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Subjective and objective sleep and self-harm behaviors in young children: A general population study

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Abstract

Significant association between sleep disturbances and suicidal ideation and/or attempts is reported in adults and adolescents. However, there is paucity of studies exploring the association between sleep and self-harm behaviors (SHB) in young children and are limited to only subjective sleep measures. We examined the association between SHB and both subjective and objective sleep in a population-based sample of 5–12 yr. old. Parents of every student in 3 local school (K-5) districts (n=7,312) was sent a screening questionnaire. Randomly selected children from this sample underwent a comprehensive history, physical examination, a 9-hour overnight polysomnogram and completed several questionnaires. Among the final sample (n=693), 27 children had SHB with adjusted prevalence of 3%. There was no difference in age, gender, obesity, or socioeconomic status in subjects with or without SHB. Significantly more children with SHB had subjective sleep difficulty and depression. Difficulty maintaining sleep and frequent nightmares were associated with SHB independent of depression or demographics. Polysomnographic %REM-sleep was significantly higher in the SHB group after adjusting for demographics and depression. These data indicate that parent reported sleep disturbances are independently associated with SHB. It is possible that higher REM-sleep is a non-invasive biomarker for risk of self-harm behaviors in young children.

Keywords

Sleep; Self-harm behaviors; Suicide; REM sleep; Nightmares; Sleep disturbances; Polysomnogram; Depression

1. Introduction

Suicide is the tenth leading cause of death in the United States (Kochanek et al., 2011). According to the 2009 National vital statistics report, there were 36,547 deaths from suicide with a death rate of 11.9 for 100,000. The number of deaths from suicide in the 5–14 age

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group were 266 in the year 2009 in USA, with a suicide death rate of 0.7 for 100,000 (Kochanek et al., 2011). For every completed suicide, several non-lethal suicide attempts occur (Pfeffer, 1988; Maris, 2002). Suicidal thoughts and attempts in children, collectively can not only lead to mortality but also can cause significant morbidity as a result of non-lethal injury (Pfeffer, 1997; Doshi et al., 2005).

Several factors are known to increase the risk of suicidal ideation and/or attempts including sleep disturbances (Ialongo et al., 2004; Bernert and Joiner, 2007). Numerous studies in adults suggest strong association between sleep disturbances and suicidal ideation, suicidal attempts and completed suicide. (Fawcett et al., 1990; Turvey et al., 2002; Fujino et al., 2005; McCall et al., 2010; Bjørngaard et al., 2011). Similarly, several studies in adolescents found an association between suicide and sleep disturbances (Tishler et al., 1981; Choquet and Menke, 1989; Choquet and Kovess, 1993; Vignau et al., 1997; Roberts et al., 2001; Bailly et al., 2004; Liu et al., 2004; Barbe et al., 2005; Bernert and Joiner, 2007; Fitzgerald et al., 2011; Lee et al., 2012). However, most of these studies in children were in subjects aged 13 years or more except for the study by Roberts et al. (Roberts et al., 2001) and Barb et al. (Barb et al., 2005). Roberts et al. (Roberts et al., 2001) found that in children (age 10 to 17 yr.) insomnia or hypersomnia increased risk of suicidal ideation. Barbe et al. (Barbe et al., 2005) examined depressed children of 7 to 17 years of age and found that depressed suicidal children presented more frequently with insomnia. Both of these studies had a sample of children that were relatively younger; however, to our knowledge none have examined the association of sleep and self-harm behaviors in general population sample of children younger than 10 years old. Additionally, the sleep disturbances were assessed by only subjective report in these two studies with relatively younger children (Roberts et al., 2001; Barbe et al., 2005). However, the subjective report of sleep is limited in comparison to sleep assessment as done by a comprehensive polysomnogram. An objective polysomnogram provides data on physiological sleep measures such as rapid eye movement (REM) sleep and non-rapid eye movement sleep (NREM) along with objective measures of sleep latency, REM-latency, sleep efficiency, etc. Thus, it is important to assess both subjective and objective polysomnographic sleep in children with self-harm behaviors.

Sleep disturbances are common in children with a prevalence of 20–30% (Stores, 1996; Anders and Eiben, 1997; Liu et al., 2000; Owens et al., 2000; Sadeh et al., 2000; Singareddy et al., 2009). In this study we examined the relationship between subjective and objective polysomnographic sleep and self-harm behaviors in young children aged 5 to 12 years. We hypothesize that young children with self-harm behaviors will have increased subjective and objective sleep disturbances.

2. Methods

2.1. Subjects

Subjects for this study were participants in the Penn State Children's Cohort, a population-based study of sleep related breathing disorder. A detailed description of the study design and methods of data collection have been previously reported (Bixler et al., 2008; Bixler et al., 2009). The study was designed in two phases. In the first phase, general information from the parents about their child's sleep and behavioral patterns was collected using a screening questionnaire based on the survey published by Ali et al. (Ali et al., 1993) validated to identify children at high risk for sleep related breathing disorder. This questionnaire was sent home to parents of every elementary school student in 3 local school districts (*n* = 7,312) with a 78.5% response rate. In the second phase of this study, each year 200 children were selected from the questionnaires that were returned that year. The second phase of the study was completed in six years from year 2000 till 2006. Using a stratification of grade, sex, and risk for sleep related breathing disorder, we randomly selected children from each stratum to maintain representativeness of the original sample. Seven hundred children completed phase 2, for a response rate of 70%. We contrasted the subjects who completed the polysomnogram recording with those who completed the phase 1 questionnaire but were not selected for phase 2. There were no significant differences in age, gender, and race between the two groups. Six hundred and ninety three children who had complete data on sleep and self-harm behavior related questions were considered for this study. This study was approved by the Institutional Review Board at Penn State College of Medicine. Informed consent from parents of all participants and assent from all children was obtained prior to participation.

2.2. Key measurements

Detailed history was obtained from the parent who accompanied the child to the sleep laboratory including demographic information, medical history, psychiatric history, and medication history. Parents also completed several questionnaires pertaining to sleep and behavior including the Pediatric Behavioral Scale (Lindgren and Koeppl, 1987) and the Child Behavior Checklist (CBCL), a widely used tool for assessment of childhood behavioral abnormalities (Achenbach and Rescorla, 2001). Each child also underwent a comprehensive physical examination.

Questions about sleep and self-harm behaviors were completed by the parent of the child as a part of pediatric behavioral scale. The parent was asked to rate these questions on sleep and self-harm behaviors over the past 2 months, on a 4-point Likert scale from 0 to 3 with 0 “Almost never or not at all,” 1 “Sometimes or just a little,” 2 “Often or pretty much,” and 3 “Very often or very much.” The questions about self-harm behaviors included the following: (1) “talks about harming or killing self” and (2) “deliberately harms self or attempts suicide”. Subjective sleep disturbances were defined as parent report of “often or pretty much” or “very often or very much” on the following questions: (1) “has trouble falling asleep” as difficulty initiating sleep (DIS), (2) on either one or both probes “sleep is restless or disturbed; often tosses and turns in sleep” or “wakes up often in the night” as difficulty maintaining sleep (DMS), (3) “sleeps more than most other children” as excessive daytime sleepiness (EDS), and (4) on the probe “has nightmare or bad dreams” as frequent nightmares. Depressive symptoms were assessed using the subscale “withdrawn depressed” from the Child Behavioral Checklist (CBCL).

Obesity was defined as 95^{th} percentile of body mass index (BMI) adjusted for age and gender. Socioeconomic status (SES) was assessed based on the professional status of the parent (Gregory et al., 2009). Parent occupation was defined as professional if the parent had either a professional or managerial occupation and as non-professional if the parent was unemployed, disabled, retired, a student, or had a secretarial or non-managerial occupation. Children with at least one parent defined as professional were considered to be of relatively high SES; children with neither parent being defined as professional were considered to be of low SES.

All children underwent a 9-h PSG with a parent present in a sound-attenuated, light and temperature controlled room in our General Clinical Research Center. Children's bedtime and waketime were approximated to their typical sleep times. Each child was monitored with an infrared video and a computerized system (24 analog channel and 10 dc channel TS amplifier using Gamma software, Grass Telefactor, Inc.) including 4 channels of electroencephalogram (EEG), 2-channel bilateral electrooculogram (EOG), and chin and anterior tibial electromyogram (EMG). Respiration was assessed throughout the night by use of a thermocouple at nose and mouth (model TCT R, Grass Telefactor, Inc), nasal pressure transducer (MP 45–871 ± 2 cm H_2O, Validyne Engineering Cort), and piezoelectric thoracic and abdominal respiratory effort belts (model 1312, Sleepmate). A subjective estimate of snoring was obtained from parental report. In addition, we obtained an objective estimate of snoring during the PSG by monitoring breathing sounds with a microphone attached to the throat (model 1250, Sleepmate Technologies), as well as a separate room microphone. All-night hemoglobin oxygen saturation was obtained by pulse oximeter (model 8800, Nonin Medical) attached to the finger. A single-channel electrocardiogram (ECG) was also recorded. All PSG records were scored in accordance with The American Thoracic Society standards for cardiopulmonary sleep studies in children (American Thoracic Society., 1996). Apneas and hypopneas were scored by 2 different trained scorers, and discrepancies were resolved by the senior author (EOB). Obstructive apnea was defined as a cessation of airflow ≥ 5 sec and an out-of-phase strain gauge movement. A hypopneic event was defined as a reduction of airflow of approximately 50% with an associated decrease in oxygen saturation (SpO2) ≥ 3% or an associated breathing related arousal. Based on these data an apnea/hypopnea index (AHI) was calculated [(apneas + hypopneas)/hours of sleep). Central apneas were not included in the AHI calculation.

2.4. Statistical analysis

The children were divided into two groups [SHB (self-harm behavior) group and No-SHB group] based on the response of parents on self-harm behaviors related questions. Children who were rated by the parent as “Almost never or not at all” on both probes were included in the “No-SHB” group and the children who were rated as “Sometimes or just a little”, “Often or pretty much” or “Very often or very much” on either one or both self-harm behaviors related probes were included in the “SHB” group.

All statistical analyses were performed with SPSS software for Windows (version 17.0; SPSS, Chicago, IL). Data are reported as mean ± SD or proportions (percentages). The groups with versus without SHB were compared by χ^2 or analysis of variance (ANOVA) for significant differences in demographic and clinical features. To test the hypothesis that subjective sleep disturbances are associated with SHB we used multivariable logistic regression analysis with corresponding odds ratios and 95% confidence intervals (CIs) for the relative association between the presence of sleep disturbances and SHB. To control other factors likely to affect sleep and/or self-harm behaviors, we used four different models (table 3). In each of these models we included depression and one of the demographic variables (age, gender, obesity, or SES) in addition to the sleep disturbance. We used this method in order to protect the stability of the model, as the number of subjects with self-harm behaviors was relatively small (n=27). In order to test the hypothesis that young children with SHB versus without SHB will have more objective sleep disturbances, a one-way between groups multivariate analysis of covariance (MANCOVA) was performed to investigate group differences in mean polysomnographic measures. $P < 0.05$ was used as the criterion for statistical significance.

We accounted for the sampling probability from phase 1 to phase 2 enrollments in all of the analyses to generate population level estimates and to make inference back to population from which the phase 2 study participants were selected.

3. Results

Among the final sample of 693 children, 27 had self-harm behaviors (SHB) and 666 children did not have self-harm behaviors (No-SHB). The adjusted prevalence of self-harm behaviors in this general population sample was 3%. Children in the two groups (SHB vs. No-SHB) did not differ in age, gender, obesity, or socioeconomic status (table 1). Children with self-harm behaviors had significantly higher T scores on depression ($P<0.001$)(table 1).

Subjective sleep disturbances in children with or without self-harm behaviors are presented in table 2. Significantly more children with self-harm behaviors had difficulty initiating sleep ($P<0.001$), difficulty maintaining sleep ($P<0.001$), excessive daytime sleepiness ($P<0.001$), and frequent nightmares ($P<0.001$). Multivariable logistic regression model showed that difficulty maintaining sleep and frequent nightmares were associated with self-harm behaviors even after controlling for depression (see table 3). The association between difficulty maintaining sleep and frequent nightmares with self-harm behaviors remained strong and significant even after further controlling for age, gender, obesity or socioeconomic status. Difficulty initiating sleep and excessive daytime sleepiness were not significantly associated with SHB after adjusting for depression and any of the above mentioned demographic factors.

Adjusted polysomnographic measures in subjects with and without self-harm behaviors are presented in table 4. Percent of REM sleep was significantly higher in those with SHB ($P=0.045$), even after adjusting for age, gender, obesity, socioeconomic status, and depression. Surprisingly, there was a trend towards increase of total sleep time in children with self-harm behaviors. Sleep latency, REM latency, and other polysomnographic measures including apnea hypopnea index were not significantly different between the groups.

4. Discussion

To our knowledge this is the first study examining the association between subjective and objective polysomnographic sleep and self-harm behaviors in a general population sample of young children aged 5–12 years. Our results indicate that subjective sleep disturbances are independently associated with increased rates of self-harm behaviors in young children. Additionally, children with self-harm behaviors had significantly increased percentage of REM sleep and a non-significant increase in total sleep time.

The difficulty maintaining sleep and nightmares were independently associated with increased self-harm behaviors even after accounting for demographic factors and depression. Our findings are consistent with previous reports of significant association between insomnia symptoms and suicidal ideation (Roberts et al., 2001; Barbe et al., 2005; Bernert and Joiner, 2007) in older children. Additionally, none of the previous studies in young children have included objective polysomnographic measures. Few previous small sample studies in clinical samples, limited to adults or adolescents reported longer sleep latency, lower sleep efficiency, shorter REM latency, and higher REM percentage (Sabo et al., 1991; Keshavan et al., 1994; Agaragun and Cartwright, 2003). In our large general population sample of young children we found that children with self-harm behaviors had significantly increased REM sleep percentage. Consistent with our findings, others have shown that among adults with depression and schizophrenia, patients with suicidal ideation and/or attempts had increased REM sleep time compared to those without suicidal behavior (Sabo et al., 1991; Keshavan et al., 1994; Lewis et al., 1996). These data indicate that the association between increase in REM sleep time and self-harm behaviors is independent of the diagnosis. A possible link between increased REM sleep and self harm behavior could be serotonergic system. It is well documented that both suicide attempters and completers have reduced serotonergic activity (Ninan et al., 1984; Roy et al., 1989; Cooper et al., 1992; Asberg, 1997). Additionally, both basic and clinical research indicates that serotonin suppresses REM sleep (Kleinlogel and Burki, 1987; Lydic et al., 1987; Pastel and Fernstrom, 1987; Houdouin et al., 1991; Lawlor et al., 1991), suggesting that reduced serotonergic function in subjects with self-harm behaviors patients as a probable cause for increased REM sleep (Keshavan et al., 1994; Lewis et al., 1996). Thus, it is possible that higher REM sleep may be a non-invasive biomarker for increased risk of self-harm behaviors in young children and may play an important role for future self-harm behavior and suicide related research.

Interestingly, we found non-significant increase in objective total sleep time in children with self-harm behaviors. This is similar in direction to previous studies in adolescents and adults where increased subjective report of total sleep time was found to be associated with increased risk of suicidality (Bernart and Joiner, 2007; Fitzgerald et al., 2011). Although subjective report of difficulty maintaining sleep was independently associated with increased self-harm behaviors, there was no difference in polysomnographic wake after sleep onset (WASO) in subjects with versus without self-harm behaviors. Additionally, we did not find any association between the presence of sleep disordered breathing and self-harm behaviors in young children.

Notable strengths of this study include a large community sample of young children and use of both subjective report of sleep disturbances as well as objective measure of sleep. There are several limitations that should be considered in interpreting the results of this study. Although, a growing body of evidence reveals that young children can think about suicide, make suicidal attempts and commit suicide (Tishler, 1980; Matter and Matter, 1984; Brent et al., 1986; Pfeffer, 2000; Trad, 2000; Pompili et al., 2005; Kloos et al., 2007), the use of term "suicide" in young children is debated in the literature with a concern if young children would be able to understand the concept of suicide. In clinical and research settings, suicide risk in young children is typically assessed by asking for thoughts of harming themselves or suicide (Tishler et al., 2007; Ambrosini, 2009). The questions pertaining to self-harm behaviors as a part of this study were similarly framed. Considering the possibility of limitation in comprehending the consequences and the concept of suicide in children, we used the term self-harm behaviors instead of suicidal ideation/attempts. The information was provided by the parent for this study, which could be considered a limitation, however, in current clinical practice, information obtained from a parent plays a critical and an essential role in diagnosis of childhood behavioral and psychiatric disorders including in the assessment of self-harm behaviors. Although the total sample size was large (n=693), the group with self-harm behaviors (n=27) was relatively small. It is possible that small "n" in the suicide group could underpower the study, however, this prevalence rate is similar to previous reports (Pfeffer et al., 1984; Gould et al., 1998) and we have accordingly designed our analyses to maintain the stability of statistical models (see statistical analysis section). Lastly, the subjects had only one night of polysomnogram, thus the "first night effect" of sleeping in a foreign environment needs to be considered. It is also possible that subjects with self-harm behaviors are more likely to have such first-night effects. However, in large epidemiological studies [Sleep Heart Health Study (Silva et al., 2007), CARDIA study (Lauderdale et al., 2006), Penn State Cohort (Bixler et al., 2002)] the duration of objective total sleep time was similar, independent of whether sleep was recorded in-home versus in-laboratory. The consistency among these three large epidemiological studies in terms of objective sleep duration supports the validity of using one night polysomnogram.

In conclusion, these data indicate significant independent association between sleep disturbances and self-harm behaviors in young children and the possibility that increased REM sleep may be a biomarker for increased risk of self-harm behaviors. Prospective studies exploring this association may help further clarify the relationship between sleep and self-harm behaviors. In addition, future studies are needed to explore the possible pathophysiological mechanisms of such comorbidity between sleep and self-harm.

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Table 1

Characteristics of study sample

	SHB (n=27)	No-SHB (n=666)	*P*
Females, %	54.2%	52%	0.82
Age	8.82 (1.9)	8.77 (1.7)	0.91
*SES, %	38.9%	45.5%	0.59
Obesity, %	25.3%	14.1%	0.16
Dep (T scores)	59.45 (7.9)	53.76 (5.8)	<.001

SHB=self-harm behaviors; SES= socio economic status

Dep = depression T scores. All data are adjusted for sampling weight.

*we had data on only 518 subjects on SES.

Table 2

Subjective sleep characteristics of study sample

	SHB (n = 27)	No-SHB (n = 666)	P
Subjective sleep			
DIS	42.2%	13.3%	<.001
DMS	68.5%	21.3%	<.001
EDS	11.8%	2.4%	.010
Nightmares	26.3%	5.5%	<.001
Any sleep comp.	83.1%	27.1%	<.001

SHB= self-harm behaviors; DIS = difficulty initiating sleep. DMS = difficulty maintaining sleep. EDS= excessive daytime sleepiness. Any sleep comp.= presence of any of the sleep complaints (DIS, DMS, EDS or frequent nightmares). All data are adjusted for sampling weight.

Table 3

Multivariable logistic regression models to examine the association between subjective sleep disturbances with self-harm behaviors.

	Model 1		**Model 2**		**Model 3**		**Model 4**	
	P	OR	P	OR	P	OR	P	OR
DIS	0.07	2.79	0.08	2.75	0.06	2.84	0.12	2.50
DMS	0.01	6.92*	0.001	7.40*	<.001	7.59*	0.001	7.01*
EDS	0.20	3.20	0.25	2.88	0.26	2.73	0.43	2.25
Nightmares	0.004	5.58*	0.003	5.95*	0.003	6.04*	0.012	4.90*

All data are adjusted for sampling weight. DIS=difficulty initiating sleep, DMS=difficulty maintaining sleep, EDS=excessive daytime sleepiness; Model 1: DIS, DMS, EDS, or nightmares adjusted for age and depression; Model 2: DIS, DMS, EDS, or nightmares adjusted for gender and depression; Model 3: DIS, DMS, EDS, or nightmares adjusted for obesity and depression; Model 4: DIS, DMS, EDS, or nightmares adjusted for socioeconomic status and depression.

Table 4

Objective sleep characteristics in subjects with and without self-harm behaviors (SHB) adjusted for age, gender, obesity, socioeconomic status and depression.

	SHB (n = 27)	No-SHB (n = 666)	P
Objective sleep			
Sleep latency	24.79 (29.4)	28.84 (24.3)	0.535
REM latency	147.31(70.4)	157.51 (85.3)	0.590
Total Sleep Time	478.61 (57.5)	455.64 (47.5)	0.072
Sleep Efficiency	89.13 (10.0)	85.56 (8.2)	0.106
% Stage 1	2.04 (4.2)	3.62 (3.4)	0.088
% Stage 2	46.48 (13.5)	46.00 (11.2)	0.871
% SWS	28.54 (13.0)	30.50 (10.7)	0.496
% REM	22.95 (6.7)	19.99 (5.5)	0.045*
WASO	33.77 (40.9)	48.07 (33.7)	0.115
AHI	0.85 (2.1)	0.80 (1.7)	0.905

All data are adjusted for age, gender, obesity, socioeconomic status, depression, and sampling weight. The standard deviation is presented in parenthesis (SD). AHI=apnea hypopnea index.