Published in final edited form as:

J Sleep Disord Treat Care. ; 3(2): . doi:10.4172/2325-9639.1000133.

Concordance of Mother/Child Sleep Patterns Using Actigraphy: Preliminary Findings

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Abstract

Sleep problems are common in children with autism spectrum disorder (ASD) and are often associated with problem behaviors. Problematic sleep in the child may impact maternal sleep. We examined the association of sleep in mother-child dyads to child daytime behavior and maternal insomnia and daytime sleepiness in 11 children with ASD and 6 children of typical development (TD) using wrist actigraphs over 14 consecutive nights. Early morning awakenings were significantly associated with poorer daytime behavior as measured by the Child Behavior Checklist in both ASD and TD children. Additionally, associations were found between mother and child sleep and between the child's sleep and maternal daytime sleepiness. These results highlight the need to consider the potential interaction of maternal-child sleep in future studies.

Keywords

Sleep problems; Autism spectrum disorder; Mother-child sleep; Actigraphy; Behavior problems

Introduction

Sleep disturbances are prevalent in children with autism spectrum disorder [1–4]. In families, sleep problems in one member will often impact other family members [5]. In the general population, parents who perceive their child to have a sleep problem report having too little sleep themselves, as compared to those parents who do not report their child as having a sleep problem [6]. In children with autism spectrum disorder the impact of the child's sleep on the parent's sleep is often the reason why a child's sleep is brought to the attention of a medical professional [4]. Recent research has suggested that parents of children with autism spectrum disorder may experience more sleep problems, including poorer sleep quality and quantity than parents of typically developing children [7,8]. Further, mothers of children with poor sleep have been shown to have more mood and stress problems, than those mothers whose children did not have poor sleep [9].

Sleep problems in children with autism spectrum disorder have been associated with problem behavior [10–12]. When children with autism spectrum disorder are classified as good sleepers, or poor sleepers, by parent report the poor sleepers were found to have more problematic behavior than the good sleepers [13]. Given raising a child with autism spectrum disorder can be a tremendous strain on the parent and family [14] we posited the question of whether there was an association of mother's sleep with child behavior.

In this study our goal was to extend previous reports of sleep behaviors in mother and child dyads to encompass an expanded time frame to allow for the capture of inherent sleep variability over time. We hypothesized that child daytime behavior would be associated with more variability in both mother and child sleep behaviors. Our goals were to: 1) evaluate the relationship of mother and child sleep to behavior in children with autism spectrum disorder, and 2) relate these sleep patterns to the mother's symptoms of insomnia and daytime sleepiness.

Materials and Methods

Participants and procedure

Seventeen mother-child dyads volunteered to participate in a 14 night, in-home, protocol to evaluate the association of mother-child sleep and daytime behavior in the child. The children were participants in a larger sleep research project at Vanderbilt University, conducted between September 2011 and April 2012, evaluating the use of wireless monitoring techniques in children with autism spectrum disorder and those who were of typical development. Participants were included in the larger study if they were between the ages of 3–10 years and did not have a history of an intellectual disability, epilepsy or untreated sleep apnea; excluded typically developing children if they had a sibling with autism spectrum disorder. All children with autism met criteria for a clinical diagnosis of autism spectrum disorder confirmed by the Autism Diagnostic Observation Schedule [15], as well as a clinical interview incorporating the Diagnostic and Statistical Manual of Mental Disorders, 4th edition, text rev [16]. The children with autism spectrum disorder were classified as a good or poor sleeper based on previous work by Malow et al. [17] where this classification has been shown to differentiate problem behaviors based on parental reported sleep where the parent responded to the question "Please describe the extent to which sleep disturbance (does not fall asleep easily, wakes often, etc.) has been a problem for you in the past month on a scale from 1 to 4 (1=no concerns; 2=mild concerns; 3=moderate concerns; 4=severe concerns)." In children classified as "good sleepers" the parent's indicated no or mild sleep concerns. In children classified as "poor sleepers" the parents expressed moderate or severe concerns. Children with autism, as well as children of typical development, were recruited in an age and gender matched basis. The Institutional Review Board at Vanderbilt University approved the protocols for both studies. All mothers provided consent and children assent to this ancillary study.

After informed consent the mothers completed a series of questionnaires providing information on the child's demographic, social, and medical background. The mothers also completed questionnaires on their own sleep and daytime sleepiness. The mother and child

were then instructed on the use of the in-home actigraphy monitors and how to complete the accompanying sleep-wake diary.

Instrumentation

All mother-child dyads wore an actigraphy monitor (Phillips Respironics, 920 Emkay Drive Suite 100, Bend, OR 97702) for 14 consecutive nights on the non-dominant wrist. The acti-watch is a small-computerized wristwatch-like device, which contains an accelerometer, and is used to detect movement and can serve as a surrogate of sleep and wake patterns [18]. Actigraphy is used extensively in sleep research and clinical practice and has been validated as a highly reliable method to differentiate sleep from wake [18,19]. Data from the actigraphs were downloaded to a personal computer where the sleep variables were calculated using Actiware Version 5 software (Philips Respironics, Bend, Oregon). The time in bed was calculated from lights out until lights on the next morning. The total sleep duration was the sum of all sleep epochs within the interval between the time set on the actigraph for nighttime sleep and morning wake time. Sleep efficiency was calculated as the ratio of total nighttime sleep duration to the total time in bed. Sleep latency was calculated as the time required for sleep onset after lights out (first attempt to go to sleep). Wake after sleep onset was measured as the sum of all wake epochs during the sleep period and reflects the number of minutes scored as wake that exceeded the sensitivity threshold. The fragmentation index captures all movement regardless of the intensity of the movement. Early morning awakening was calculated as the time between when the sleep period ended and the time when the individual turns on the lights or gets out of bed. The number of wake bouts is the total number of continuous blocks, one or more epochs in duration, with each epoch of each block scored as wake, between the start time and the end time of the given interval. The average wake bout is the scored total wake time divided by the number of wake bouts, for the given interval.

Questionnaires

The Child Behavior Checklist [20] was used to evaluate daytime behavior in the child. The Child Behavior Checklist is a validated parentally completed questionnaire used extensively in pediatric research to examine daytime behaviors in children. The Child Behavior Checklist has two separate modules, one for ages 1 ½ to 5 years and one for ages 6–18 years. The Checklist for ages 1 ½ to 5 years consist of 7 Syndrome Scales and 6 DSM-Oriented Scales. For ages 6 – 18 years there were 8 Syndrome Scales and 6 DSM-Oriented Scales. For this study we collapsed our data across age groups and included scales common to both age groups.

Maternal sleep behaviors were evaluated with The Insomnia Severity Index [21]. This is a self-report questionnaire used to evaluate insomnia severity and has been validated as a measure to detect changes in perceived sleep difficulties in adults with insomnia [22]. The questionnaire contains 5 questions reflecting areas such as the severity of the sleep onset and sleep maintenance insomnia problems, satisfaction with current sleep patterns, and how they interfere with daily functioning.

The Epworth Sleepiness Scale [23] is a self-report questionnaire used to evaluate the general level of daytime sleepiness in adults. The questionnaire consists of 8 questions representing typical daytime situations commonly found in daily life. It has been validated as a reliable method to distinguish individuals with a wide range of sleep disorders from those without.

Statistical analysis

Due to the pilot nature of this study no formal sample size calculations were performed. Descriptive statistics were computed for all major variables. Actigraphy parameters for mother and child were averaged across nights for each participant and are reported as averages and standard deviations. Kruskal-Wallis tests were used to determine overall differences among groups, and for parameters that showed overall significant differences, Mann-Whitney U tests were used for pairwise analysis. Spearman rank correlations (rs) were used to evaluate associations between actigraphy sleep variables, child behavior measures and maternal insomnia and sleepiness. Results are presented as mean (standard deviation) and given the pilot nature of the study, we did not pursue formal multiple comparison adjustment. A p-value of less than 0.05 was considered statistically significant. Analyses were performed using the Statistical Analysis Software (Version 9.2; Cary, NC).

Results

Participant characteristics

Children ranged in age from 4–10 years with an average age of 7.4 (1.8) years (good sleepers = 7.5 (2.3) years; poor sleepers = 6.8 (1.8) years; typical development = 7.8 (1.3) years). There were 11 children with autism spectrum disorder, six classified by their mothers as good sleepers and five classified as poor sleepers. Six children were of typical development and were classified as good sleepers by their mothers. The final sample consisted of 14 boys (4 good sleepers and 5 poor sleepers and 5 of typical development) and three girls (2 autism spectrum disorder good sleepers and 1 of typical development). The mother's ages ranged from 31–49 years with an average age of 37.8 (5.2) years. The mothers of good sleepers averaged 39.2 (5.2) years, mothers of poor sleepers averaged 38.4 (7.1) years and mothers of children of typical development averaged 35.8 (3.5) years. All mothers had some college with 1 having a post-graduate degree, 8 having bachelor degrees, and 8 having an AA degree or specialized training. Seven mothers were stay at home mother's (4 of the autism good sleepers, 3 of the autism poor sleepers, and 1 of the children with typical development). Of the mother's that worked 3 were registered nurses, 1 was a dietician, 1 was a dental assistant, 2 worked as assistants in schools, and 1 owned her own business.

There were no exclusions for medication in this study. Of the 17 children, 7 were not on any medications (3 autism good sleepers, 2 autism poor sleepers, and 2 children of typical development). Of the remaining children 2 typically developing children were on montelukast sodium and 1 was on ibuprofen. The medications in the 6 remaining children with autism are shown in Table 1.

Sleep behaviors

The three groups of mothers and children (autism spectrum disorder–good sleepers, autism spectrum disorder–poor sleepers, and typical development) differed on objective measures of sleep (Table 2). In the mothers, the autism spectrum disorder–good sleepers and the autism spectrum disorder–poor sleeper’s mothers took significantly longer to fall asleep than the mothers of the children with typical development. Further, the typical development mothers had significantly more wake bouts. In the children, significant differences were found among all groups for time in bed, total sleep time, and sleep latency. The autism spectrum disorder–good sleepers also had more efficient sleep and less restless sleep than the autism spectrum disorder–poor sleepers.

Associations between night time sleep and daytime behavior

All Child Behavior Checklist scales were significantly associated with some subjective sleep measurement except the attention problems, rule breaking and conduct scales (Table 3). Early morning waking’s and sleep latency were the two primary sleep measurements associated with the child’s daytime behavior. More specifically, both the average and standard deviation for early morning waking in the child, and the standard deviation of the early morning waking in the mother, as well as the average and standard deviation of the mothers sleep latency were associated with child behavior problems.

Association of sleep and maternal daytime sleepiness

Variability in the child’s nighttime sleep patterns was associated with more daytime sleepiness in the mother. Variability of the child’s sleep patterns was determined from the standard deviation of the following actigraphic sleep variables with the total score on the Epworth Sleepiness Scale from the mother: wake after sleep onset ($r_s=0.54$, $p=0.03$); number of wake bouts ($r_s=0.63$, $p=0.009$); and average wake bouts ($r_s=0.65$, $p=0.006$). Additionally, mothers who took longer to fall asleep endorsed higher levels of daytime sleepiness ($r_s=0.57$, $p=0.02$).

Relation of objective sleep measurements and maternal insomnia

Objective sleep measurements for the children were not found to be associated with maternal insomnia. However, mothers who took a longer time to fall asleep, or had greater variability when falling asleep reported more insomnia symptoms as exhibited by higher scores on the Insomnia Severity Index ($r_s=0.6$, $p=0.02$ and $r_s=0.5$, $p=0.04$ respectively).

Relationship of mother and child sleep

Positive associations were found between the sleep of the autism spectrum disorder –good sleeper mother and child for time in bed ($r_s=0.7$, $p<0.0001$), and total sleep time ($r_s=0.49$, $p<0.0001$). The autism spectrum disorder–poor sleeper mother-child dyad showed associations for sleep efficiency ($r_s=0.50$, $p<0.0001$), fragmentation ($r_s=0.27$, $p<0.05$); wake after sleep onset ($r_s=0.51$, $p<0.0001$), and the percent wake bouts ($r_s=0.39$, $p<0.004$). The typical development mother-child dyad showed associations for total sleep time ($r_s=-0.25$, $p<0.03$). When all groups of sleepers were combined significant associations were found

between mother and child for time in bed ($r_s=0.38$, $p<0.0001$), total sleep time ($r_s=0.30$, $p<0.0001$) and sleep fragmentation ($r_s=0.17$, $p<0.02$).

Discussion

Our study explored the relationship between mother and child sleep and how sleep is associated with child daytime behavior and maternal insomnia and daytime sleepiness. Using objective sleep measurements, our study adds to the growing body of evidence showing an association between sleep initiation and sleep maintenance insomnia and daytime behavior in children [10,13]. Further, our findings augment previous reports showing associations between sleep in the child and parent [7,24,25] and extends previous reports by showing that disrupted nighttime sleep in the child may be associated with daytime sleepiness in the mother. Of interest, our study is one of the first that we are aware of that has reported the impact of a child's early morning awakening on daytime behavior in children with autism, as well as children with typical development.

In general parents of children with autism spectrum disorder tend to report more sleep problems for themselves than parents of children with typical development [8]. We found few differences between the mothers of the autism spectrum disorder—good sleepers, autism spectrum disorder—poor sleepers, and typical development across the majority of sleep parameters. Whereas parents of children with autism spectrum disorder were previously reported to have shorter actual sleep time than parents of children with typical development [7] in our study differences were found only with sleep onset insomnia and the number of wake-bouts during the night. Previous studies, using parental self-report have differed in their findings looking at maternal sleep across varying types of sleepers. Meltzer and Mindell [9] using self-report in mothers of children with typical development, with and without sleep problems, found no differences in sleep latency between mothers of good and poor sleepers, however they did find mothers who identified their children as having significant sleep disruptions also reported more night waking's related to their child. Further, parents who reported more severe sleep problems in their child reported that their sleep problems were more adversely affected [8].

Our study adds objective evidence to the literature showing an association between mother and child sleep, as well as child sleep and mother daytime sleepiness [25]. Interestingly we found no association between child sleep and mother's insomnia, which might be attributable to the small sample size. The relationship between parent-child sleep and child sleep and parent functioning has previously been reported, with the most salient associations being the sleep quality and quantity with daytime functioning in the mother [26,27].

Sleep problems and associated poorer behavior in children with autism spectrum disorder have been reported in the literature. Differences in affective problems (autism spectrum disorder - good sleepers vs. autism spectrum disorder - poor sleepers, and typical development vs. both autism spectrum disorder - good sleepers and autism spectrum disorder - poor sleepers), attention problems (autism spectrum disorder differed from typical development), and anxious/depressed (autism spectrum disorder -poor sleeper differed from typical development) have been reported [17]. Early morning wakings have consistently

been reported in children with autism spectrum disorder [28,29]. Our study found a strong association between early morning waking's, in both the mother and child, and behavioral problems. Previously, disordered sleep as a contributing factor to problematic daytime behavior in children with autism spectrum disorder has been posited [17]. Our findings suggest that it is possible that these early morning wakings may contribute to behavioral problems, however directionality cannot be determined.

The strengths of our study include a well-characterized group of children with autism spectrum disorder, whose clinical diagnosis was confirmed with the Autism Diagnostic Observation Schedule. Sleep measurements were objectively obtained for two consecutive weeks, which enabled us to capture variability inherent in real life situations. Our study was also able to highlight interesting patterns and trends in this population. The study however was limited by a small sample size and limited information on maternal social and medical demographics. The small sample size also precluded us from analyzing age, gender, or additional socio-economic differences.

In summary, our findings reinforce previous work showing an association between poor sleep and problematic daytime behavior in children with autism spectrum disorder, as well as the association between mother-child sleep. It further expands the need to consider early morning wakings when assessing sleep in children with autism spectrum disorder, as well as children of typical development. Our work is not able to determine direction of causality, and future efforts are recommended to identify this as an important step in interventional studies aimed at improving sleep and behavior in children with autism spectrum disorder and their mothers.

Acknowledgments

This research was supported in part by a Donna and Jay Richards – Hobbs Discovery Grant from the Vanderbilt Kennedy Center for Research on Human Development, Vanderbilt University Medical Center, as well as in part by Vanderbilt CTSA Grant 1 UL1 RR024975 from the National Center for Research Resources, National Institutes of Health.

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Table 1

Medication use in children with autism spectrum disorder.

	Melatonin	SSRI's	Antipsychotics	Stimulants	GI Medications	Antihistamine/Antiasthmatic
Autism Good Sleeper						
1		x	x		x	
2	x			x	x	
3	x					
4	x				x	
			x			
Autism Poor Sleeper						
1	x					x
2						x

Comparison of Actigraphy Parameters Among Mother and Child for Autism Spectrum Disorder: Good Sleepers, Autism Spectrum Disorder-Poor Sleepers and Typically Developing Children.

J Sleep Disord Treat Care. Author manuscript; available in PMC 2014 October 14.

Table 3

Association between sleep parameters and the Child Behavior Checklist Scales ¹.

ChildBehavior Checklist Scale	Child		Parent		
	Average Early Morning Wakening	Standard Deviation Early Morning Wakening	Average Sleep Latency	Standard Deviation Sleep Latency	Standard Deviation Early Morning Wakening
Anxious/depressed	0.8 ^c	0.8 ^b	0.4	0.5	0.5 ^a
Withdrawn	0.6 ^a	0.7 ^b	0.5 ^a	0.6 ^a	0.6 ^a
Social problems	0.6 ^a	0.6 ^a	0.6 ^a	0.6 ^a	0.5 ^a
Thought problems	0.6 ^a	0.7 ^a	0.5 ^a	0.5 ^a	0.6 ^a
Aggressive behavior	0.7 ^b	0.7 ^b	0.4	0.4	0.6 ^a
Internalizing	0.7 ^b	0.8 ^b	0.4	0.5 ^a	0.6 ^a
Externalizing	0.6 ^a	0.6 ^a	0.4	0.4	0.5
Total Score	0.6 ^a	0.7 ^a	0.5	0.5 ^a	0.6 ^b
Affective problems	0.6 ^a	0.7 ^b	0.3	0.4	0.4
Anxiety problems	0.8 ^b	0.8 ^c	0.4	0.5 ^a	0.5 ^a
Somatic complaints	0.5 ^a	0.4	0.1	0.0	0.2
ADHD problems	0.3	0.3	0.6 ^a	0.5	0.5

¹ Only scales with significant associations are shown. Values reported are spearman correlations (rs).

^a p < 0.05,

^b p < 0.005,

^c p < 0.0005.