidirectional relationship between sleep and daytime behavior, there could be other factors that influence both. For example, having a neurodevelopmental disorder might not only result in core ASD symptoms but also impaired behavior and regulation of sleep. ASD symptoms, such as a lack of social awareness or nonfunctional routines, may impact both sleep and daytime behavior. In addition, cognitive level

may be related to both sleep and daytime behavior, which is why, in the current study, our global measure of cognitive ability was used as a covariate. Environmental variables, such as parent stress or family circumstances, also may impact sleep and behavior. Future research should focus on the relationships among all of these variables (ie, sleep, behavior, IQ, ASD symptoms, environmental factors) and the relative contribution of each to outcome and quality of life.

Despite these limitations, the results of this study provide additional support that nighttime sleep problems in children with ASDs are related to negative outcomes during the day, particularly in the area of internalizing and external-

izing behavior problems, although adaptive functioning is also related to sleep problems. In addition, children with ASDs and moderate to severe sleep problems seem to fare worse than children with ASDs and mild sleep problems, particularly in the area of adaptive functioning. Future studies need to examine the impact of improving sleep habits in children with ASDs and sleep problems. If improving sleep habits results in improved daytime functioning, then the HRQoL for both children with ASDs and their families may also improve.

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# The Relationship Between Sleep Problems and Daytime Behavior in Children of Different Ages With Autism Spectrum Disorders

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