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Sleep and mood during hospitalization for high-dose chemotherapy and hematopoietic rescue in pediatric medulloblastoma

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Abstract

Objective: Disrupted sleep is common in pediatric cancer, which is associated with psychological distress and may impact neural recovery. Information regarding sleep during pediatric brain tumor treatment is limited. This study aimed to describe objective sleep-wake patterns and examine the sleep-mood relation in youth hospitalized for intensive chemotherapy and stem cell rescue.

Methods: Participants included 37 patients (M age = 9.6 ± 4.2 years) enrolled on a medulloblastoma protocol (SJMB03) and their parents. Respondents completed a mood disturbance measure on three days and patients wore an actigraph for five days as an objective estimate of sleep-wake patterns. General linear mixed models examined the relation between nocturnal sleep and next-day mood, as well as mood and that night's sleep.

Results: Sleep duration was deficient, sleep efficiency was poor, and daytime napping was common, with large between-subjects variability. There were minimal mood concerns across all days. The sleep and next-day mood relationship was non-significant ($p > 0.05$). Greater parent-reported child mood disturbance on day 2 was associated with decreased same-night sleep ($p < 0.001$) and greater patient-reported mood disturbance was associated with greater same-night sleep latency ($p = 0.036$).

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CONFLICT OF INTEREST

All Authors disclose no affiliations or other areas of conflict of interest considered to be relevant and important with any organization that to any author's knowledge has a direct interest in the subject matter discussed.

Conclusions: Patients with medulloblastoma are vulnerable to disturbed sleep during hospitalization and mood may be an important correlate to consider. Sleep and mood are modifiable factors that may be targeted to maximize daytime functioning.

BACKGROUND

Youth with central nervous system (CNS) tumors are at increased risk for poor sleep quality, difficulties initiating and maintaining sleep, daytime sleepiness, and fatigue compared to youth with non-CNS malignancies and healthy peers.^{1–3} Adult survivors of pediatric medulloblastoma also report difficulties with alertness despite adequate sleep.⁴ Research has focused on subjective reports, and little is known about objective sleep-wake patterns during treatment. Sleep disturbance may be related to the tumor and CNS-directed therapies including chemotherapy, surgery, and radiation that disrupt the circadian, homeostatic, and psychophysiologic processes involved in sleep-wake regulation.⁵ Sleep is essential for immune function and neuronal recovery,⁶ and maladaptive strategies to manage sleep such as daytime napping may perpetuate sleep problems and negatively impact neurocognitive and psychosocial outcomes.⁷

Disrupted sleep in healthy children is associated with poorer neurocognitive functioning,^{8,9} academic performance,⁸ and quality of life.¹⁰ Youth with brain tumors, including medulloblastoma, are particularly vulnerable to these disruptions and report poorer quality of life than peers (both healthy and with non-CNS cancers).² Cancer survivors report greater psychological distress and depressive symptoms than siblings or demographically matched controls and those treated for CNS tumors are particularly at risk.^{11–13} This vulnerability may be compounded by poorer sleep quality and associated emotion dysregulation.¹⁴ Healthy sleep is essential to memory consolidation, attention, executive function, and emotion regulation.^{8,15,16} Patients with medulloblastoma are vulnerable to deficits in these areas, thus it is important to elucidate what additional role sleep may play in daytime functioning. Healthy children with poor sleep are 6.9 times more likely to have comorbid anxiety or depression than those without sleep problems.¹⁷ Emerging evidence suggests sleep disturbances predate depression, after controlling for demographics and baseline depression.^{18–20} Few studies examine objectively measured sleep in relation to mood outside of cross-sectional studies of youth with depression.^{21–23} Studies in juvenile arthritis and sickle cell disease have utilized subjective measures of sleep quality and only focused on interactions between sleep quality and mood in relation to daily pain.^{24,25} There is scant research investigating mood in pediatric brain tumors during active treatment when the disease process, surgery, CNS radiation, hospitalizations, and decreased opportunities for social interactions may increase risk for poorer mood. No previous work has examined sleep and mood in pediatric patients with brain tumors.

Previous studies in pediatric oncology have focused on sleep among inpatient pediatric leukemia and solid tumors.^{26,27} Youth hospitalized for cancer treatment have poorer sleep efficiency than peers who are healthy, chronically ill, and hospitalized for non-cancer illnesses.²⁶ Up to 40 nightly awakenings occur in pediatric oncology inpatients (compared to 4–6 nocturnal arousals in healthy children²⁸), and the longest sleep period for most patients is one to two hours, in comparison to healthy children who typically have brief arousals with

return to sleep rather than complete awakenings.^{26–28} Poor sleep may negatively impact daytime functioning including mood and be associated with maladaptive strategies such as daytime napping to compensate for poor nighttime sleep. Changes in sleep can persist following discharge, which can result in daytime dysfunction such as depressive symptoms.^{29,30}

Patients with medulloblastoma may have increased vulnerability to sleep and daytime impairments, but the group is understudied compared to other pediatric cancers. As treatment requires frequent night awakenings, it was hypothesized that this sleep disruption may result in daytime mood disturbance. Therefore, it is important to investigate potential treatment targets to maximize patient outcomes. Our goal was to describe mood disturbance and objective sleep-wake patterns during inpatient treatment for medulloblastoma and to examine the sleep-mood relationship after controlling for demographic and clinical characteristics.

METHODS

Participants and Procedures

Patients 4 to 19 years of age who were enrolled on a therapeutic protocol for medulloblastoma at St. Jude Children's Research Hospital (i.e., SJMB03) and their parents were recruited prior to admission for their second or third 4- to 6-day hospitalization for high-dose chemotherapy and hematopoietic cell rescue. Patients were prescribed antiemetics as follows, if the patient had breakthrough vomiting with ondansetron every 8 hours, they were administered lorazepam (plus/minus) diphenhydramine or promethazine. Corticosteroids were not prescribed during chemotherapy administration due to the potential impairment of the blood-brain barrier permeability. No sleep medications or anti-depressants were administered. Participants were eligible if they spoke English and could provide parental consent and child assent (or consent for patients 18 years old). Patients were excluded if experiencing serious neurological effects (e.g., posterior fossa syndrome) that would interfere with self-reports. Assignment to a sleep hygiene intervention or standard of care (SOC) in the larger study was made using a group randomized design. Participants wore actigraphs daily, and to minimize patient burden while allowing for comparison of change, mood was reported on day of admission, the midpoint of hospitalization, and day of discharge. The study was approved by the institutional review board (IRB).

Fifty-six patients were eligible, and 43 consented. The most common refusal reason was chemotherapy intensity and not wanting additional burden. Six were removed from the study due to complications and increased acuity of care during hospitalization. Of the 37 enrolled, 19 were randomized to the intervention: 90 minutes of protected sleep with bundled nursing care, stimulus control, darkened room, and relaxation exercises. There were no significant differences between intervention and SOC in mood and sleep measures. The primary intervention outcome found no group differences in brain tumor site, risk, presence of VP shunt, gender, or age. The high-risk disease group had shorter sleep duration and greater wake after sleep onset.³¹ The treatment difference between average and high-risk patients was the radiation dose, which occurred prior to this study.

Measures

Wrist Actigraphy.—The Micro-mini motionlogger (Ambulatory Monitoring Inc., Ardsley, NY) provided an objective estimate of sleep-wake patterns. The wristwatch-style device contains a biaxial piezoelectric sensor with an epoch length of 60-seconds. Families were instructed to press the event marker when attempting sleep and upon awakening. The system's software utilized Sadeh's algorithm, an approach validated against polysomnography in children.³² Patients wore actigraphs throughout their hospitalization (up to 5 days), with most being four days.

Mood Disturbance.—The Behavioral, Affective and Somatic Experiences Scale Revised (BASES, revised) was originally designed for nurses to complete, has been adapted for self- and parent-report, and was validated for measuring short-term functioning in children hospitalized for intensive therapy.^{33,34} The revised BASES includes 5 subscales, with the Mood Disturbance subscale (7 items) used in this study. Patients 5 years of age and parents rated the child's experiences on a 5-point scale on the day of admission (day 0), day 2 or 3, and the evening before discharge, with recall periods of one day and consistent with the intended use.³⁴ Daily mood was computed by summing the 7 items for self-report (range=7 to 35) or 8 items for parent-report (range=8 to 40), with higher scores indicating greater mood disturbance. For those missing one item, the average of the answered items of the same individual was imputed for the missing item. This approach may be used for a small proportion of missing data, as has been conducted with the Brief Symptom Inventory and Neurocognitive Questionnaire,^{35,36} and missing data in this sample represented 5% to 7% for the parent and child BASES (respectively). Mood data for a given day were excluded if most items were missing. The BASES is intended to be sensitive to change^{33,34} and has been found to have good internal consistency ($\alpha=0.82 - 0.86$) for the mood disturbance subscale.³⁴

Data Analysis

Descriptive statistics were estimated for participant characteristics, sleep variables, and mood across all days of measurement. The coefficient of variation (standard deviation divided by mean across nights) was calculated to describe night-to-night variability of sleep. To examine the sleep-mood relationship, nocturnal sleep duration was chosen based on past studies indicating that adequate sleep duration is essential to child health outcomes, including mental health and immunologic functioning.³⁷ Sleep onset latency is calculated as the minutes from attempting sleep onset and was explored due to its larger intra-individual variability and research on adolescents with depression describing longer sleep latency as the most consistent correlate of mood.¹⁹ General linear mixed models for longitudinal data (i.e., SAS PROC MIXED with repeated measures) were implemented to evaluate change in sleep (measured daily) and mood (measured every other day), to examine both prior night's sleep duration and sleep latency (nights 1 and 4) as predictors of next-day mood (days 2 and 5), and to examine daytime mood (day of admission and day 2) as a predictor of that night's sleep duration and sleep latency. Analyses accounted for within-patient correlations across days and adjusted for age, gender, body mass index (BMI) z-score, and disease risk classification. Descriptive statistics were stratified by age groups (i.e., 12 years and 13 years) most consistently described across national sleep and health organizations in terms of

recommendations for age-based sleep needs.³⁷ Age was included as a covariate in regressions rather than stratifying by age due to the study sample size.

RESULTS

Participant Characteristics

Participants included 37 patients ($M=9.6 \pm 4.2$ years old) and the parent present during hospitalization (if 18 years of age). The majority of participants identified as Caucasian (83.8%), 43.2% of participants were female, and the majority of parents were mothers, with three fathers. Twenty-one (56.8%) of the patients had high-risk disease, defined as presence of metastatic disease within the neuraxis or presence of residual disease ($>1.5\text{cm}^2$) at the primary site after surgery. The remaining patients had average risk disease, defined as presence of localized tumor without overt evidence of invasion beyond the posterior fossa, gross total resection ($<1.5\text{cm}^2$), and no evidence of extraneural metastasis. Participant characteristics are summarized in Table 1.

Objective Sleep

Table 2 includes summary statistics of the daily and five-day average for each sleep measure. Nocturnal sleep duration was insufficient ($M_{\text{child}}=398.1 \pm 96.0$ minutes, $M_{\text{adol}}=360.7.1 \pm 65.3$ minutes), and nighttime sleep included prolonged sleep latency ($M_{\text{child}}=45.6 \pm 32.9$ minutes, $M_{\text{adol}}=60.3 \pm 41.1$ minutes), a high number of awakenings ($M_{\text{child}}=19.6 \pm 5.8$ and $M_{\text{adol}}=15.4 \pm 5.6$ per night), substantial wake after sleep onset ($M_{\text{child}}=151.0 \pm 48.0$ minutes, $M_{\text{adol}}=169.1 \pm 74.9$ minutes), and poor sleep efficiency ($M_{\text{child}}=71.4 \pm 10.7\%$, $M_{\text{adol}}=68.6 \pm 10.5\%$). There were also frequent and extended periods of daytime napping for children ($M=148.4 \pm 77.9$ minutes) and adolescents ($M=220.8 \pm 126.1$ minutes).

The standard deviation across all patients and all nights was high (Table 2), suggesting large between-subjects variability in nocturnal sleep duration, sleep latency, and sleep efficiency. The mean coefficient of variation (M_{CV}), obtained by taking the means of the coefficients of variations for each individual across nights for sleep latency ($M_{\text{CV}}=1.07 \pm 0.51$), nocturnal sleep duration ($M_{\text{CV}}=0.21 \pm 0.15$), sleep efficiency ($M_{\text{CV}}=0.16 \pm 0.11$), and total sleep per 24 hours ($M_{\text{CV}}=0.21 \pm 0.13$), suggested large intra-individual variability in sleep latency. There were no significant differences in nocturnal sleep duration ($p=0.75$) or sleep latency ($p=0.89$) across days based on linear mixed models for longitudinal analyses.

Mood

Summary statistics are displayed in Table 2 for self-reported (child= 11 ± 3.0 , adolescent= 14.3 ± 5.3) and parent-proxy ($M_{\text{child}}=14.1 \pm 5.8$; $M_{\text{adol}}=18.7 \pm 6.1$) mood. There were no significant univariate differences in parent-reported ($p=0.35$) or child-reported ($p=0.58$) mood disturbance across all measurement days (data not shown).

Sleep-Mood Relationship

Self-report—There was no significant relation between nocturnal sleep duration and next-day self-reported mood ($\beta=0.007$, $\text{SE}=0.004$, $p=0.09$) or sleep latency and next-day mood ($\beta=0.001$, $\text{SE}=0.009$, $p=0.87$) when adjusting for demographic and clinical characteristics.

Mood disturbance scores were lower on day 2 than day 5 ($\beta = -0.99$, $SE = 0.43$, $p = 0.03$). Mood disturbance was associated with shorter nocturnal sleep duration that night ($\beta = -6.44$, $SE = 2.94$, $p = 0.04$), while mood was a non-significant predictor of sleep latency ($\beta = 2.10$, $SE = 1.61$, $p = 0.20$) when adjusting for covariates. Children with average-risk disease obtained more sleep than those with high-risk disease ($\beta = 137.16$, $SE = 36.86$, $p = 0.001$). Results are summarized in Tables 3 and 4 and the supplemental table.

Parent-report—Nocturnal sleep duration ($\beta = 0.01$, $SE = 0.009$, $p = 0.21$) and sleep latency ($\beta = 0.003$, $SE = 0.02$, $p = 0.90$) were non-significant predictors of next-day mood when adjusting for covariates. Mood disturbance was associated with greater sleep latency ($\beta = 2.73$, $SE = 1.26$, $p = 0.04$). There was a significant mood-time interaction for sleep duration, such that greater mood disturbance was a non-significant predictor on the night of hospital admission ($\beta = -0.27$, $SE = 3.24$, $p = 0.93$) but was associated with shorter sleep duration on day 2 ($\beta = -9.98$, $SE = 2.42$, $p = 0.0001$). Children with average risk disease obtained more sleep than those with high-risk disease ($\beta = 111.72$, $SE = 33.62$, $p = 0.003$). Results are summarized in Tables 3 and 4. In exploratory analysis examining mood patterns over the hospitalization, there were no significant differences in sleep between those with stable, worsened, or improved parent-reported mood (i.e., on day 2 versus day of admission, $p > .05$).

CONCLUSIONS

This study examined objective sleep estimates and subjective mood disturbance in youth with medulloblastoma who were hospitalized for high-dose chemotherapy and hematopoietic cell rescue. Most studies in pediatric brain tumors have focused on survivors, subjective sleep, and/or those referred to an outpatient clinic for sleep or hypersomnia complaints.^{1,2,38,39} There is no known research examining the relation between mood and objectively measured sleep in youth with chronic illness and there is a paucity of information on objective sleep estimates during inpatient treatment for pediatric medulloblastoma.

Results showed that average nocturnal sleep duration fell well below the recommendations for optimal health in children (9 to 12 hours) and adolescents (8 to 10 hours)³⁷ and that sleep was highly fragmented. In contrast to previous studies finding that healthy children spend 85–95% of their time in bed sleeping,⁴⁰ our inpatients with medulloblastoma spent an average of 71% of their time in bed sleeping. Compared to previous studies of youth hospitalized for ALL⁴¹ and solid tumors or acute myeloid leukemia,²⁷ our participants exhibited qualitatively more wake after sleep onset minutes and average number of nocturnal awakenings,^{27,41} poorer sleep efficiency,⁴¹ and lower nocturnal sleep duration.^{27,41} Findings can reflect the multitude of factors that may impact sleep during hospitalization for cancer treatment, including extrinsic (e.g., noise from room entries/exits for patient monitoring or infusion pumps) and intrinsic (e.g., chemotherapy and medication effects, physical discomfort, CNS disease effects) sources of sleep disruption. The differences from previous research^{27,41} may reflect greater vulnerability for poor sleep and daytime fatigue in medulloblastoma patients admitted for high-intensity chemotherapy compared to other previously studied pediatric cancers.^{1–3,5} In particular, treatment included high-dose

chemotherapy requiring frequent monitoring and need to awaken patients multiple times at night to urinate to minimize chemotherapy-related nephrotoxicity, which placed them at greater risk of extrinsic impact on sleep than those with ALL, AML, or solid tumors. Furthermore, recovery from recent neurosurgery may have contributed to increased fatigue and discomfort above what is experienced by other pediatric cancer cohorts.

Our findings for nocturnal sleep duration were qualitatively similar to previous research including youth with a history of brain tumors who presented to an outpatient sleep center for concerns regarding daytime sleepiness.³⁹ Though both groups exhibited significant daytime sleep, mean daytime sleep in our participants was approximately 70 minutes greater.³⁹ Greater time in bed during hospitalization may affect the time patients engage in physical therapy or other activities that may provide physical and psychosocial benefits. Although all sleep variables exhibited between-subjects variability, sleep latency was the only variable with statistically significant intra-individual variability. Preliminary evidence suggests depression is associated with greater future risk of variability in sleep latency, sleep latency variability is associated with shorter average sleep duration, and sleep variability has implications for health and well-being.⁴² This suggests both mean sleep and sleep variability warrant further examination.

Despite limited concerns for mood disturbance, self-reported mood disturbance was associated with shorter sleep duration and was a non-significant predictor of sleep latency, while parent-reported mood was associated with both decreased sleep duration and longer sleep latency. Nocturnal sleep duration and sleep latency were non-significant predictors of daytime mood, but additional research with a larger sample is needed before conclusions can be made regarding the sleep-mood relation among children with brain tumors hospitalized for treatment. Studies among healthy children and young adults provide support for sleep disturbance predating the onset of depression.^{18–20} Our contradictory findings may reflect our examining the sleep-mood relation within a given day rather than use of daily assessments and the need to consider potential confounding variables (e.g., maternal sleep and depression as well as the role of illness in the current sample).²⁰ Studies in pediatric rheumatoid arthritis and sickle cell disease have found that mood, pain medication use, and stress moderate or mediate the sleep-pain relation,^{24,25,43} suggesting that interactions between sleep and physical symptoms may be important to consider in pediatric cancer.

Study Limitations

Despite the important study contributions, there are several limitations. Because of our small sample size, the analyses were not stratified by age group. However, a descriptive of all outcome measures by age is provided in Table 2. An additional limitation was this study functioning as part of a larger study powered to address intervention aims rather than these exploratory aims for mood and sleep. Our sample consisted primarily of Caucasian youth. Although this may reflect the greater incidence of pediatric brain tumors amongst non-Hispanic whites,⁴⁴ we cannot generalize results to those from other racial/ethnic backgrounds also affected by brain tumors. We were unable to examine the daily mood-sleep relation due to an insufficient number of within-participant observations for mood. Additional research is needed to understand the role of mood and both subjective and

objective sleep measures during pediatric brain tumor treatment. Future research could explore the direction and strength of the mood-sleep relationship utilizing daily assessments and multilevel modeling to explore within- and between-subjects relationships. Examination of potential moderators, mediators, or covariates in this population, as well as consideration of stratification by age is warranted. This study investigated patient functioning during hospitalization, which likely presents differently in an outpatient setting. Crabtree et al.,³ however, found that fatigue persists during the first two months of pediatric brain tumor treatment despite stability in subjective sleep (i.e., parent-reported bedtime, wake time, sleep duration), suggesting that sleep complaints are present regardless of the setting. Lastly, we did not evaluate other sleep domains that may impact functioning (e.g., fatigue, daytime sleepiness, and sleep-disordered breathing). Children with a history of brain tumors are vulnerable to experiencing daytime sleepiness and sleep disordered breathing,^{38,39} but it is unclear the degree to which these problems present during active treatment. Given the impact of sleepiness and sleep-disordered breathing on cognitive functioning, sleep-wake patterns, and psychosocial functioning,^{45,46} it is important to investigate the presence and role of these factors across treatment.

Clinical Implications

Disease and treatment-related factors are associated with increased risk for sleep-wake disturbance in children undergoing medical treatment for brain tumors such as medulloblastoma. Referrals for sleep intervention average 6.9 years following brain tumor diagnosis despite the distress and impairment associated with these disturbances,³⁸ highlighting the importance of regular evaluations and intervention to maximize daytime functioning. Our findings support the need to ask patients about their sleep and psychosocial functioning throughout treatment and consider pursuing interventions. Patients exhibit significant sleep disruption that is associated with mood disturbance during hospitalization and is likely to persist during outpatient treatment, which must be adequately addressed given the potential effects on neurobehavioral functioning. Insufficient sleep and fragmented sleep defined as poor sleep efficiency and/or multiple night awakenings can have adverse effects on emotional and neurobehavioral functioning including sustained attention, memory, inhibition, working memory, mood, and emotion regulation.⁴⁷ Additional information is needed to better understand sleep and daytime functioning during medical treatment and survivorship and to aid in the development of interventions to address sleep, mood, and other domains of daytime functioning in individuals undergoing treatment for pediatric brain tumors.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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TABLE 1

Participant characteristics (n=37)

	N (%)	Mean±SD	Range
Age		9.6±4.2 years	4.0 – 19.0
Gender			
Males	21(56.8)		
Females	16(43.2)		
Race/Ethnicity			
Caucasian	31(83.8)		
African American	5(13.5)		
Asian	1 (2.7)		
Body Mass Index		−0.2±1.5	−3.6 – 2.4
Disease Risk			
Average	16(43.2)		
High	21(56.8)		

N, number; SD, standard deviation

TABLE 2

Mean and standard deviation of sleep and mood across hospitalization.

Day	N	Sleep Onset Latency (Min)	Number of Night Wakings	Nocturnal Sleep (Min)	WASO (Min)	Sleep Efficiency (%)	Daytime Sleep (Min)	Parent-Report Mood	Child-Report Mood
<i>Children, ages 4–12 years</i>									
0 [‡]	26	25.1±26.6	18.9±6.1	396.5±104.5	131.3±62.5	74.3±13.5	N/A [‡]	13.6±5.7	11.0±3.2
1	26	33.0±41.2	19.5±8.6	415.3±103.8	135.4±58.3	74.7±11.9	174.8±132.3	-	-
2	26	44.0±65.5	20.0±8.3	407.3±126.3	175.1±74.6	68.5±16.8	91.5±93.2	13.2±6.6 [§]	10.3±4.0 [§]
3	26	45.7±57.6	19.9±7.1	374.9±125.5	169.7±75.3	67.4±14.9	190.3±120.9	-	-
4	22	33.3±33.8	20.5±8.0	398.4±118.3	143.6±61.7	72.1±14.9	134.0±96.2	-	-
5	2	3.5±4.9	10.0±8.5	383.0±117.4	84.0±77.8	81.2±18.3	115.5±12.0	15.3±8.0	11.4±3.1
All	26	45.6±32.9	19.6±5.8	398.1±96.0	151.0±48.0	71.4±10.7	148.4±77.9	14.1±5.8	11.1±3.0
<i>Adolescents, ages 13 years</i>									
0 [‡]	10	38.2±36.4	12.6±6.8	363.5±137.0	91.7±69.6	82.8±10.2	N/A [‡]	19.4±7.1	13.5±4.7
1	10	45.5±55.3	13.1±8.1	416.5±162.7	136.4±91.5	73.3±19.7	259.1±183.7	-	-
2	10	34.5±42.9	16.3±8.7	344.0±121.5	182.4±123.2	65.7±18.8	179.4±124.2	18.3±6.7 [§]	15.0±7.1 [§]
3	10	42.3±57.1	18.6±5.6	336.8±84.2	208.7±111.1	62.1±16.2	190.4±121.1	-	-
4	10	28.3±35.3	20.5±7.9	376.1±73.0	173.6±67.1	68.2±11.4	176.9±149.6	-	-
5	2	135.0±147.1	17.0±8.5	291.0±147.1	190.0±179.6	61.1±33.9	345.0±410.1	19.6±8.3	15.7±8.3
All	10	60.3±41.1	15.4±5.6	360.7±65.3	169.1±74.9	68.8±10.5	220.8±126.1	18.7±6.1	14.3±5.3

Min, Minutes; WASO, wake after sleep onset

[‡]Day 0 is day of hospital admission[‡]Not applicable, as daytime sleep not measured on day of admission[§]Day 3 for 1 participant, else Day 2

TABLE 3

Multiple regressions: Previous night sleep predicting next-day mood.

Independent Variable [†]	Parent Report		Self-Report	
	β	SE	β	SE
Sleep Onset Latency (Minutes)	0.003	0.02	0.001	0.009
Sleep Duration (Minutes)	0.01	0.009	0.007	0.004

β , beta estimate; SE, standard error

[†] Separate regressions and adjusted for time, age, gender, race, disease risk group, and BMI z-score

TABLE 4

Multiple regressions: Daytime mood predicting nighttime sleep.

Dependent Variable [†]		β	SE	β	SE
Sleep Onset Latency (Minutes)	Parent-reported Mood	2.73	1.26*	Self-reported Mood	2.10 1.61
Sleep Duration (Minutes)	Parent-reported Mood, Day 0	-0.27	3.24	Self-reported Mood	-6.44 2.94*
	Parent-reported Mood, Day 2	-9.98	2.42***		

β , beta estimate; SE, standard error

[†]Separate regressions and adjusting for time, age, gender, race, disease risk, and BMI z-score

* p -value < .05

*** p -value < .001