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Exploring bidirectional relationships: Child sleep duration, child behavior problems, and parenting stress in families of children with autism spectrum disorder

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ABSTRACT

Background: Youth with Autism Spectrum Disorder (ASD) are at-risk for sleep and behavior problems, and their parents are at-risk for high stress. Child sleep duration, behavior problems, and parenting stress are interrelated; however, directionality of these associations is unclear and research including youth with ASD is lacking. Using a day-to-day, within-person design, this study explores the directionality of these relationships in families of children with ASD.

Method: Twenty-six children (ages 3–5, 73.1 % male, 65.4 % Hispanic/Latino) with ASD and their mothers participated in a 14-day study. Child sleep duration (parent-report and actigraphy), behavior problems, and parenting stress were measured daily. Constructs were decomposed into their within- and between-person components and analyzed with random intercept cross-lagged panel models.

Results: While between-person relationships were directionally expected in that shorter sleep, more behavior problems, and greater parenting stress were associated, within-person relationships were complicated. Better-than-average child behavior was associated with less next-day parenting stress, yet more parenting stress than average was associated with better next-day child behavior. As expected, longer-than-average child sleep was associated with less next-day parenting stress, while greater child behavior problems were associated with less sleep that night.

Conclusions: Understanding the directionality of associations between child and parent factors allows for the optimization of interventions to improve the quality of life for families of children with ASD. Interventions that target child behavior and/or help parents manage stress while maintaining effective parenting strategies for sleep and behavior may be useful.

1. Introduction

One in 44 children in the United States are affected by Autism Spectrum Disorder (ASD), a neurodevelopmental disorder characterized by persistent deficits in social functioning and repetitive, restrictive patterns of behavior (Maenner et al., 2021). In addition

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to the core diagnostic features, preschool-aged children with ASD frequently present with co-occurring health problems, with sleep-related difficulties being among the most prominent (Lamônica et al., 2021; Ming et al., 2008; Richdale & Schreck, 2009). Poor sleep, such as difficulties initiating or maintaining sleep, and short sleep duration, affect up to 82 % of preschool-aged children with ASD (Kang et al., 2020). The high prevalence of sleep difficulties in this population is especially problematic because poor sleep has far-reaching effects, impacting both child and family functioning (Richdale & Schreck, 2009).

Factors contributing to poor sleep in children with ASD are multifactorial (e.g., Souders et al., 2017), and likely involve a complex interplay between intrinsic factors (e.g., psychophysiological arousal—Santapuram et al., 2022; Schiltz, Fenning, Erath, & Baker, 2022; Schiltz, Fenning, Erath, Baucom et al., 2022; neurotransmitter dysfunction—Lorsung et al., 2021; and co-occurring emotional and behavioral problems— Schiltz, Fenning, Erath, & Baker, 2022; Mazurek et al., 2016, 2019; Mazurek & Petroski, 2015; Shui et al., 2018), as well as environmental contributors (e.g., poor sleep hygiene—Mazurek et al., 2016). Individuals with ASD also have a high rate of co-occurring medical difficulties that can contribute to poor sleep (e.g., disorders that cause pain or discomfort, such as gastrointestinal issues, which can lead to significant sleep disturbance—Buie et al., 2010; Reynolds & Malow, 2011; respiratory problems such as obstructive sleep apnea, which can lead to fragmented or poor-quality sleep—Santapuram et al., 2022; Tomkies et al., 2019; and neurological disorders that result in abnormal sleep architecture—Al-Beltagi, 2021). Prior research has shown a link between poor sleep and impaired daytime functioning in preschool-aged children with ASD (Kang et al., 2020; Sikora et al., 2012; Wang et al., 2021). Much of this research has focused on sleep problems predicting internalizing and externalizing behavioral problems or correlations between the two, with a large proportion of studies relying on parent-reported data (Hirata et al., 2016; Lamônica et al., 2021; Sadikova et al., 2022; Sikora et al., 2012; Wang et al., 2021). Though research utilizing objective measures of sleep has largely confirmed the presence of common parent-reported sleep problems, relying solely on parent-reported perceptions of sleep difficulties has the potential to be skewed by parenting stress or parents' subjective understanding of what "poor sleep" means (Bangerter et al., 2020). Of note, studies that focus exclusively on preschool-aged children with ASD while utilizing objective measurements of sleep (e.g., actigraphy or polysomnography) in addition to parent-reported sleep data are limited.

Studies utilizing objective measurements of sleep and parent-reported sleep data on school-aged children and adolescents with ASD note that decreases in total sleep time (TST) predict increases in internalizing and externalizing behavior problems, including anxiety, depression, affective issues, aggression, and disruptive behavior (Cohen et al., 2018; Malow et al., 2006). Further, a controlled trial of melatonin showed that treating sleep difficulties in children ages 3 to 10 years old with ASD significantly improved parents' view of their child's temperament, demandingness, and noncompliance (Malow et al., 2012). Internalizing and externalizing behavior problems have also been shown to predict decreases in sleep duration and quality, suggesting a potential bidirectional relationship (Adams et al., 2014; Shui et al., 2018). Conversely, while bidirectional relationships were examined, a study by Sadikova and colleagues (2022) only found a unidirectional, between-person relationship between ASD symptom severity and sleep, such that greater ASD symptom severity (i.e., repetitive behavior, communication, atypical behavior, and peer interaction) was associated with worse sleep 5-years later. Thus, the literature on associations between sleep and daytime behavior in youth with ASD is mixed and further evaluation, particularly at the within-person level, is needed.

Parents of children with ASD typically report higher levels of stress on average relative to parents of children with neurotypical development and other intellectual and developmental disabilities (IDD; Baker-Ericzen et al., 2005; Barroso et al., 2018; Dabrowska & Pisula, 2010; Estes et al., 2009; for a review, see Hayes & Watson, 2013). Carefully controlled longitudinal studies indicate that parenting stress, or the distress experienced by a parent in response to the challenges and demands associated with the parenting role (Abidin, 2012) among families of children with ASD is associated with child difficulties, particularly co-occurring externalizing behavior problems, which in turn, may exacerbate child behavior problems over time (Lecavalier et al., 2006; Postorino et al., 2019; Rao & Beidel, 2009; Zaidman-Zait et al., 2014) and contribute to poorer parent and family wellbeing long-term (Allik et al., 2006; Baker-Ericzén et al., 2005; Rao & Beidel, 2009). Child sleep difficulties have similarly been associated with parenting stress in these families (e.g., Goodlin-Jones et al., 2008; Meltzer & Mindell, 2007), with child sleep problems predicting elevated parenting stress even after accounting for other important factors, such as ASD symptoms and demographic characteristics (Hoffman et al., 2008). It is possible that the relationship between poor child sleep and parenting stress is mediated by worsening parental sleep and fatigue (Goldman et al., 2012). However, research on the potential bidirectional relationship between poor child sleep and parenting stress in this population is lacking (Martin et al., 2019).

Though some research has explored the relationships between child sleep, child behavior problems, and parenting stress in pairs, questions remain. First, these three constructs have rarely been evaluated together, and more research is needed to explore the directionality of these associations in preschool-aged youth with ASD. Clinically, understanding the directionality of associations will allow for the optimization of intervention strategies that more effectively address the unique needs of families of children with ASD. Second, when these relationships have been evaluated in pairs (e.g., parent stress and child behavior problems), they have often been examined with cross-sectional designs, focusing on average symptoms over time in unidirectional analyses. Further, when constructs have been examined longitudinally, allowing for speculation on the directionality of effects, the temporal relationships have been spaced apart by months or years, and we have little understanding of more immediate changes (i.e., day-to-day). By using a within-person, daily-level design, questions can be answered about how a change in functioning from a person's average (e.g., being more stressed than usual) impacts immediate outcomes (e.g., next-day child behavior).

Per methodologists, the within-person level, rather than the between-person level, should be the focus when attempting to draw causal inferences from data and avoid biased model effects (Hamaker et al., 2015). Between-person data answers questions regarding cross-sectional or group effects, which may not accurately conceptualize most underlying developmental theories that involve unstable, state-like variables (e.g., aggression) that are affected by a multitude of other factors (e.g., situation, temperament, culture, socioeconomic status, education, etc.; Berry & Willoughby, 2016). Further, between-person relationships often do not exemplify

within-person relationships across time and may lead to inaccurate claims of causation (Hamaker et al., 2015; Pritsker, 2021). Interestingly, though within-person level data is preferred when examining cross-lagged models to draw inferences at the within-person level, between-person level data are more often analyzed within developmental literature (Pritsker, 2021), which can be misleading (see Berry & Willoughby, 2016; Curran & Bauer, 2011; Hamaker et al., 2015 for review).

Accordingly, the purpose of this study is to explore the directionality of relationships between child sleep duration, child behavior problems, and parenting stress in a diverse group of families of children with ASD at the daily, within-person level. Based on prior research examining between-person effects, it was hypothesized that there would be bidirectional relationships between constructs such that longer child sleep duration would predict better child behavior and vice versa; longer child sleep duration would predict lower parenting stress and vice versa; and better child behavior would predict lower parenting stress and vice versa. In addition to utilizing daily standardized measures of child behavior problems and parenting stress, this study used a combination of daily objective actigraphy and subjective parent-reported sleep diary measures, which is recommended as best practice when exploring the presence and effects of sleep difficulties (Richdale & Schreck, 2009).

2. Methods

2.1. Participants

Participants (N=26) were recruited from a larger randomized controlled trial examining the efficacy of Mindfulness-Based Stress

Table 1
Participant demographics (N = 26).

	M (*SD*)	*n* (%)
Child Characteristics		
Age in months	53.35 (9.5)	
Male		19 (73.1 %)
Race/Ethnicity		
White, non-Hispanic/Latino		6 (23.1 %)
White, Hispanic/Latino		13 (50.0 %)
Asian, non-Hispanic/Latino		3 (11.5 %)
Asian, Hispanic/Latino		2 (7.7 %)
Pacific Islander, non-Hispanic/Latino		1 (3.8 %)
Native American & White, Hispanic/Latino		2 (7.7 %)
Primary Caregiver Characteristics		
Age in years	33.27 (4.88)	
Race/Ethnicity		
White, non-Hispanic/Latina		6 (23.1 %)
White, Hispanic/Latina		14 (53.8 %)
Asian, non-Hispanic/Latina		3 (11.5 %)
Pacific Islander, non-Hispanic/Latina		1 (3.8 %)
Asian & Pacific Islander, non-Hispanic/Latina		1 (3.8 %)
Asian & White, non-Hispanic/Latina		1 (3.8 %)
Annual household income		
< $30k		4 (15.4 %)
$30k to <$50k		4 (15.4 %)
$50k to <$70k		3 (11.5 %)
$70k to < $90k		6 (23.0 %)
>$90k		7 (26.9 %)
Education		
High school or less		5 (19.2 %)
Some college		6 (23.0 %)
Technical or associate degree		4 (15.4 %)
Bachelor's degree		7 (26.9 %)
Graduate degree		3 (11.5 %)
Child Sleep Characteristics		
Actigraphy		
Nights recorded	8.95 (4.49)	
Sleep duration in hours	8.16 (1.55)	
Bedtime in 24-hour time	21:45 (1:46)	
Waketime in 24-hour time	7:25 (1:44)	
Wake after sleep onset in minutes	80.74 (50.39)	
Awakenings recorded	19.36 (8.27)	
Awakening length in minutes	4.21 (2.35)	
Efficiency percentage	84.43 (8.82)	
Parent-report		
Total sleep time in hours	8.85 (2.35)	46 (14 %)
Days including naps	1.40 (0.82)	
Naptime in hours (n = 46)		

Reduction (MBSR) compared to Psychoeducational Support (PE) in reducing parenting stress in families of young children with ASD. Only data from the baseline assessment were used in the current study. These families were recruited from September 2020 to March 2021 primarily through [NAME OF AGENCY REMOVED FOR BLIND REVIEW], a statewide agency that contracts services for individuals with developmental disabilities. Additional recruitment was done through participating universities, community groups, local agencies that offer services for children with ASD, and community events for families of children with developmental disabilities.

Inclusion criteria for the larger clinical trial were: (a) child community ASD diagnosis confirmed by study-administered assessments; (b) child age 3 to 5 years, and (c) parent ability to complete study procedures in English. Exclusionary criteria included: (a) positive screen for active parental psychosis, substance abuse, or suicidality according to the associated modules of the Structured Clinical Interview for DSM Disorders, Research Version Non-Patient Edition (First et al., 2002); (b) parent participation in an auxiliary mental health treatment or support group, given potential confounds with the interventions in the larger clinical trial; and (c) child motor impairment that would prevent participation in the assessment tasks described in the procedures (e.g., difficulty sitting independently).

See Table 1 for complete parent and child demographic information. Parents were all biological mothers who were predominantly self-identified as White, Hispanic/Latina with at least some college education and annual household income of $70,000 or less. Children were parent-identified as primarily White, Hispanic/Latino males with a community diagnosis of ASD confirmed by study clinical best estimate procedures (see Procedures section for more details). In terms of their child's adaptive functioning, parents reported an average Adaptive Behavior Composite (Vineland-3 ABC) score of 71.87 (SD = 7.91; range 53 to 83) on the Vineland Adaptive Behavior Scales, Third Edition (Sparrow et al., 2016), with all scoring in the moderately low to low range (below a score of 85), indicating delays in adaptive functioning. In terms of subjective child sleep, parents reported an average total sleep time of 8.85 hours (SD = 2.35 hours). On average, children napped for 1.40 hours (SD = 0.82), though only 14 % of reported days included naps. In terms of objective child sleep, actigraphy recorded an average total sleep time of 8.16 hours (SD = 1.55 hours). On average, children went to bed at 21:45 (SD = 1 hour, 45 minutes) and awakened at 7:25 (SD = 1 hour, 44 minutes). Children also had an average of 19.36 nighttime awakenings (SD = 8.27) with each awakening lasting 4.21 minutes (SD = 2.35 minutes). Average sleep efficiency was recorded as 84.43 % (SD = 8.82 %), where 85 % is considered within normal limits. More detailed information on sleep parameters can be found in Table 1.

2.2. Procedure

Due to the COVID-19 pandemic, all study procedures were conducted remotely. Procedures were approved by the Institutional Review Board of participating universities. Study information was disseminated to parents through the recruitment sources listed above. Interested parents contacted the research team and completed a phone screening to determine initial eligibility for the larger trial based upon demographics and parent mental health. During screenings, families identified one caregiver as the "primary caregiver," defined as the parent the child spends the most time with, who was then the primary participant in the study. Families who met preliminary eligibility on the phone screen were scheduled for a baseline assessment where study staff obtained informed consent, gathered demographic and service utilization information, and conducted structured clinical interviews to evaluate the child's ASD symptoms and adaptive behavior skills. Parents also completed a packet of questionnaires.

ASD diagnostic status was ascertained using the Autism Diagnostic Interview-Revised (ADI-R; (Rutter, LeCouteur , et al., 2003), a gold-standard parent interview. Three children did not meet the diagnostic threshold on the ADI-R but were retained in the current sample following completion of clinical best estimate procedures. All three of these children had an existing community diagnosis of ASD and met the age-adjusted clinical threshold on the SCQ (SCQ; Total Score $\geq$ 12; Corsello et al., 2007; Rutter, Bailey, et al., 2003), and they also met clinical criteria on the Social Responsiveness Scale-2 (SRS-2; Constantino & Gruber, 2012), a widely used parent-report measure of social difficulties and restricted interests.

At the end of the baseline assessment, parents were screened to participate in the current daily diary study. Unrelated to the present analyses, the daily diary included items monitoring day-to-day marital interactions, thus the primary caregiver had to currently be in a long-term relationship (i.e., dating or married) and living with their partner or spouse. Participation occurred *prior* to receiving the intervention and involved answering questions daily for 14 typical days (i.e., not during vacations or holidays) via Qualtrics, an online questionnaire platform. As part of the daily questionnaire, parents were asked questions about their child's sleep, including sleep and wake times, duration, and nap times, their child's behavior, and parenting stress. Parents were instructed to complete the surveys around the same time each day, which was identified prior to intervention participation, and to respond to questions with respect to the previous 24 hours.

On the days where parents completed the daily diary questionnaire, the child with ASD wore an ActiGraph GT3XP-BTLE accelerometer from bedtime to awakening (ActiGraph, 2020). Devices were placed on the child's wrist or ankle, where placement was dependent on the child's sensory tolerance. Parents were asked to specify where the actigraph was worn (i.e., wrist or ankle) each night. Participants wore the actigraph on the wrist 60.64 % of nights (n = 114 nights) and on the ankle for the remainder of nights (n = 74 nights). Actigraphy data were screened for artifacts and wear-time was validated utilizing parent-reported bedtime and wake time prior to analyzing sleep via validated scoring algorithms (Sadeh, 2011).

Participants were compensated for their participation contingent on the number of daily diary entries completed (but not actigraph compliance), with a bonus amount offered to incentivize consecutive diary entries. Participants were compensated $40 for completing at least 10 consecutive days of diary entries, with an added $10 bonus if they completed all 14 days. If participants completed fewer than 10 consecutive days of diary entries, they were allowed to complete additional days by continuing their diary entries to reach a minimum of 10 consecutive days.

2.3. Measures

2.3.1. Demographic information

Child and parent ages, ethnicities, family income, child diagnoses, and services received were collected via parent interview.

2.3.2. Parenting stress

Parents responded on a 7-point scale (1 "not stressful" to 7 "extremely stressful") to the statement, "Overall, how stressful were your parenting experiences with your child?" Parents were asked to refer to the previous 24 hours. Higher scores were indicative of greater parenting stress. This item has been previously used in daily diary studies of families of youth with ASD and was significantly correlated with other measures of parenting stress (Hartley et al., 2018). To further evaluate the validity of this item, we examined the correlation between the average daily level of parenting stress on this single item and parents' baseline ratings of parenting stress as measured via the Parenting Stress Index – Parental Distress subscale (Abidin, 1995), a global measure of parenting stress that was given to study participants during the baseline visit for purposes of the broader study. These measures were significantly positively correlated ($r = .58$, $p < .001$).

2.3.3. Child behavior problems

The Scales of Independent Behavior (SIB-R; Bruininks et al., 1996), modified for daily measurement by asking parents to refer to the previous 24-hour period, was used to examine the occurrence and severity of eight different types of problem behaviors: hurtful to self, unusual or repetitive habits, hurtful to others, socially offensive behavior, destructive to property, withdrawal or inattentive behavior, disruptive behavior, and uncooperative behavior. These items have been used with young (i.e., preschool) samples (Lecavalier et al., 2006; Smith et al., 2019), have good reliability and validity, and have strong correlations with externally validated measures of the same constructs (Hartley et al., 2018). The modified version of the SIB-R to be used as a daily report has been established in previous studies (Goetz et al., 2019; Hartley et al., 2016, 2018). The current analyses utilized daily behavior severity ratings, a sum of severity ratings across all problem behavior subtypes reported within the same day. Each behavior type was scored on a five-point Likert scale, ranging from 1, *not serious* to 5, *extremely serious*, yielding a daily overall behavior severity score (possible range: 8 to 40), with higher scores indicating greater severity of behavior problems.). This measure demonstrated adequate reliability in the present sample ($\alpha = .74$).

2.3.4. Child sleep duration

Daily objective measurements of child sleep duration (i.e., total sleep time; TST) were measured utilizing wrist- or ankle-worn ActiGraph GT3XP-BTLE accelerometers. TST was defined as the total time spent asleep during a single sleep episode, accounting for nighttime awakenings, and was derived via the ActiSleep software (ActiGraph, 2020). Actigraphy provides reliable monitoring of sleep parameters and is sensitive to clinical interventions (Sadeh, 2011). Parent-reported child sleep was measured via the daily diary. Parents were asked to report their child's sleep duration using the number of hours and minutes of sleep, which were combined into a single value in the metric of hours. Nap duration was included in the parent-reported sleep diary total sleep time calculations as per the American Academy of Sleep Medicine recommendations (Paruthi et al., 2016). Due to sensory sensitivities for some children, actigraphs were not consistently worn throughout the day. Thus, nap duration was not included in objectively measured sleep parameters.

2.4. Analysis

Data were analyzed using the Dynamic Structural Equation Modeling framework within Mplus Version 8 (Muthén & Muthén, 2017). Within this framework, time-series observations are decomposed into their respective within-person and between-person components and lagged effects of the within-person processes can be estimated. We were primarily interested in the within-person bidirectional effects between parent stress, child behavior problems, and child sleep (both objective and parent-reported sleep duration). Specifically, two models were fit (one for each measure of sleep) in which the within- and between-person components were separated and lagged effects for the within-person components were estimated. Within these models, parent stress and behavior problems were predictors of sleep, after controlling for previous night's sleep, and parent stress and behavior problems were each predicted by previous night's sleep, after controlling for both parent stress and behavior problems from the previous day. The within-person components of parent stress and behavior measurements from the same day were permitted to covary, and the covariances between sleep, parent stress, and behavior at the between-person level were estimated. Given the relatively small level-2 (i.e., child) sample size, random slopes for the within-person effects were not estimated. Consequently, the model is equivalent to the random intercept cross-lagged panel model, emphasizing the within-group effects rather than the between-group effects or a combination of the between- and within-group effects (see, e.g., Hamaker et al., 2015). While the sample size is small, the repeated observations across 14 days increases power and the ability to detect significant effects. Further, this study design, including a similar sample size with repeated daily observations, is consistent with prior studies examining sleep and behavior in a clinical youth sample (Van Dyk et al., 2016).

Child behavior problems and child sleep were treated as continuous variables, while parenting stress was treated as ordinal. All non-missing responses were included in the analyses (e.g., if a participant's response was missing on one or more variables within a single day, all non-missing responses were still included). Mplus Version 8 (Muthén & Muthén, 2017) allows for missing data to be imputed during the estimation process. When utilizing Bayesian estimation with diffuse priors, as in the current analyses, the estimates are comparable to those obtained through Full-Information Maximum Likelihood Estimation (see Hamaker et al., 2018).

3. Results

3.1. Concurrent relationships

Though the within-person effects are of most interest, the between-person effects will also be described, as they most closely compare to effects presented in the literature. According to the intraclass correlation coefficients (ICCs), the percentage of total variance was nearly equally accounted for by within- and between-person differences for child behavior problems (ICC =.49) and parenting stress (ICC =.57), whereas objective sleep duration (ICC =.67) and subjective sleep duration (ICC =.73) had relatively greater between-person variance. Within-person and between-person correlations between the primary variables of interest at a given time point (concurrent, not sequential relationships) are as follows: Behavior problems and parent stress were significantly correlated at both the within-person (r =.47) and between-person (r = 0.50) levels, indicating that parents of children with more behavior problems, on average across all time points, also tended to have higher levels of average stress and that this was also true at a given time point at the within-person level. Objective sleep duration significantly correlated with behavior problems (r = -0.48) at the between-person level, but not at the within-person level (r = -0.06), such that children who slept more, on average across all time points, tended to have less severe behavioral problems. Objective sleep duration was not significantly correlated with parenting stress at the between- or within-person level (r = -0.43 and r = -0.06, respectively). In contrast, subjective sleep duration significantly correlated with behavior problems (r = -0.14) and parent stress (r = -0.27) at the within-person level, but not at the between-person level (r = 0.17 and 0.33, respectively). Finally, the correlation between objective and subjective sleep was significant at the within-person level (r = 0.51) but not at the between-person level (r = -0.17).

3.2. Sequential, lagged effects

The standardized parameter estimates and 95 % confidence intervals from the fitted random intercept cross-lagged panel models are displayed in Table 2. Parent stress was not a significant within-person predictor of objective nor parent-reported sleep duration. Child behavior problems were a significant within-person predictor of parent-reported sleep duration, but not objective sleep duration. Specifically, and consistent with hypotheses, as child behavior problems increased by one standard deviation, parent-reported sleep duration for that night decreased by 0.149 standard deviations (i.e., 11 minutes). Note, however, that the standardized coefficient for behavior problems on objective sleep was almost equivalent to that for parent-reported sleep, but the parameter has a substantially wider confidence interval indicating less precision in the estimate. Interestingly, sleep duration from the previous night was not a significant predictor of sleep duration the next night, regardless of how sleep duration was measured, indicating high variability in sleep patterns.

In both sleep models, behavior and parent stress from the previous day were significant predictors of behavior for the current day, but sleep duration (objective and parent-report) was not a significant predictor of behavior problems. Specifically, as child behavior problems increased by one standard deviation, child behavior problems the next day increased by 0.338 and 0.337 standard deviations in the models controlling for objective and parent-reported child sleep duration, respectively. Contrary to hypotheses, as parenting stress increased by one standard deviation, child behavior problems the next day decreased by 0.164 and 0.151 standard deviations in the model controlling for objective and parent-reported child sleep duration, respectively. Additionally, parent-reported child sleep duration, but not objective sleep duration, was a significant predictor of parenting stress the following day. As expected, as parent-reported child sleep duration increased by one standard deviation, parenting stress decreased by 0.234 standard deviations the next day. Parenting stress from the previous day was not a significant predictor of parenting stress the following day, indicating high

Table 2
Standardized parameter estimates and confidence intervals from the fitted models.

Level	Outcome	Prior Time Point Predictor	Objective Sleep Duration		Parent-report Sleep Duration	
			Estimate	CrI	Estimate	CrI
Within	Sleep	Sleep (lag)	0.104	-0.100, 0.322	0.022	-0.110, 0.157
Within		Parent Stress (lag)	0.016	-0.198, 0.227	0.127	-0.023, 0.273
Within		Child Behavior Problems (lag)	-0.137	-0.320, 0.058	-0.149	-0.280, -0.016 *
Within	Parent Stress	Parent Stress (lag)	-0.024	-0.182, 0.142	0.014	-0.1244, 0.178
Within		Child Behavior Problems (lag)	0.168	0.020, 0.319 *	0.139	-0.007, 0.284
Within		Sleep (lag)	-0.059	-0.246, 0.131	-0.234	-0.346, -0.117 *
Within	Child Behavior Problems	Child Behavior Problems (lag)	0.338	0.195, 0.484 *	0.337	0.196, 0.480 *
Within		Parent Stress (lag)	-0.164	-0.297, -0.025 *	-0.151	-0.283, -0.009 *
Within		Sleep (lag)	-0.056	-0.222, 0.111	-0.083	-0.192, 0.028
	Correlations					
Within	Child Behavior Problems and Parent Stress		0.454	0.352, 0.545 *	0.447	0.345, 0.537 *
Between	Sleep and Parent Stress		-0.475	-0.757, -0.036 *	0.385	-0.014, 0.678
Between	Sleep and Child Behavior Problems		-0.528	-0.790, -0.109 *	0.215	-0.202, 0.571
Between	Child Behavior Problems and Parent Stress		0.499	0.110, 0.755*	0.498	0.111, 0.755 *

Note. Lag = The variable from the previous time point. CrI = credible interval.
*represents statistical significance at p <.05.

variability. Although the estimates of the effect of behavior problems on parenting stress the next day were similar in both models, it was only statistically significant in the model for which objective sleep duration was used. Consistent with hypotheses, as behavior problems increased by one standard deviation, next day parenting stress increased by 0.168 standard deviations. See Fig. 1 for visual conceptualization.

4. Discussion

As expected and consistent with prior research, at the between-person level, parents of children who were reported to have more behavior problems, on average across all time points, also tended to have higher levels of parenting stress. Further, shorter sleep duration, on average, was associated with higher levels of parenting stress and greater child behavior problems. However, both these findings and prior research have either aggregated data across time (i.e., average, between-person relationships) or examined relationships longitudinally across longer time intervals without decomposing the between- and within-person variance (Neece et al., 2012). By focusing on averaged data or relationships across long periods of time, we are unable to determine how functioning changes when an individual differs from their *own* average at the *day-to-day level* (e.g., how being more stressed than usual may impact next-day behavior), as much of the within-person variability is lost (Bei et al., 2015). By focusing on the within-person level, inferences can be made that directly inform treatment intervention and prevention. For example, while between-person data is able to identify groups of individuals at more or less risk, within-person data is able to identify how individuals within those groups respond to immediate changes in their mood, behavior, and social functioning, while avoiding biased model effects (Pritsker, 2021).

Despite confirming prior research at the between-person level, our findings differed when examining the within-person, cross-lagged relationships between parenting stress, child behavior, and child sleep, underscoring the importance of parsing apart between- and within-person effects. Specifically, child behavior was bidirectionally related to parenting stress when controlling for objective sleep duration, which resembled a negative feedback loop. Unexpectedly, on days parents reported more parenting stress than usual, next day child behavior problems were reported to be less than usual, but as expected, when child behavior problems decreased, next day parenting stress also decreased. It is possible that increased parenting stress in response to greater child behavior problems may have elicited effective parental coping and parenting strategies (Menezes et al., 2021), as evidenced by the subsequent decreases in child behavior problems. Prior research suggests that parental adaptive coping may buffer aspects of parenting behavior in families of children with ASD and co-occurring behavior problems (Alostaz et al., 2021) and better family functioning has been associated with improvements in externalizing problems, internalizing problems, and social functioning (Szatmari et al., 2021). Alternatively, it is also possible that when parents experience increased stress they may be more likely to engage in negative parenting behaviors (e.g., criticism, harsh discipline). Harsh parenting practices may *temporarily* stop a child from misbehaving, briefly leading to reduced next-day parenting stress; however, over time, negative parenting practices have consistently been found to exacerbate child behavior problems in children with ASD (Bader & Barry, 2014). Future research may benefit from differentiating and/or concurrently measuring parenting stress alongside other aspects of parental coping and parenting behavior to further dismantle this effect. Exploring within-person associations between child behavior, parenting behavior, and parenting stress will be integral in understanding the short- and long-term consequences of transactional dynamics in families of children with ASD.

In the model including parent-report of child sleep duration, child sleep duration and parenting stress were unidirectionally related. Consistent with prior research, as parent-reported child sleep duration increased, next-day parenting stress decreased. Additionally, child behavior unidirectionally predicted child sleep duration that night. As expected, as child behavior problems decreased from average, objective sleep duration increased that night. Regarding child behavior, it appears that when parents reported being more stressed than usual, immediate child outcomes were improved. However, elevated levels of parenting stress have been linked to

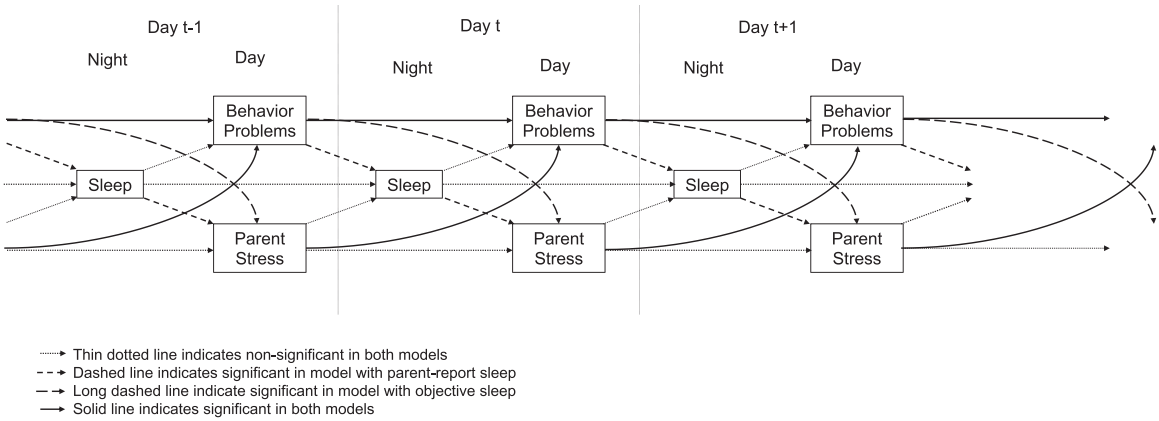

Fig. 1. Random intercept cross lagged panel of parenting stress, child behavior, and child sleep duration. *Note.* This diagram illustrates the within-person relationships between behavior problems, parenting stress, and sleep duration (both parent-report and objective actigraphy) across time, as modeled within the random intercept cross-lagged panel models. Between-person components of these variables were permitted to covary within the between-person level of the model (not pictured).

unfavorable familial and marital functioning, in addition to poor parent physical and mental health (Allik et al., 2006; Rao & Beidel, 2009). Thus, supporting parents in managing parenting stress to reduce perceived stress while preserving effective and positive parent-child interactions may be a fruitful intervention target. Specifically, growing research supports the efficacy of mindfulness-based interventions in reducing parenting stress for parents of children with ASD specifically (Rayan & Ahmad, 2017) and developmental disabilities more broadly (Chan & Neece, 2018; Neece, 2014). Additionally, some research on children with general developmental delays has indicated that reductions in parenting stress following these stress-reduction interventions may have a collateral benefit in reducing child behavior problems (Chan & Neece, 2018; Neece, 2014).

Beyond acknowledging the importance of identifying and improving parental stress, our results most strongly support existing research identifying the need to address behavioral problems in youth with ASD. Our findings indicate that when youth with ASD display greater behavior problems than usual both child sleep that night and parenting stress the next day worsen. Thus, by improving and stabilizing child behavior, there may be positive downstream effects on other aspects of child (e.g., sleep) and family (e.g., parental stress) functioning. Early behavioral interventions are often highly effective in reducing problem behavior among young children with ASD (Bearss et al., 2015; Horner et al., 2002), and may have collateral benefits for reducing parenting stress and improving child sleep as well.

Moving forward, parent-reported child sleep was more often a predictor and/or outcome of child behavior and parenting stress compared to objectively measured child sleep. Taken together with the observed variability in sleep patterns, it is possible that parent-reported sleep provides information on essential aspects of sleep that are not readily measured by actigraphy and may also overlap conceptually with aspects of daytime behavior (e.g., bedtime resistance, sleep depth, limit setting difficulties, co-sleeping; Blok et al., 2022; Devnani & Hegde, 2015; Levin & Scher, 2016). It will be important for future studies to directly measure these more qualitative aspects of child sleep to examine associations with child behavior and parenting stress. Our findings were comparable to prior research in that, despite the potential poor validity of parent-reported sleep, research on pediatric sleep rarely utilizes objective measures of sleep, even though the inclusion of both parent-reported and objectively measured sleep is recommended (Gregory & Sadeh, 2012; Perpétuo et al., 2020). Future research may benefit from exploring why different methods of measuring sleep duration yielded different results. Interestingly, parents reported their children slept slightly more on average than what was detected by objective actigraphy. Parent reports of child sleep may better proxy parental experiences of child sleep than actual sleep difficulties. For example, night awakenings that do not require parental intervention may not be accounted for. Further, given shared method variance, it may be that parent-reported child sleep is biased by parenting stress and child behavior problems. Even so, when controlling for prior-day parenting stress in the present study, child behavior problems predicted parent-reported sleep duration, and parent-reported sleep duration predicted next-day parenting stress. Thus, even if biased, parent-reported child sleep duration still appears to have meaningful clinical implications. In addition to objective measures, clinicians and researchers alike should continue to use subjective reports of child sleep duration as they tend to be less burdensome, cost-effective, and provide useful information. Further, clinicians should aim to optimize sleep in youth with ASD, even if only indicated as problematic per parent report. Brief, parent-based sleep education interventions for youth with ASD exist that have been shown to effectively improve child sleep when measured via actigraphy and by parent report (Malow et al., 2014; McCrae et al., 2021).

4.1. Limitations

Though this study significantly contributes to the literature describing the complex within-person relationships between sleep, parenting stress, and behavior in youth with ASD, the results represent preliminary findings. In terms of limitations, this study occurred during the COVID-19 pandemic, which necessitated a virtual assessment modality due to prohibitions regarding in-person activities. Given that these data were collected during the pandemic, generalizing to non-pandemic times requires caution. Similarly, the participant inclusion criteria dependent on parent relationship status, the small sample size, and other relevant factors (e.g., age, cognitive functioning) impede generalization to the larger population. Future research should include a more robust sample to draw definitive conclusions.

As mentioned above, between-person level data are more often analyzed within developmental literature (Pritsker, 2021) even though cross-sectional or group effects may not accurately conceptualize most underlying developmental theories that involve unstable, state-like variables (Berry & Willoughby, 2016). Accordingly, methodological strengths in the current study include the utilization of within-person, daily-level data to draw inferences at the within-person level. However, these data were collected over a 14-day period, which is a relatively short timeframe and therefore more prone to bias. Future research would benefit from analyzing data over a longer timeframe to better conceptualize trends and patterns that emerge within models that include state-like variables that may vary from day to day. Further, effect sizes were relatively small; while statistically significant, results may be less meaningful from a clinical standpoint. Future research should examine how small changes (improvements or decreases) in these parameters are perceived by patients and families.

Other methodological strengths include the measurement of subjective and objective sleep and the use of a validated measure of child behavior problems. However, objective sleep solely included nocturnal sleep time, while omitting nap duration due to sensory sensitivities. Though most participants did not take naps during the day (86 % of reported days did not include naps), a finding consistent with another study looking at daytime sleep habits in young children with ASD (Schwichtenberg et al., 2011), future research should incorporate nap duration in the objective total sleep time metric for children up to age five, as per recommendations of the American Academy of Sleep Medicine (Paruthi et al., 2016). Of note, even relatively small decreases in overall total sleep time, including the omission of daytime naps, can negatively affect daytime behavior and thus should be accounted for in future studies (Berger et al., 2012; Sadeh et al., 2003).

Further, qualitative aspects of sleep, such as the sleep environment, bedtime routines, and sleep quality (e.g., the presence of snoring, nighttime awakenings, sleep efficiency, bedtime, and waketime) were not formally analyzed in the current study. Accordingly, causal inferences cannot be drawn. However, studies have found that children with ASD experience longer sleep onset latencies, more nighttime awakenings, prolonged nighttime awakenings, poorer sleep efficiency, and earlier morning awakenings compared to typically developing peers (Herrmann, 2016). These qualitative sleep difficulties likely impact parenting stress, child behavior problems, and child sleep (Galli et al., 2022). Though beyond the scope of the current study, the analysis of qualitative sleep characteristics is necessary for researchers to adequately characterize sleep difficulties in children with ASD, in addition to being optimal intervention targets.

Additionally, parenting stress was measured with only a single item. Although this item has been used in prior research (Hartley et al., 2018) and correlates with other measures of parenting stress within our study, it may not fully capture the complexities of stress experienced by parents of individuals with ASD. Further, we did not measure parenting behaviors which could help explain our observed relationship between parenting stress and child behavior problems. Future studies should consider measuring broader aspects of parental stress and/or more objective indicators of parents' stress response such as cortisol in addition to considering mediational models with more proximal predictors of child behavior problems (e.g., parenting strategies, child psychophysiology). Indeed, recent evidence that aspects of children's psychophysiology may protect against sleep difficulties in this population (Schiltz, Fenning, Erath, Baucom et al., 2022) or may interact with sleep challenges to further exacerbate risk for daytime behavior problems (Schiltz, Fenning, Erath, & Baker, 2022) underscores the importance of exploring bioregulatory processes that may underlie sleep-behavior associations.

4.2. Implications

In conclusion, utilizing a within-person, daily-level design, rather than a between-person design or a design that does not effectively decompose the within- and between-person effects, allows researchers to draw less biased causal inferences about within-person outcomes (e.g., how a change in functioning from a person's own average impacts immediate outcomes). Understanding the directionality of associations between child (i.e., behavior, sleep) and parent (i.e., stress) factors allows for the optimization of intervention strategies that can target outcomes to improve the quality of life for families of children with ASD. For example, consistent with prior research, child behavior was the most stable variable across time and was shown to negatively impact both sleep and parenting stress. These findings suggest that early intervention targeting co-occurring behavior problems may reduce the risk for otherwise highly prevalent difficulties related to sleep and parenting stress in families of young children with ASD. Thus, intervening with child behavior may have cascading positive effects for both the child and family. Similarly, parenting stress was related to both child behavior and sleep. Accordingly, finding ways to reduce parenting stress while maintaining effective parenting strategies may also be a fruitful target for intervention. Future research is needed to evaluate such interventions and better understand the nuances of related outcomes (i.e., subjective vs. objective reports of sleep).

CRediT authorship contribution statement

Iwamoto: Validation, Formal analysis, Investigation, Data curation, Writing – original draft, Visualization. **Neece:** Conceptualization, Methodology, Writing – review & editing, Supervision, Funding acquisition. **Nair:** Writing – review & editing, Supervision. **Rockwood:** Software, Formal analysis, Data curation, Visualization. **Fenning:** Conceptualization, Methodology, Writing – review & editing. **Krantz:** Conceptualization, Methodology, Validation, Investigation, Data curation. **Van Dyk:** Conceptualization, Methodology, Writing – original draft, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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