First Night Effect Analysis in a Cohort of Young Children with Autism Spectrum Disorder

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Study Objectives: To evaluate for the first night effect (FNE) in a group of young children with autism.

Design: Analysis of polysomnographic data from a 2-night sleep laboratory study.

Setting: Clinical Center of the National Institutes of Health.

Patients or Participants: 15 children (aged 2-10 years) with a diagnosis of an ASD.

Interventions: None.

Measurements and Results: Polysomnographic analysis showed the presence of a FNE for wake after sleep onset (WASO) minutes, stage 2, and sleep efficiency, but not for REM sleep parameters or TST.

Conclusions: In this 2-night polysomnographic analysis of sleep stages in young children with autism, we did not find the expected second night increase in total sleep time or REM sleep percentage or a decrease in REM sleep latency. This lack of an FNE for TST and REM parameters suggests that a single-night polysomnogram may be sufficient to evaluate children with an ASD for TST or REM parameters.

Keywords: Autism, first night effect

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The first night effect (FNE) refers to the well-accepted phenomenon of a poorer quality of sleep on the first night when subjects undergo two or more consecutive nights in the sleep lab. Typically, FNE effects include lower sleep efficiency, less total sleep time, less REM sleep, longer latency to REM sleep, and more intermittent awake time on night one. While this phenomenon is well recognized among adult populations, there are few exclusively pediatric studies that have examined FNE, and fewer still that have included young children with disorders affecting development.

The largest pediatric study examining the FNE was performed in 1984. It was a laboratory-based evaluation of 87 healthy children between the ages of 6 and 15 years. This experiment reported an increase in TST and a decrease in sleep latency for night two. It also revealed similar second night findings as had been seen in adult cohorts, namely, better sleep efficiency, fewer wake after sleep onset (WASO) minutes, decreased REM latency, and increased REM percentage. Palm et al. conducted a 2-night at home study in 1989 on 18 healthy children between 8 and 12 years and did not find such an effect. Instead, there was an increase in sleep latency, an increase in percentage of stage 1 sleep, and an increase in REM latency, all on the second night.

The majority of FNE data in children have come from studies using patient populations that frequently undergo overnight polysomnography (PSG) as part of a routine diagnostic assessment. Several studies have examined the FNE among children with suspected sleep disordered breathing (SDB) and obese children who are at risk for developing SDB. Scholle et al. evaluated 131 children between the ages of 2 and 17 years with suspected SDB for 2 nights in the laboratory. The work concluded that while there was a FNE effect for WASO and REM percentage, a second night was not needed for pertinent respiratory parameters. Similarly, Verhulst et al. examined 70 children between the ages of 2 and 17 years, also referred for SDB, and found a FNE for REM sleep parameters but not for respiratory measures. Li et al. compared 46 obese children to 44 normal weight children between the ages of 7 and 15 years. The groups were later further broken down for the presence or absence of SDB, and sleep architecture was examined using a 2-night, laboratory-based study. Children with and without SDB had increased TST and greater sleep efficiency on the second night. Children without SDB were found to have more REM, decreased REM latency, and decreased stage 2 on the second night.

Several studies have used the FNE principle to compare children with mood disorders or ADHD with typical controls as a way to interrogate sleep as a proxy for optimal mental health. For instance, Bertocci et al. examined 51 children between the ages of 8 and 17 years with a diagnosis of major depressive disorder (MDD) for three consecutive nights in the lab. This study explored sub-
Sixteen children between the ages of 2 and 10 years, including 2 females, were enrolled in the study after their parents/guardians consented to participation. One subject’s data could not be used, as loss of leads during night 2 prevented the acquisition of a readable study. No children were taking any medications during data collection period. Subjects were evaluated via a 2-step process that included testing both behavior and sleep.

Behavioral evaluations at the NIH assessed cognitive function and symptoms of ASD. The ASD diagnosis was based on clinical observations and information obtained from the Autism Diagnostic Observation Schedule13 and the Autism Diagnostic Interview-Revised.14 Development and overall functioning were assessed with the Vineland Adaptive Behavior Scales, Second Edition15 and cognitive/developmental testing using either the Mullen Scales of Early Learning16 or the Differential Ability Scales, Second Edition.17 Nonverbal developmental quotients were obtained for each child. The ratio score was calculated as the mean of the age equivalents of the nonverbal sections of the test divided by the chronological age and multiplied by 100 (Table 1).

### Polysomnogram

Eligible participants completed a 2-night polysomnographic observation in the NIH clinical center sleep laboratory. The overnight recordings included a referential, 21-lead electroencephalogram montage, electro-oculogram, electrocardiogram, and surface electromyogram (chin, anterior tibialis). Lights out approximated child’s usual bedtime. All recordings were videotaped. The data were then analyzed for sleep architecture using Grass telefactor software (Grass Technologies, West Warwick, RI) by AJR, a neurologist with board certification in neurology, neurophysiology, and sleep medicine; he was blind to diagnosis and night order. Scoring was done according to the guidelines published in the AASM (American Academy of Sleep Medicine) Manual for the Scoring of Sleep and Associated Events.18 The following variables were calculated: total sleep time (the total time in bed minus the sleep latency and time spent in wakefulness after sleep onset), sleep efficiency index (total sleep time divided by time in bed × 100), minutes spent in each sleep stage (N1, N2, N3, and REM sleep), percentage of each stage relative to total sleep time, latency to sleep onset (measured from lights out to the first epoch of sleep), and latency to REM sleep (measured from the first epoch of sleep to the first epoch of REM sleep).

### RESULTS

Summary data are presented for the 15 subjects studied for 2 nights. Descriptive statistics for the first and second night as well as statistical comparison of differences are presented in Table 2.

There were no significant differences between night one and night two for the following parameters: TST, stage 1%, SWS%, REM%, sleep latency, or REM latency. Stage 2 showed a significant difference, with 53.22% of the night spent in this stage on the first night versus 57.52% of the night on the second. The WASO decreased on night two from a mean of 26.05% to 7.33% of the night, and the sleep efficiency increased from 78.03% to 88.71%. Both WASO and sleep efficiency also showed significantly different standard deviations between nights, as the variance decreased appreciably for both these parameters on the second night (Figure 1).

### Table 1—Sample demographics

<table>
<thead>
<tr>
<th>Variable</th>
<th>N = 15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male/Female</td>
<td>13/2</td>
</tr>
<tr>
<td>Diagnosis Autism/PDD-NOS</td>
<td>13/2</td>
</tr>
<tr>
<td>Age, mean ± SD</td>
<td>5.24 (1.69)</td>
</tr>
<tr>
<td>Nonverbal DQ, mean ± SD</td>
<td>59.49 (18.84)</td>
</tr>
<tr>
<td>Vineland ABC, mean ± SD</td>
<td>66.93 (7.28)</td>
</tr>
</tbody>
</table>

DQ, developmental quotient.

### MATERIALS AND METHODS

**Subjects**

The National Institutes of Health’s (NIH) Combined Neurosciences Institutional Review Board approved the protocol.
DISCUSSION AND LIMITATIONS

Growing interest in the interaction between sleep and overall health, including obesity and mood disorders, has led to several studies examining the FNE in children and adolescents. Evidence from a variety of patient populations and studies of healthy children suggest that children, much like adults, show improvements in sleep quality from the first to second night in the sleep laboratory, with some measures of sleep quality continuing to improve when data from subsequent nights are collected. The most consistently reported changes are in TST, SE, WASO, and REM parameters. Prior to this report, no study has explicitly examined the first night effect in a group of young children with autism.

Table 2—Mean differences in sleep variables by night

<table>
<thead>
<tr>
<th></th>
<th>Night 1 Mean (SD)</th>
<th>Night 2 Mean (SD)</th>
<th>Difference (SE)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total sleep time, min</td>
<td>460.32 (105.94)</td>
<td>501.99 (72.20)</td>
<td>-41.67 (38.37)</td>
<td>0.30</td>
</tr>
<tr>
<td>Stage 1, %</td>
<td>4.97 (2.15)</td>
<td>4.33 (2.60)</td>
<td>0.65 (0.90)</td>
<td>0.48</td>
</tr>
<tr>
<td>Stage 2, %</td>
<td>53.22 (5.94)</td>
<td>57.52 (5.28)</td>
<td>-4.31 (1.98)</td>
<td>0.047</td>
</tr>
<tr>
<td>SWS, %</td>
<td>24.16 (7.10)</td>
<td>21.83 (5.74)</td>
<td>2.33 (2.27)</td>
<td>0.32</td>
</tr>
<tr>
<td>REM, %</td>
<td>17.67 (5.57)</td>
<td>16.30 (5.70)</td>
<td>1.37 (1.99)</td>
<td>0.50</td>
</tr>
<tr>
<td>WASO, %</td>
<td>26.05 (26.37)</td>
<td>7.33 (5.65)</td>
<td>18.72 (7.36)</td>
<td>0.023</td>
</tr>
<tr>
<td>Sleep latency, min</td>
<td>28.33 (31.46)</td>
<td>28.17 (27.29)</td>
<td>0.17 (10.78)</td>
<td>0.99</td>
</tr>
<tr>
<td>REM latency, min</td>
<td>109.80 (53.08)</td>
<td>131.93 (67.36)</td>
<td>-22.13 (17.57)</td>
<td>0.23</td>
</tr>
<tr>
<td>Sleep efficiency, %</td>
<td>78.03 (13.82)</td>
<td>88.71 (6.03)</td>
<td>-10.67 (4.15)</td>
<td>0.022</td>
</tr>
</tbody>
</table>

Standard errors and p-value are based on paired t-tests. All p-values are two tailed. Number of observations = 15.

Figure 1—Plot of subjects, n = 15, for common sleep variables affected by FNE: TST, SE, WASO, and REM %
The examinations included herein represent modified sleep studies, as respiratory measures were not recorded. The children were primarily very low functioning and non-verbal, and initial attempts to include the respiratory belts and thermistor were not successful. We acknowledge that it is a limitation that renders it impossible to know the potential contribution of obstructive sleep apnea (OSA) to sleep architecture in this particular study. However, the lack of respiratory parameters may not have had a direct impact on the interpretation of the results, as sleep architecture is preserved in children with OSA without the associated EEG arousal and measurable sleep fragmentation that often follows obstructive events in adults.20

In this cohort of young children with autism, we found a significant first night effect for WASO minutes, sleep efficiency, and N2 percentage. We did not find a first night effect for either REM percentage or REM latency. We acknowledge that the sample size was small. A post hoc power analysis (conducted using G*Power 3.1.2) suggests a minimum detectable effect size of ω = 0.78 for our sample size, assuming α = 0.05 (2-tailed) and using G*Power 3.1.2). This was not an industry supported study. The authors have indicated no financial conflicts of interest.

The lack of REM parameter change in this population stands in marked contrast to cumulative existing data on sleep acclimation from other populations and opens up interesting questions regarding underlying neuropathologic differences. While it is possible that the WASO and sleep efficiency changes in the expected direction were found by chance, we feel it is more likely that this population of children acclimates to the sleep lab differently. This information is valuable, given both the expense and expertise needed to evaluate the sleeping brain in individuals with autism. Although our small sample size limits generalizability of these results, they suggest that it may not be necessary to submit young children with autism to two consecutive nights in the sleep lab to mitigate the FNE on either TST or REM measurements.

REFERENCES


SUBMISSION & CORRESPONDENCE INFORMATION

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DISCLOSURE STATEMENT

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