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Nighttime sleep and daytime nap patterns in school age children with and without asthma

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Abstract

Objective—This research examines subjective and objective report of naps and nighttime sleep in 9–11 year old children with and without asthma.

Methods—This between subjects study collected prospective self-report diary and objective actigraphy measures of sleep from 27 children with and 27 without asthma during a 7-day/6-night at-home monitoring period.

Results—Thirty-two percent of participants reported daytime naps. Nappers were more likely to be children with asthma (12/27 vs. 5/27, p=0.04) even though the children with asthma did not report being more tired, sleepy or less alert in the morning. Nappers did not differ from non-nappers on self-report measures of overall sleep quality or number of awakenings but were documented, via objective measures, to have later (clock time: 23:05 vs. 22:21, p=0.04) and more variable (Levine's Test for Equality of Variances: F=10.68, p=0.002) sleep onset times than non-nappers. Sleep offset times did not differ between the nappers vs. non-nappers therefore nappers had fewer total minutes of nighttime sleep than did the non-nappers (437 vs. 465, p=0.04). Later (clock time: 23:01 vs. 22:15, p=0.01) sleep onset times were also documented in minority vs. Caucasian children.

Conclusions—Napping appears a more common behavior than expected especially in children with asthma or of minority ethnicity but the reasons are unclear. Self-report measures may not capture important sleep characteristics that objective measures can identify. Strategies to reduce late and variable bedtimes of all children are needed given our awareness of the negative cognitive, emotional and behavioral consequences of poor sleep in children.

Key terms

childhood sleep; napping; asthma; actigraphy

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INTRODUCTION

Background

Sleep is an important component in children's physical and intellectual growth and development[1]. Yet, surveys suggest that 25% of the children in the US have some type of sleep disturbance. Sleep problems include medical disorders such as obstructive sleep apnea and restless legs syndrome and behavioral disorders such as parasomnias (e.g. bruxism, nightmares, sleep terrors, sleep enuresis) or disturbances related to problematic bedtime routines[2–5]. Inadequate sleep in school-age children has been associated with increased school absenteeism, reduced school achievement and cognitive functioning[6–11], obesity[12–17], attentional difficulties and behavior problems[18–21]. Studies also report that sleep disturbances and insufficient sleep in children have been associated with hyperactivity, daytime sleepiness, and irritability[1, 22]. The prevalence of sleep problems and its potential impact on child well being highlights the need for early identification of inadequate sleep to improve child health.

Despite the prevalence of sleep problems, screening children for sleep habits and adequate sleep is insufficient. A survey by Owens[23] found that more than 20% of primary care providers did not routinely screen school-aged children for sleep problems, and only 25% routinely screened toddlers and school-age children for snoring, despite their knowledge of the importance of sleep and the associations among sleep, behavior, health, and school performance. Another study by Chervin[24] reviewed medical records of children with sleep problems and found that pediatricians seldom address sleep issues. In addition, less than 50% of parents of 4–12 year-old children report that they discuss sleep with their child's pediatrician[25]. Furthermore, parents responding to a national survey of sleep behaviors report that only 38% of their school age children's health care providers ever ask about sleep[26].

Most of the research in pediatric sleep addresses sleep quality in healthy children or in children with sleep disorders such as obstructive sleep apnea. Few studies address sleep quality in children with chronic illness. Compared to healthy children, children with chronic illness require increased specialized health care, and are more likely to miss days from school and require special education services[27]. In addition, many children with chronic illness experience exacerbations and remissions of their disease, and recurrent symptoms (i.e. breathing problems, pain, fatigue) that may interfere with their sleep. Likewise, insufficient sleep may negatively influence how children cope with their chronic illness, symptom exacerbations, and activities of daily living. Therefore, the purpose of this study was to examine nocturnal sleep and daytime nap patterns, as measured by actigraphy and self-report, in a sample of school age children with and without asthma.

Methods

Participants

Approval for this between-subjects study was obtained from the Institutional Review Board at the University of Washington, Seattle, WA. From 2002 through 2005, 55 children (19 girls) 9-to-11 years of age with and without asthma, and their parents were recruited from the community to provide prospective sleep and nap data from the children. Recruitment sites included elementary schools, grocery stores, a university research recruitment web page, and a local check cashing facility. Some children asked their parents to take part after a schoolmate/friend had participated. Recruitment fliers read in part "Would You and Your Child Like to Help With a Study Looking at Sleep and Asthma In Children". Since we were attempting to match groups on age and gender, the next line initially read, "WE NEED Children 9, 10, or 11 years who **DO** and **DO NOT** have asthma to participate with their parent." Interested families contacted the research coordinator who explained the purpose of the study, discussed specific

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study procedures and screened for eligibility. Children were free of colds for the proceeding two weeks, and had no other chronic illness except allergies, a common co-morbid condition in children with asthma. Children were excluded if they had a diagnosis of cystic fibrosis, heart disease or past surgery, seizure disorder, diabetes, bleeding disorders, or a sleep disorder or family history of a diagnosed sleep condition in a first-degree relative. In addition, children taking oral steroids for any reason in the past two weeks were excluded. Of the 58 families who inquired about the study, three declined to participate (two due to siblings unable to participate together and one due to scheduling difficulties). One additional child with asthma did not provide consistent enough data to be included in the analysis; therefore the final analysis includes 54 children.

Procedures for Data Collection

After telephone screening to insure eligibility, an information packet about the study was mailed to the family along with a 7-day sleep/nap diary, wrist actigraphy watch (Actiwatch-Score monitor, Mini-Mitter, Bend, OR/USA) and instructions for using both. Parents of children were contacted by telephone mid-week to determine receipt of study materials, review procedures to insure they understood directions and to answer questions prior to the start of the data collection period. Parental consent and child assent were obtained. Children with asthma maintained their usual treatment regimen. Once monitoring began, the children reported in daily diaries and were requested to wear an Actiwatch-Score monitor on the non-dominant wrist for six nights.

Daily Diary

Each morning children reported in the diary the time they went to bed on the previous night and number of awakenings. They also rated the overall quality of their prior night's sleep, and perceived morning tiredness, sleepiness and alertness in their diary using a four point scale (0–3 for morning tiredness, sleepiness, and alertness; 1–4 for sleep quality). Each evening children reported in their diary the number of daytime naps taken. Children were asked to complete their diary report independent of their parent. Parents were asked to support and encourage their children to use the diaries when they woke the child and put them to bed but did not directly supervise the entries. The child's Actiwatch-Score alarm went off 4 times during the day, including at 8 am and 8 pm reminding the child of their participation in a study and need to record in the diary. The research coordinator also called the family the first day of starting the diary, mid-week and 1 day before the last diary day to remind them of twice a day recording. Diaries were returned to the research coordinator at the end of the 7-day reporting period.

Wrist Actigraphy

The Actiwatch-Score 64 (Mini-Mitter-Respironics, Inc., Bend, OR/USA) actigraph used in this study provides continuous motion data using an omni-directional accelerometer to monitor the speed and degree of motion. The motion data were scored as sleep or wake using Actiware-Sleep 3.4 analysis software (MiniMitter-Respironics, Inc., Bend, OR/USA) with a validated algorithm[28]. Sleep/awake times were scored using the Sleep-Watch software program (Mini-Mitter, Bend, OR/USA) in 60-second epochs. The sleep variables derived from the actigraphy monitoring included: 1) sleep onset, defined as the first 10-minute segment with no more than one epoch of any recorded activity; 2) sleep offset, defined as the last 10-minute segment with no more than one epoch of any recorded activity; and 3) total sleep time, defined as the amount of time between sleep onset and sleep offset that is scored as sleep. Others have found 5 days or more to adequately capture the child's sleep routine[29].

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Data analysis

Demographic characteristics of the sample were summarized using frequencies and percentages. Two-sided Pearson Chi-Square tests were used to assess potential differences in these demographic variables. Mean values were then calculated across the 6 reporting nights for Actigraphy-derived sleep variables and 7 reporting days for diary self-reported variables for each child. Individual variability in sleep onset, offset and total sleep time was calculated as the standard deviation of each of these variables over the 6 nights. Comparison of mean differences in all Actigraphy-derived and diary self-reported sleep variables between nappers and non-nappers were assessed using two-sided t-test analysis. Two sided t-test analysis was also used to assess mean differences between ethnic minority and Caucasian children's sleep variables. A significance level of $p<0.05$ was set a priori.

RESULTS

Our sample consisted of 54 children; 27 with provider diagnosed asthma. Males were disproportionately represented in the asthma group at a 2:1 ratio which approximates the prevalence of asthma during the middle school years[30,31]. Children with asthma and those without did not differ by gender, race, ethnicity, or education of the child's female care provider. There were more 9 year old children in the asthma group ($p=0.03$); however when age was analyzed in months, no significant differences were found between the two groups. Tanner staging of pubertal maturation, all children being either stage 1 or 2 and grade in school also did not differ between the two groups. The demographic characteristics of nappers differed from non-nappers only in their asthma status (12/27 vs. 5/27, $p=0.04$). See Table 1 for specifics.

Forty nine children provided a minimum of 5 nights of usable actigraphy data. Most children provided diary information for the day before starting to wear the Actiwatch-Score and each day thereafter. A total number of 39 days contained self-reported naps. Twenty-seven out of these 39 nap-days were reported by the children with asthma. The number of reported naps for any given day by an individual child varied from one to three. Although eight children reported naps on only one day, five noted them on over half of their reporting days. Two children with asthma reported naps on all days.

Nappers and non-nappers did not differ on any sleep measure obtained from child self-report in their week long diary. For example, nappers did not differ from non-nappers in self-reported number of night awakenings, overall quality of sleep, or morning reports of tiredness, sleepiness or alertness. However, several objective measures of sleep obtained via actigraphy did differ by nap status. See Table 2.

Actigraphy identified that the average sleep onset was significantly later by 45 minutes (23.09 vs. 22.35, $p=0.04$) in children reporting daytime naps. Both as a group (Levene's Test for Equality of Variances: $F = 10.68$, $p=0.002$) and as individuals across reporting nights ($t= -3.055$, $df=23.37$, $p=0.001$) nappers reported more variability in their sleep onset times than did non-nappers. Three children having asthma who reported the most frequent number of nap-days were also found by actigraphy to have very short nighttime sleep. During 18 nights of report by these three children only 5 nights contained greater than 8 hours of nighttime sleep, and all but one night was of less than 8 hours of sleep. The mean total number of minutes slept during the night was also significantly shorter in children reporting naps (437 vs. 465, $p =0.04$). In contrast, the average sleep offset times (i.e. time the children woke up) and the variability in mean total sleep time did not differ significantly by nap status.

Based on prior literature that suggested potential ethnic differences in children's sleep patterns, we extended our analysis. We grouped minority vs. Caucasian children because this division split the sample most equally (See Table 1), there was no theoretical rationale for an alternative

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split and further division created small numbers in all but the Caucasian group. Average sleep onset tended to be later by 50 minutes (23.02 vs. 22.26, $p<0.01$) in ethnic minority children. No significant differences were found in other variables, however consistent trends across the objectively measured data pointed to potential disparities in minority children's sleep. Differences in mean total sleep, with minority children getting on average 25 minutes less per night, approached significance as did variability in night-to-night total sleep. Variability in sleep offset (rise times) also approached significance being more varied in ethnic minority children. See Table 3 for a presentation of these consistent trends.

DISCUSSION

Our findings indicate that 32% of our study participants napped regardless of whether or not they had asthma. This finding is striking given the National Sleep Foundation's Sleep in America Poll results that reported only 2% of 6 year old children napped daily and that children who got the age recommended amount of nighttime sleep were the least likely to nap[26]. The nap percentages we found are also higher than previous reports that 1 to 14% in school-aged children nap[32, 33]. Our percentages are higher than previously reported which may have been influenced by our recruitment strategies. Parents concerned about their child's sleep may have chosen to participate in greater numbers than those with fewer sleep concerns. Their children may indeed have had more problematic sleep and thus napped more then a representative sample of all children with and without asthma. Future research with children of these ages, where sleep is only one of many recruitment foci, could help determine if the high percentage of napping we found is more prevalent today than in the past or was largely influenced by our recruitment procedures.

In our study the average nighttime sleep duration measured objectively via actigraphy was 7.52 hours (7.29 hr and 7.75 hr for nappers and non nappers respectively). This is much less than the parent reported mean of 9.4 hours in the Sleep in America Poll for 1st through 5th graders and the 10–11 hours recommended by experts on the Sleep of American Children web site. The mean bedtime (sleep onset) in our study was near 11pm for nappers. This contrasts with the mean of 9pm for school age children in the 2004 Sleep in America Poll[26]. Our high rate of napping may be related to the study children's inadequate nighttime sleep, asthma, and variability in sleep onset times.

In our study, nappers were more likely to be diagnosed with asthma. Indeed 44% of the children with asthma self-reported daytime naps in their diary. Average nighttime sleep duration between children with asthma and without asthma via actigraphy did not differ however. Physiologic demands of asthma with unrecognized nighttime symptoms, or the fact that perhaps children with asthma require more sleep than their non-asthma peers may be responsible for this combination of findings. A recent study found that parents of children with asthma report less satisfaction with their child's sleep than do parents of children without asthma[34]. Additional research is warranted on sleep patterns and nighttime symptoms in children with chronic illnesses, especially asthma. Whether subtle respiratory symptoms in children with asthma influence nighttime sleep and drive for daytime naps requires further investigation. Symptoms common in asthma (wheeze and chronic cough) have been associated with difficulty falling asleep, restless sleep, and daytime sleepiness[35]. The specific etiologies of the differential sleep characteristics between children with and without asthma must be identified to develop effective interventions in the children with asthma.

Total nighttime sleep as measured by actigraphy was shorter for nappers than non-nappers. Rise times (sleep offset times) seen in this study were likely due to school start times, since the majority of children in our study participated during the school year, Sunday through Thursday night. In our study, nappers had more variability in their bed times/sleep onset (30

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minutes) but not their rise times. Daytime napping may compensate for insufficient nighttime sleep however; this may be impractical when school, social or athletic activities prevent adequate daytime rest periods. A recent study found that a 30 minute extension of sleep or an hour restriction impacted healthy children's neurocognitive function the following day[36]. A 30 minute extension was associated with improvements in memory, sustained attention, and behavioral inhibition tasks. Additional research is warranted to determine the impact of sleep extension and restriction in healthy children and in those with chronic illness. If a 20–30 minute difference in nighttime sleep as seen in our study lead children to nap, could an in-home intervention to extend sleep by this amount provide beneficial effects and alleviate the need for daytime napping for children. Parents, counselors and health care providers may believe it too difficult to enact behavior changes that require large increases in nighttime sleep but may be willing to attempt interventions targeting a 20–30 minute extension if they felt it would bring improvements for the child's health and functioning. If such extensions brought desired outcomes, families might then be motivated to make further improvements in the child's sleep until the recommended amount of sleep is obtained on a regular basis.

If daytime napping is indeed an indication of the need for more nighttime sleep, attention needs to be given children who report naps even if they do not concurrently report morning tiredness, sleepiness or overall poor sleep quality. We found such morning self reports did not differ by nap status and others have found only modest correlations as well[37]. Self-report may be insensitive to the subtle need to supplement inadequate nighttime sleep in most children, particularly when self report is obtained upon awakening in the morning. In addition, sleepiness, tiredness, and alertness are subjective states and what is 'typical' for the child may soon become 'normal' for the child and not be perceived by them as worthy of special comment. Indeed, the more slowly and chronic the perception, the less likely the child may be to report it as unusual. Relying on the child to complain of morning sleepiness/tiredness to initiate a more formal assessment of sleep thus appears inadequate. Parent or child report of napping however should always trigger assessment. Future research should examine the extent to which self-report of napping actually captures even brief naps children may take while watching TV, videos, or studying by verifying them with daytime actigraphy analysis.

Objective assessment of sleep onset and offset is necessary since we found neither parent nor child diary report of bedtime the same as time of sleep onset determined by actigraphy for most children. Objective measures should also be used to monitor improvements in sleep when interventions are implemented so reporting bias is minimized. We found actigraphy as an objective assessment tool to be acceptable to all children and parents in the study. Although children did at times forget to return the actigraphy to their wrist after bathing or swimming, the vast majority provided complete data. Children reported showing off their 'wrist computer' to peers and none reported feeling stigmatized by wearing it. If an underlying physiologic concern is suspected to cause inadequate sleep, a sleep specialist should be consulted to determine if a sleep laboratory polysomnographic objective assessment is advisable, either immediately or subsequent to actigraphy evaluation. Future polysomnographic research with children is also needed to determine if/how daytime napping in school age children alters nighttime sleep architecture since little is known in this area.

Similar to others, we found racial differences between minority and Caucasian children in time of sleep onset and trends in total sleep duration as well as variability of sleep duration and sleep offset, all with minority children showing disadvantage. Goodwin and colleagues found that young Hispanic children napped more frequently than young Caucasian children; however by age 9–11 these differences were no longer true[33]. In addition, total night sleep time was less for these Hispanic children regardless of age which could suggest that daytime sleep was supplementing insufficient nighttime sleep. A recent report by Adam and colleagues found that Hispanic children also slept less on weekends[38]. Sleep duration was associated with the child's

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amount of television, computer and video game use, sports, and religious and social activities. Shorter nighttime sleep durations extending to the weekend continue any negative influences of inadequate weekday sleep, possibly contributing to academic disparities.

Evidence-based early interventions to improve children's sleep are needed. Child health practitioners report that they feel ill equipped for this type of life style counseling and they want more clinical research in the area[39]. Books are written to directly help parents of young children but less is available for the parents of school age children and the children themselves. The National Sleep Foundation web site provides brief materials to increase knowledge of the sleep needs of school age children however, improving family knowledge alone will probably be inadequate to generate and sustain the needed behavior change necessary for most youth. Cognitive behavioral approaches implemented by counselors or health practitioners using age appropriate motivational interviewing strategies with both parent and child might prove effective to resolve behavior related sleep problems before they become entrenched or resistant to brief interventions. Much more research is needed in the area to test effectiveness of theoretically sound strategies since evidence found in the current study continues to suggest American school age children are not getting adequate nighttime sleep.

Limitations

There are several limitations to this study. First, the age range of children was limited to 9–11 years so, findings are not necessarily applicable to older or younger children. We studied only non-chronically ill children and those with asthma and possible concurrent allergies therefore, the extent to which findings can be generalized to children having additional chronic illnesses is unknown. We were particularly interested in weekdays when the children's napping would be constrained by school starts and additional research protocols prohibited us from gathering data of the subsequent weekend nights' sleep. Thus we do not know the stability of the children's sleep patterns or the impact of the prior week's sleep on weekend night and daytime sleep. Wording of recruitment fliers may have attracted parents whose children indeed had more sleep issues than typical 9-to −11 year old children and unexamined variables including the child's prior night's sleep architecture, home sleeping environment, cultural practices, family race, ethnicity, education and socio-economic status should be investigated for their potential influence on napping. Lastly, the child's report of napping was self-report vs. actigraphy verified and without a day and time-stamp we are unable to verify that the children actually recorded twice a day to reduce recall problems. With improved digital diary equipment this limitation might be eliminated in future research.

In summary, we found napping to be a more common behavior in school age children then anticipated. Children with asthma and those of minority status were disproportionately represented in the napping group. Children self-reporting napping had evidence of later and more variable bedtimes, and they obtained less sleep than advisable for their age. Although napping may be a compensatory behavior for children with inadequate nighttime sleep, it is likely not available to the child when most needed; weekdays during the school year. Much more needs to be learned about sleep in school age children with and without chronic illnesses but, for now, the design and testing of effective strategies to reduce variability and increase duration of nighttime sleep in school age child who nap seems paramount.

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Table 1

Child and Parent Demographic Characteristics by Napping Status (N=54)

	Non-Nappers n=37		Nappers n=17		
	n	**(%)**	**n**	**(%)**	**P value**
Asthma					0.04*
Yes	15	(40.5)	12	(70.6)	
No	22	(59.5)	5	(29.4)	
Gender					0.06
Female	10	(27.0)	9	(52.9)	
Male	27	(73.0)	8	(47.1)	
Race					0.91
American Indian/Alaska Native	3	(8.1)	2	(11.8)	
Asian	4	(10.8)	1	(5.9)	
Native Hawaiian or other Pacific Islander	1	(2.7)	1	(5.9)	
Black or African American	7	(18.9)	4	(23.5)	
White	22	(59.5)	9	(52.9)	
Ethnicity					0.39
Hispanic or Latino	8	(21.6)	2	(11.8)	
Not Hispanic or Latino	29	(78.4)	15	(88.2)	
Age (yr)					0.66
9	13	(35.1)	8	(47.1)	
10	15	(40.5)	5	(29.4)	
11	9	(24.3)	4	(23.5)	
Tanner stage					0.55
1	14	(37.8)	5	(29.4)	
2	23	(62.2)	12	(70.6)	
Grade in school					0.68
3	5	(13.5)	4	(23.5)	
4	11	(29.7)	6	(35.3)	
5	14	(37.8)	4	(23.5)	
6	6	(16.2)	3	(17.6)	
Missing	1	(2.7)	0	(0)	
Female primary care provider education					0.49

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	Non-Nappers n=37		Nappers n=17		
	n	(%)	n	(%)	P value
High school diploma or GED	4	(10.8)	3	(17.6)	
Some college	9	(24.3)	7	(41.2)	
Bachelor's degree	11	(29.7)	4	(23.5)	
Master's degree	9	(24.3)	2	(11.8)	
Doctoral of professional degree	4	(10.8)	1	(5.9)	

*p<0.05.

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Table 2

Sleep Self Report Diary and Objective Actigraphy Measures of Nappers vs. Non-Nappers (N=54)

	Non-Nappers (n=37)		Nappers (n=17)		
	Mean	**(SD)**	**Mean**	**(SD)**	**P value**
Self-report variables					
Awakenings last night	0.70	(0.67)	0.78	(0.60)	0.68
Tired upon awakening	1.64	(0.66)	1.61	(0.65)	0.88
Sleepy upon awakening	1.68	(0.60)	1.65	(0.52)	0.85
Alert upon awakening	1.62	(0.78)	1.50	(0.75)	0.61
sleep quality	3.24	(0.53)	3.16	(0.63)	0.63
Actigraphy variables					
sleep onset	22.35	(0.83)	23.09	(1.33)	0.04*
sleep offset	7.36	(0.85)	7.52	(0.87)	0.52
total sleep, min	465.47	(41.22)	437.60	(54.42)	0.04*
sleep onset variability	0.64	(0.36)	1.08	(0.53)	<0.01*
sleep offset variability	0.71	(0.44)	0.76	(0.52)	0.67
total sleep variability, min	45.51	(24.72)	56.57	(30.01)	0.16

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Table 3

Sleep Self Report Diary and Objective Actigraphy Measures of Caucasian vs. Ethnic Minority Children (N=54)

	Caucasian (n=31)		Ethnic Minority (n=23)		
	Mean	**(SD)**	**Mean**	**(SD)**	**p**
Self-report variables					
Awakenings last night	0.74	(0.49)	0.69	(0.80)	0.79
Tired upon awakening	1.63	(0.64)	1.62	(0.67)	0.94
Sleepy upon awakening	1.68	(0.51)	1.65	(0.64)	0.85
Alert upon awakening	1.48	(0.75)	1.71	(0.77)	0.28
sleep quality	3.16	(0.51)	3.27	(0.62)	0.44
Actigraphy variables					
sleep onset	22.26	(0.84)	23.02	(1.19)	0.01*
sleep offset	7.31	(0.82)	7.55	(0.88)	0.31
total sleep, min.	467.26	(36.92)	442.47	(55.84)	0.06
sleep onset variability	0.71	(0.36)	0.87	(0.57)	0.24
sleep offset variability	0.62	(0.33)	0.86	(0.57)	0.08
total sleep variability, min	43.29	(23.11)	56.68	(29.73)	0.06

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