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Reduced sleep quality in healthy girls at risk for depression

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SUMMARY

Depression is characterized by sleep difficulties, but the extent to which subjective and objective sleep disturbances precede depression are unclear. This study was designed to examine perceptions of sleep quality in addition to actigraphy- and diary-measured sleep variables in healthy girls at low and high familial risk for major depressive disorder. Forty-four healthy daughters and their mothers completed a week of daily sleep diary and actigraphy; 24 girls had mothers with no history of psychopathology (low risk, mean age 14.92 years), and 20 girls had mothers with recurrent depression during the daughter's lifetime (high risk, mean age 14.12 years). All daughters had no current or past psychopathology. High-risk girls reported significantly poorer subjective sleep quality than did low-risk girls ($P = 0.001$). The two groups of participants did not differ in actigraphy- or diary-measured sleep duration, onset latency or snooze duration. Healthy girls at high familial risk for depression report poorer sleep quality than do girls at low risk for depression, despite the absence of group differences in objective sleep disturbances as measured by actigraphy or daily diary. This pattern of findings may reflect a broader cognitive or physiological phenotype of risk for depression.

Keywords

actigraphy; adolescent; depression; risk; sleep

INTRODUCTION

Sleep disturbances have been associated consistently with major depressive disorder (MDD). Electroencephalographic (EEG) assessments have revealed a range of sleep anomalies in individuals with MDD, including decreased time from sleep onset to the first rapid eye movement (REM) period, increased REM density, decreased slow-wave sleep, fragmented sleep, and altered timing of various stages of sleep (Riemann *et al.*, 2001; Tsuno *et al.*, 2005). One of the strongest risk factors for developing MDD is a family history of depression, and EEG anomalies during sleep, such as reduced REM latency occurring in familial patterns, are associated with risk for developing depression (Giles *et al.*, 1998), and predict subsequent depression in high-risk individuals (Rao *et al.*, 2009).

While reports of disturbed sleep are a common symptom of MDD, it is not clear that these complaints are based on actual sleep difficulties. For example, although depressed children and adolescents report more sleep disturbances than do their non-depressed peers, these reports are not always accompanied by EEG-measured anomalies during sleep (Bertocci, 2005). Similarly, sleep disturbances such as insomnia have been reported in the absence of distinguishing EEG characteristics (Rosa and Bonnet, 2000); indeed, a diagnosis of

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insomnia is dependent on self-reported sleep difficulties and daytime impairment rather than on a particular finding from polysomnography.

One possible explanation for this discrepancy involves biases in individuals' reports of their sleep quality. Individuals at high risk for depression have been found to have negative biases in processing information (Joormann *et al.*, 2008). These biases may influence the perception of sleep in high-risk individuals even in the absence of gross sleep disturbances. Thus, depressed individuals or individuals at high risk for depression may be biased towards reporting poor sleep quality despite having objectively undisturbed sleep.

In the present study, we examined perceptions of sleep quality as well as diary measures and quantitative actigraphy of sleep and sleep disturbance in a sample of young girls at high familial risk for MDD by virtue of having mothers diagnosed with recurrent depression (high risk), and a matched sample of girls whose mothers have no history of psychopathology (low risk). None of the girls had past or current psychopathology. We specifically targeted mothers because of evidence documenting the greater impact of maternal than paternal depression on cognitive and behavioral functioning (Goodman & Tully, 2008), as well as on patterns of sleep (Armitage *et al.*, 2009). We assessed daughters because depression is more prevalent and more severe, with an earlier age of onset, in females than in males (Lewinsohn *et al.*, 2000; Nolen-Hoeksema & Hilt, 2009). We hypothesized that, compared with low-risk girls, high-risk girls would have more negative perceptions of their sleep, indexed by reports of poorer sleep quality and lower morning refreshment, greater difficulty initiating sleep, and waking earlier than desired. We also predicted that, in both actigraphy and daily dairies, high-risk girls would have more sleep disturbances than low-risk girls, including longer sleep onset latency, more awakenings, more wake after sleep onset (WASO), and more snooze time.

MATERIALS AND METHODS

Participants

Forty-four mothers and their biological daughters, ages 10–16 years, were recruited from the community via online advertisements, radio ads, posters and fliers posted around the Bay Area. Participants were able to contact the study either via phone or email. Girls were classified as low risk or high risk based on their mothers' history of MDD. Whereas low-risk girls had mothers with no history of any Axis-I psychopathology, including MDD, high-risk girls had mothers with at least two past episodes of MDD within their daughters' lifetime. The mothers of high-risk and low-risk daughters were matched on demographic variables. Both the low-risk and high-risk daughters were carefully screened to exclude any past or present Axis-I disorder. Mothers were interviewed with the Structured Clinical Interview for Diagnosis of DSM-IV (First *et al.*, 1997), and daughters were interviewed using the Schedule for Affective Disorders and Schizophrenia for School-Age Children, Present and Lifetime version (Kaufman *et al.*, 1997). All research was conducted in accordance with HIPAA and the Stanford University Institutional Review Board.

Daily diary

Girls were asked to complete a sleep diary each day immediately upon waking for 1 week. They responded to questions about specific aspects of their last night's sleep, including awakening time, bedtime, sleep onset latency, number of awakenings, WASO and snooze duration. They also responded to questions assessing their perceptions of the quality of their sleep, including sleep onset difficulty ('how difficult was it to fall asleep?'), sleep quality ('how well did you sleep last night?'), morning refreshment ('how rested did you feel when you woke up?') and early/late waking. These latter questions were answered on five-point

Likert scales, ranging from 'not at all' to 'somewhat' to 'very'. For example, sleep quality was rated from 'not well at all' to 'somewhat well' to 'very well', and early/late waking was rated from 'much too early' to 'right on time' to 'much too late'. Both immediately upon waking and at bedtime, girls also rated their current mood, making ratings of happiness, sadness, calm, anxiety, boredom and excitement on five-point Likert scales ranging from 'not at all' to 'somewhat' to 'very'. At the end of the week, participants completed the short form of the Children's Depression Inventory (CDI-S; Kovacs, 1985).

Actigraphy

Participants wore an Actiwatch 2 device (Philips Respironics – Bend, OR, USA) set to record movement epochs of 30 s on their non-dominant wrist for the entire week. Actigraphy data were analysed using Actiware 5 (Philips Respironics). Major rest periods were automatically generated using a medium wake threshold. Sleep immobility thresholds were set for 10 min at onset and 10 min at end; sleep timing, duration, number of awakenings, sleep onset latency, WASO, sleep efficiency, sleep activity counts and snooze duration were extracted for each individual across the week. The algorithms used to calculate wake, as well as the selection of the appropriate threshold for scoring wakefulness from actigraphy, have been discussed previously (Kushida *et al.*, 2001). All data were imported into SPSS 16 for statistical analysis; all *t*-tests conducted were two-tailed.

RESULTS

Demographic and clinical characteristics of the participants

Demographic and clinical characteristics of the low- and high-risk girls are presented in Table 1. The two groups of participants did not differ significantly in girls' age, mothers' age or CDI-S score (all $P > 0.05$). Moreover, the mean CDI-S score for both groups was well below the cutoff score for probable depression (Kovacs, 1985). Three individuals, all low risk, were found to have CDI-S scores above the cutoff; excluding these individuals from the analyses did not alter the reported findings.

Subjective reports of sleep quality

We examined group differences in subjective reports of sleep quality using ratings from the sleep diary (Fig. 1). A one-way (by risk group) multivariate analysis of variance (MANOVA) conducted on the subjective reports of sleep quality (sleep onset difficulty, sleep quality, morning refreshment and early/late waking) yielded a significant effect for risk group ($F_{4,39} = 3.50$, $P = 0.016$). Follow-up tests indicated that the high-risk girls reported significantly poorer sleep quality than did the low-risk girls ($t_{42} = 3.47$, $P = 0.001$, Cohen's $d = 1.04$); the two risk groups did not differ in reports of sleep onset difficulty ($t_{42} = 1.42$), morning refreshment ($t_{42} = 1.30$) or early/late waking ($t_{42} = 1.23$, all $P > 0.05$).

Actigraphy- and diary-measured sleep

To examine whether the group difference in subjective reports of sleep quality reflected group differences in specific actigraphy-measured or diary-measured sleep variables, we compared scores of the low- and high-risk girls on these variables (Table 1). A two-way (group: low risk versus high risk; repeated over measurement: actigraphy versus diary) MANOVA conducted on these five variables yielded a significant main effect of measurement ($F_{5,38} = 145.22$, $P < 0.001$). The main effect of group was not significant ($F_{5,38} = 1.16$), nor was the interaction of group and measurement ($F_{5,38} = 0.386$, $P > 0.05$). Follow-up *t*-tests yielded significant differences between diary and actigraphy measurements of awakenings ($t_{43} = 26.5$, $P < 0.001$) and WASO ($t_{43} = 9.71$, $P < 0.001$), but not of duration ($t_{43} = 1.71$), sleep onset latency ($t_{43} = 0.46$) or snooze duration ($t_{43} = 0.623$, all $P > 0.05$).

Mood

We examined the possibility that group differences in sleep quality were related to group differences in morning and evening mood. We conducted a two-way (group: low risk versus high risk; repeated over measurement: morning versus evening) MANOVA on the low-risk and high-risk girls' ratings of happiness, sadness, calm, anxiety, boredom and excitement. This analysis yielded a significant main effect of morning versus evening measurement ($F_{6,34} = 11.317$, $P < 0.001$), but no significant effect of risk group ($F_{6,34} = 0.952$, $P > 0.05$), or interaction of risk group and time of measurement ($F_{6,34} = 0.597$, $P > 0.05$). Thus, low- and high-risk girls did not differ in their morning or evening ratings of mood.

DISCUSSION

Individuals at high familial risk for depression are characterized by many of the affective, cognitive and biological anomalies that have been associated with MDD, even before the first onset of the disorder (Joormann *et al.*, 2008). In the present study, we found that high-risk girls with no present or past psychopathology reported poorer sleep quality than did low-risk girls. Despite these subjective reports, however, high-risk girls did not differ from their low-risk counterparts in actigraphy- or diary-measured sleep duration, sleep onset latency, WASO, awakenings or snooze duration, or in morning or evening ratings of their mood. Importantly, this pattern of findings in non-depressed girls at elevated risk for MDD mirrors previous work documenting complaints of poorer sleep quality in the absence of objective sleep disturbances in currently depressed adolescents (Bertocci, 2005). Thus, subjective sleep disturbances, even in the absence of objective sleep disturbances, may be a marker of risk for major depression.

Several factors could account for this pattern of results. First, consistent with their reports of poor quality sleep, the high-risk girls in this study may be experiencing sleep disturbances that are not captured by actigraphy. This possibility is consistent with previous research that has documented trait-like, depressotypic characteristics of EEG-measured sleep in healthy individuals at high risk for psychiatric disorder, including decreased REM latency (Rao *et al.*, 2009) and increased REM density (Friess *et al.*, 2008). Studies of currently depressed individuals have documented anomalies in several facets of EEG activity and architecture (Armitage, 1995). It is possible, therefore, that changes in sleep architecture begin early in development (Armitage *et al.*, 2009) and persist as a marker of elevated risk for psychopathology, manifesting as reduced sleep quality. The use of polysomnography in this high-risk group is needed to determine whether self-reported difficulties in sleep quality are related to EEG-measured sleep characteristics, such as decreased REM latency (Rao *et al.*, 2009) or reduced slow-wave sleep, that have been found in other high-risk populations.

Another explanation for these findings involves the influence of negative cognitive biases on perceptions of sleep in individuals at high risk for depression. Individuals with sleep problems may show cognitive biases toward insomnia- and anxiety-consistent interpretations of ambiguous information (Ree *et al.*, 2006). Depressotypic cognitive biases may lead high-risk girls to perceive and/or recall the quality of their sleep as being more negative than is objectively warranted. Importantly, reduced sleep quality in the high-risk girls was not due to a negative mood induction procedure; indeed, low- and high-risk girls did not differ in their levels of morning or evening mood. Thus, negative mood does not appear to be necessary to identify reports of poor sleep quality. Future studies should assess specific biases in affect and time estimation to examine the possible effect of such biases in high-risk populations on subjective reports of sleep quality.

The data obtained in this study did not support our predictions that individuals at risk for depression would exhibit longer sleep onset latency and more, and longer, awakenings than

would low-risk individuals. Although diary-reported measures of sleep are inherently subjective, the measurement differences found between diary-reported and actigraphy-measured sleep were driven by differences in number of awakenings and WASO; while actigraphy measures include small awakenings in computing the total for awakenings and WASO, participants only reported larger awakenings that occurred on average less than once per night. Actigraphy has utility as a diagnostic and research tool for circadian and sleep disorders (Ancoli-Israel *et al.*, 2003), but it is unclear if it is equally useful for detecting changes in sleep architecture in individuals with depression or at risk for this disorder. If reports of poor sleep quality precede objective sleep disturbances, it is possible that these disruptions would be evident using actigraphy in an older sample of individuals at risk for MDD. Future research should examine this possibility more explicitly.

Sleep disturbances are common in depression; if they precede the onset of this disorder, they may be a biological marker of elevated risk for MDD. Anomalies in EEG sleep characteristics in depressed adolescents have been found to persist even after remission (Rao & Poland, 2008), suggesting that they are a stable physiological marker of MDD. On the other hand, complaints of sleep difficulties in the absence of significant disturbances in EEG-measured sleep are central features of sleep disorders such as insomnia (Rosa & Bonnet, 2000). Perceptions of sleep quality, particularly in depressed individuals, may not accurately reflect disturbances in sleep architecture (Armitage *et al.*, 1997). Sleep complaints may be independent of, but complementary to, EEG sleep characteristics as an endophenotype that characterizes high-risk individuals prior to the onset of MDD. Understanding the mechanisms that underlie sleep complaints may lead to improved identification of premorbid symptoms in high-risk populations, as well as to the development of novel diagnostic and therapeutic procedures for depression.

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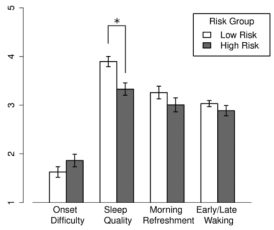

Figure 1.
Subjective indices of sleep quality reported by low-risk and high-risk girls. ‘Subjective Rating’scale is 1 (‘not at all’); 3 (‘somewhat’); 5 (‘very’). *$P < 0.001$.

Table 1

Demographic, clinical and sleep characteristics of the participants

	Low risk mean (SD) n=24	High risk mean (SD) n=20	P	d
Child age (in years)	14.92 (2.15)	14.12 (2.20)	> 0.05	0.37
Mother age (in years)	48.69 (4.08)	47.7 (7.13)	> 0.05	0.15
CDI-S score	1.95 (3.66)	2.05 (2.12)	> 0.05	0.03
Actigraphy sleep duration (min)	488.24 (54.78)	479.87 (30.41)	> 0.05	0.19
Diary sleep duration (min)	502.10 (70.28)	485.42 (44.85)	> 0.05	0.28
Actigraphy sleep-onset latency (min)	15.27 (9.61)	14.31 (7.16)	> 0.05	0.11
Diary sleep-onset latency (min)	15.11 (9.94)	16.38 (11.77)	> 0.05	0.12
Actigraphy WASO (min)	47.98 (15.25)	42.86 (24.24)	> 0.05	0.26
Diary WASO (min)	8.29 (22.61)	9.18 (11.23)	> 0.05	0.05
Actigraphy awakenings	35.87 (9.91)	33.66 (6.52)	> 0.05	0.26
Diary awakenings	0.41 (0.48)	0.64 (0.53)	> 0.05	0.45
Actigraphy snooze duration (min)	12.83 (6.97)	18.03 (14.32)	> 0.05	0.58
Diary snooze duration (min)	11.46 (6.88)	16.76 (14.18)	> 0.05	0.60

CDI-S, Children's Depression Inventory – Short Form; WASO, wake after sleep onset. *P*-values and effect sizes (Cohen's *d*) are presented for group differences.