Published in final edited form as:
J Am Acad Child Adolesc Psychiatry. 2008 February ; 47(2): 148–155. doi:10.1097/chi.0b013e31815cd9bc.

Objective Sleep in Pediatric Anxiety Disorders and Major Depressive Disorder

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Abstract

Objective—To examine objective and subjective sleep problems in early-onset anxiety and depression.

Method—Children and adolescents (46% female, ages 7 to 17 years) with anxiety disorders (n = 24), major depressive disorder (MDD) without comorbid anxiety disorders (n = 128), or no history of psychiatric disorder (n = 101) spent two consecutive nights in a sleep laboratory and completed self-reports of sleep quality.

Results—On objective measures, the anxiety group exhibited more awakenings than the MDD group, less slow-wave sleep than the control or MDD group, and greater night 2 sleep latency than the MDD or control group. The anxiety group exhibited no decrease in rapid eye movement latency from the first night to the second. The MDD group exhibited less time awake than the control group and less stage 1 sleep than the anxiety or control group. On subjective measures, young people with anxiety reported greater sleep latency on the second night and no decrease in sleep latency. Age was covaried in analyses.

Conclusions—Findings provide objective and subjective evidence of sleep disturbance in children and adolescents with anxiety disorders and replicate findings of limited objective sleep disturbance in those with MDD. Sleep problems are an important consideration when treating young people with anxiety.

Keywords

anxiety; depression; objective sleep; sleep problems; early onset

Sleep problems and affective disorders are common and often co-occurring difficulties experienced by children and adolescents.[1–3] The co-occurrence of sleep problems with affective disorders is worthy of attention because the combination of difficulties can result in a more pernicious course and greater impairment of functioning than these problems in isolation.[4] In addition, the relation between sleep problems and affective functioning in young people appears to be bidirectional.[5] For instance, depressive symptoms predict insomnia in adolescents,[6] and sleep problems predict later anxiety and depression.[7]

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Disclosure: Dr. Birmaher has participated in forums sponsored by Solvay Pharmaceuticals and Abcomm and has also presented on bipolar disorders in children at a meeting sponsored by Solvay. The payment for this conference was given to the WPIC Residency Training Program. He also has received royalties for publications from Random House. The other authors report no conflicts of interest.

Sleep problems and anxiety disorders have been linked at many points in the life span.[8] However, investigations of sleep problems in children and adolescents with a specific focus on anxiety have generally been conducted only at the level of subjective reports. For instance, a recent study with clinician and parent reports indicated that most young people with anxiety disorders experience at least three sleep-related problems.[9] Furthermore, studies have typically included population-based samples with a range of anxiety symptoms rather than clinically diagnosed samples with anxiety disorders.[10] The present study, a large, controlled study using polysomnographically measured sleep in children and adolescents with anxiety disorders, addresses this gap in the literature.

Major depressive disorder (MDD) is also prevalent in young people[2] and is linked strongly to sleep problems across the life span. Several studies have reported a relation between MDD and disturbance in subjective sleep in children and adolescents,[11,12] but findings on objective sleep problems in young people with depression have been mixed. Although some studies have reported poor sleep quality in young people with depression,[13] several have not.[14–16] A recent study by our research group reported subjective sleep complaints in youth with depression but did not detect objective evidence of disturbed sleep.[11] These findings suggest that young people with depression may exhibit objective sleep quality similar to that of those without psychiatric disorders but may perceive their sleep as disturbed. Until now, we were not able to address whether young people with anxiety disorders show a similar pattern of objective or subjective sleep problems.

The relative dearth of studies using polysomnographic measures is particularly salient given that studies have highlighted discrepancies between subjective and objective sleep measures. Reasons for these discrepancies could include the following: each set of measures quantifies somewhat different aspects of sleep and may therefore capture different dimensions of sleep problems, reports of subjective sleep problems may simply reflect distorted perceptions of sleep, or objective measures may be insensitive to subtle but real changes in sleep quality that contribute to subjective disturbances. Given these discrepancies and evidence that depressed children primarily revealed subjective sleep problems, our previous findings raised questions about both subjective and objective sleep in children with anxiety, of which there has been little in the way of controlled sleep studies.

In addition to contributing to knowledge of the patho-physiology of these disorders, examining sleep disturbances in both depression and anxiety furthers understanding of how these two types of affective disorders may manifest differently during childhood and adolescence. Depression and anxiety frequently co-occur in children and adolescents,[17] but they may be related to sleep problems in different ways. One prospective longitudinal study reported that sleep problems predict later anxiety but not later depression.[18] The etiology of sleep problems in the two types of disorders may also differ. For example, shared environment may be particularly important to the association between sleep problems and anxiety,[19] whereas shared genes may be more important to the association between sleep problems and depression.[20] A more thorough understanding of sleep disturbances in these disorders will also provide a foundation for developing appropriate treatments for sleep problems in the two types of disorders.

Using both subjective and objective measures, this study examined a range of sleep characteristics in children and adolescents with anxiety, MDD, both disorders, or no history of psychiatric disorder. Data from some MDD participants were included in our earlier report on sleep.[11] Given the mixed and limited evidence concerning the associations between sleep and internalizing disorders, we set out to address three main research questions: Is anxiety associated with sleep problems? Is MDD associated with sleep problems? Do data obtained from subjective and objective measures of sleep problems provide different answers to these

questions? We tentatively hypothesized that whereas anxiety disorders and symptoms would be associated with both objective and subjective sleep problems, MDD and depressive symptoms would be associated with subjective sleep problems only.

METHOD

Participants

Participants were children and adolescents in a multidisciplinary study of neurobehavioral characteristics of pediatric affective disorders. Of all of the participants, 128 had MDD without comorbid anxiety disorders, 24 had anxiety disorders (14 with and 10 without comorbid MDD), and 101 were healthy (control) participants with no history of a psychiatric disorder. Discrepancies in group sizes occurred because the larger longitudinal study from which participants were drawn has only recently begun to expressly include participants with anxiety disorders. Participants in the depression and anxiety groups were recruited from the Child and Adolescent Depression Program at Western Psychiatric Institute and Clinic in Pittsburgh and from radio and newspaper advertisements. Participants in the control group were recruited from advertisements. The demographic characteristics of the sample are presented in Table 1. Control participants were younger than those in the MDD or anxiety groups ($F_{2,247} = 7.63$, $p < .005$; Scheffé $p < .005$ and $p < .05$, respectively), less likely to be adolescents (Pearson $\chi^2 = 10.64$, $p < .01$; post hoc $\chi^2 = 6.04$, $p < .05$ and $\chi^2 = 9.20$, $p < .005$, respectively), and had higher socioeconomic status than those in the MDD group ($F_{2,230} = 14.50$, $p < .001$; Scheffé $p < .001$).

Diagnoses were determined through administration of the Schedule for Affective Disorders and Schizophrenia for School-Age Children-Present and Lifetime Version.[21] Each participant and a parent (or guardian) were interviewed separately by a bachelor's degree–level research specialist trained according to local diagnostic reliability standards. Reliability for depressive and anxiety diagnoses was >90% and was maintained through monthly department-wide diagnostic reviews. A child and adolescent psychiatrist provided best-estimate diagnoses. Participants in the MDD and anxiety groups were in a current episode. Diagnoses in the anxiety group were generalized anxiety disorder ($n = 19$), overanxious disorder ($n = 20$), panic disorder ($n = 6$), separation anxiety disorder ($n = 8$), and social phobia ($n = 7$). Participants with anxiety disorders were examined as a single group because statistical power limited our ability to examine the disorders separately and because the disorders are frequently comorbid[17] and have common genetic liability.[22] Because we tentatively hypothesized that anxiety would be associated with objective sleep but MDD would not, we included participants with comorbid anxiety disorders and MDD in the anxiety group.

Participants in the control group were free of lifetime major psychiatric disorder and were at low familial risk of depression. Low risk was defined as absence of lifetime affective disorder in first-degree relatives; absence of lifetime mania, schizoaffective disorder, or schizophrenia in second-degree relatives; and lifetime MDD in <20% of second-degree relatives. First- and second-degree relatives were interviewed using the Schedule for Affective Disorders and Schizophrenia for School-Age Children-Epidemiologic Version.[23]

Participants were excluded for use of medication with central nervous system or hypothalamic-pituitary effects within the past 2 weeks; lifetime use of fluoxetine; significant medical illness; extreme obesity (weight >150% of ideal body weight); IQ <70; eating disorder, developmental disorder, or schizophrenia; phobia of intravenous needles; learning disabilities; and use of nicotine, drugs, or alcohol. For participants who had taken medication during the current episode, medication was tapered under the guidance of the participant's psychiatrist.

Pubertal development was determined through physical examination by a trained physician or nurse practitioner, using five stages of breast, genital, and pubic hair development as described by Marshall and Tanner.[24] Percentage agreement for Tanner stage classification has been ≥90. Participants were categorized as children if they were Tanner stage <3 and as adolescents if they were Tanner stage ≥3.

Procedure

The study protocol was approved by the University of Pittsburgh Institutional Review Board. Participants' parents or guardians were told about the procedures of the study and signed an informed consent form. Participants 14 to 16 years old provided consent, and participants younger than 14 years provided verbal assent. Participants were admitted to the Child and Adolescent Sleep and Neurobehavioral Laboratory at Western Psychiatric Institute and Clinic for a neurobiological assessment that included three consecutive nights of standard polysomnography.

During the week before the sleep assessment, participants maintained their usual sleep/wake schedules and kept detailed sleep logs in their home environment. According to logs, participants obtained a mean 9.3 (SD 1.1) hours of sleep per night (9.6 [SD 0.8] and 8.9 [SD 1.2] for children and adolescents, respectively). MDD, anxiety, and control groups did not differ in mean amount of sleep ($F = 0.44$, $p > .60$). Participants were not permitted to nap during the day and were instructed to abstain from caffeine, nicotine, and any medications in the week before the assessment.

Polysomnography—Sleep data were analyzed from two consecutive nights (data were not included for night 3 because that protocol included sleep-disrupting procedures). Data were missing for eight participants for night 1 (three anxiety, three MDD, two control) and seven participants for night 2 (five anxiety, one MDD, one control), and none for both nights because participants declined or technical problems were encountered. Participants from the anxiety group were more likely to be missing data than were participants from other groups (Pearson $\chi^2 = 6.01$, $p < .05$ for night 1; Pearson $\chi^2 = 27.13$, $p < .001$ for night 2). Missing data on night 2 were positively correlated with age and BMI (Spearman $\rho = .16$ and .15, respectively, $p < .05$) but not with symptoms.

Sleep scoring was conducted in 30-second epochs using standard criteria.[25] Scorers were blind to diagnosis and achieved adequate interrater reliability. The following variables were computed: total sleep time, number of awakenings, time awake, sleep latency, total rapid eye movement (REM) time, REM latency, REM density, time in sleep stages 1 to 4, and total slow-wave sleep. Sleep onset was defined as the first of ten consecutive minutes of stage 2 or deeper sleep. Total sleep time was computed within the total sleep period. Time awake was computed as wakefulness after sleep onset and before waking time. Sleep latency was computed as the difference between bedtime (i.e., lights out) and sleep onset. Total REM time was computed as time in REM sleep. REM latency was computed as time from sleep onset to the first epoch of the first REM period lasting at least 3 minutes. REM density was scored on a 5-point scale for number of eye movements per epoch and then divided by total number of REM epochs. Total slow-wave sleep was computed as the sum of time in stage 3 and stage 4 sleep.

Subjective Sleep Quality—On each morning, participants completed a questionnaire[11] with a visual analog scale for each of the following: sleep quality, ease of waking, number of awakenings, time awake, and sleep latency.

Symptom Ratings—Anxiety symptoms were measured through self-and parent report on the Screen for Childhood Anxiety and Related Disorders.[26] Depressive symptoms were

measured through self-report on the Children's Depression Inventory[27] for 8- to 12-year-olds and on the Beck Depression Inventory[28] for 13- to 18-year-olds. Symptoms were assessed on the day of the second night of sleep recordings. Symptom data were available for 77 participants because symptom instruments were added in recent phases of the study.

Data Analyses

Developmental Effects on Sleep—As expected, and as reported in other studies,[29] pre-/early pubertal children exhibited more total sleep time, more stage 4 sleep, more slow-wave sleep, and less stage 2 sleep than did mid-/late pubertal adolescents. During night 2 only, children exhibited more time awake than did adolescents. Children reported a greater ease of waking than did adolescents during night 2.

Data Analytic Strategy—Because distributions were positively skewed for most variables, a log transform was applied to variables whose skewness statistic was greater than twice the SE (these included all but the following: total REM time, stage 2 sleep, stage 4 sleep, and slow-wave sleep). Repeated-measures analyses of covariance (ANCOVAs) with group, night, and group × night as factors were conducted for each sleep variable. Because of developmental changes in sleep, age differences between groups, and age effects in the variables of interest, age was included as a covariate (pubertal development was not included because it is highly correlated with age). For significant effects, effect size was computed as partial η^2 ($\eta_p 2$), which reflects proportion of variance attributed to a particular effect. Effect size measures the magnitude of a relation and provides useful additional information because it is independent of sample size. Post hoc tests were computed using one-way analyses of variance and pairwise Scheffé tests. Pearson correlations were computed for analyses with affective symptoms.

RESULTS

Group Differences in Objective Sleep

ANCOVAs to test whether anxiety disorders are associated with objective sleep problems (Table 2) revealed a group main effect for number of awakenings ($\eta_p 2 = .04$), time awake ($\eta_p 2 = .06$), sleep latency ($\eta_p 2 = .04$), stage 1 sleep ($\eta_p 2 = .05$), stage 2 sleep ($\eta_p 2 = .03$), stage 4 sleep ($\eta_p 2 = .07$), and slow-wave sleep ($\eta_p 2 = .07$). On both nights, the anxiety group had more awakenings than the MDD group and less slow-wave sleep than the MDD and control groups. On night 2, the anxiety group had greater sleep latency than the MDD and control groups. On night 1, the MDD group had less time awake than the control group and less stage 1 sleep than the anxiety and control groups.

There were main effects for night for sleep latency ($\eta_p 2 = .01$) and REM density ($\eta_p 2 = .07$). In general, sleep latency decreased and REM density increased from night 1 to night 2.

There was a marginally significant group × night interaction for REM latency ($\eta_p 2 = .03$). Post hoc analyses indicated that whereas both the MDD and control groups exhibited a decrease in REM latency from night 1 to night 2 ($F_{1,91} = 16.17$, $p < .001$ and $F_{1,70} = 12.78$, $p < .005$, respectively), the anxiety group exhibited equivalent REM latency for the two nights ($F_{1,11} = 0.89$, $p > .35$).

Analyses conducted to test MDD group × development and MDD group × development × sex effects, analyses for development × sex effects within the MDD group, and ANCOVAs with sex as a covariate indicated that developmental status and sex did not interact with MDD to influence sleep. Analyses conducted with group × development did not indicate a significant interaction effect.

Group Differences in Subjective Sleep

ANCOVAs to test whether participants with anxiety or MDD have higher rates of subjective sleep problems than controls (Table 3) revealed a marginally significant group effect for subjective sleep latency ($\eta_p 2 = .04$). This was qualified by a group × night interaction effect ($\eta_p 2 = .07$). Post hoc analyses for each night indicated a group effect for night 2 only ($F_{2,146} = 6.17$, $p < .005$, $\eta_p^2 = .08$), with the anxiety group reporting longer sleep latency than the MDD and control groups. Within-group post hoc analyses indicated that whereas both the MDD and control groups reported decreased sleep latency from night 1 to night 2 ($F_{1,70} = 21.10$, $p < .001$ and $F_{1,59} = 5.75$, $p < .05$, respectively), the anxiety group reported equivalent sleep latency for the two nights ($F_{1,18} = 0.64$, $p > .40$).

Findings for Pure Anxiety Group

To examine whether findings were influenced by the presence of a subgroup in the anxiety group with co-morbid MDD, analyses with significant group or group × night effects were conducted with this subgroup excluded. All of the findings held except for the group effect for number of awakenings ($F = 3.36–6.18$, $p < .05$ for significant findings; $F = 2.05$, $p = .18$ for awakenings).

Findings for New MDD Group

To examine whether findings were influenced by a subgroup of MDD participants ($n = 89$) who were included in an earlier paper on sleep disturbance,[11] main analyses with significant group or group × night effects were conducted again with this subgroup excluded. For objective variables, group differences remained for time awake ($F_{2,81} = 3.05$, $p = .05$, $\eta_p^2 = .07$), sleep latency ($F_{2,85} = 3.03$, $p = .05$, $\eta_p^2 = .07$), stage 2 sleep ($F_{2,85} = 6.15$, $p < .001$, $\eta_p^2 = .13$), stage 4 sleep ($F_{2,85} = 15.52$, $p < .001$, $\eta_p^2 = .27$), and slow-wave sleep ($F_{2,85} = 10.73$, $p < .001$, $\eta_p^2 = .20$). For subjective variables, group and group × night effects were no longer evident for sleep latency.

Relation Between Symptoms and Sleep Characteristics

To examine whether current symptoms were associated with sleep characteristics, correlations were computed using total depressive symptoms, total child-rated anxiety symptoms, and total parent-rated anxiety symptoms. Depressive symptoms were modestly inversely correlated with slow-wave sleep during night 1 ($r = −0.16$, $p < .05$), subjective ease of waking after night 1 ($r = −0.20$, $p < .05$), objective total sleep time during night 2 ($r = −0.20$, $p < .05$), and subjective sleep latency during night 2 ($r = −0.47$, $p < .01$). Child-rated anxiety symptoms were moderately and positively correlated with objective sleep latency during night 2 ($r = 0.46$, $p < .05$). Child-rated anxiety symptoms were modestly inversely correlated with subjective ease of waking after night 1 ($r = −0.25$, $p < .05$), stage 3 sleep during night 2 ($r = −0.47$, $p < .05$), subjective sleep quality during night 2 ($r = −0.28$, $p < .05$), and subjective ease of waking after night 2 ($r = −0.24$, $p < .05$). Parent-rated child anxiety symptoms were modestly inversely correlated with children's subjective sleep quality during night 2 ($r = −0.26$, $p < .05$).

DISCUSSION

This study provides objective and subjective sleep data from a large sample of children and adolescents with depression and/or anxiety disorders and healthy controls, all studied in the same environment under the same conditions. Overall, young people with anxiety disorders showed more evidence of objective sleep problems compared to healthy controls or those with MDD, even when those with comorbid MDD were excluded from the anxiety group. In contrast, the objective sleep measures in the children and adolescents with MDD were similar to those of the control group.

Sleep problems in the anxiety group were more evident in polysomnography-based than in subjective sleep measures. For example, despite having more awakenings and more minutes awake by these objective measures, young people with anxiety did not report experiencing these any more than did young people with MDD or healthy young people. The only variable for which both objective and subjective differences for anxiety disorders (and anxiety symptoms) emerged was sleep latency. Thus, a noteworthy associated finding is that young people with anxiety generally appear to be less aware of, or perhaps underreport, their sleep problems. For sleep latency, however, it appeared that young people without anxiety disorders tend to estimate their sleep more correctly.

Strikingly, youths with anxiety disorders showed greater objective sleep latencies than those of the control or MDD group on night 2 only. In the "first-night effect," sleep latency typically decreases with adjustment to the sleep laboratory environment, with youths falling asleep more quickly on the second night.[30] The first-night effect was not evident in the anxiety group, which suggests that anxiety interferes with the processes of adjusting to sleeping in the laboratory. Our findings may thus be related to first-night effects in the other two groups. Furthermore, the anxiety group was more likely to be missing night 2 EEG data, which suggests that the first-night experience may have influenced willingness to participate in a second night of recordings.

Consistent with our earlier findings, young people with MDD did not show evidence of objective sleep disturbances as measured by polysomnography. In fact, during the first night, the MDD group had significantly less time awake than did the control group. However, contrary to our hypotheses and our recent findings,[11] young people with MDD also did not differ from control participants in subjective sleep. Depressive symptoms (rather than MDD) were associated with sleep problems to a limited extent, but this could be attributable to co-morbid depression in the anxiety group. Previous studies have also reported that, in contrast to the adult literature, there is not a consistent link between objectively assessed sleep problems and depression in children or adolescents. A meta-analysis revealed that the sleep of depressed youths was largely indistinguishable from that of controls.[31] Furthermore, in contrast to previous findings that reduced REM latency predicts the recurrence of depression in depressed adults,[32] findings about predictive value of REM latency in children and adolescents have been less strong.[33] The maturity of the CNS could be implicated, and investigations of the microarchitecture of sleep have argued that depression × sex interactions may indicate alterations in neurodevelopment in some individuals.[34]

Our findings suggest that the anxiety group experienced heightened anxiety or "stress" during the night. Sleep problems in young people with anxiety disorders could reflect the vigilance processes and biased information processing postulated to characterize early-onset anxiety.[35] Because vigilance interferes with the feelings of safety that are critical to the onset and maintenance of sleep,[36] especially slow-wave sleep, it may contribute to the longer sleep latency and reduced deep sleep in young people with anxiety. Of note, we reported a similar pattern of findings with perisleep-onset cortisol, which was unusually high in children with anxiety disorders but not those with depression.[37] Thus, it may be that anxiety in childhood is particularly associated with a set of disruptions in sleep-related physiology.

The apparent lack of awareness of sleep problems in the anxiety group was a surprising finding. Because people are believed to have unreliable memories concerning sleep, it is possible that young people with anxiety use other cues, such as daytime arousal, to interpret or make inferences about their sleep. An anxious child who interacts with responsive, caring staff at a sleep laboratory and is temporarily relieved of managing worries about school may be less aware of sleep difficulties. Alternatively, some young people with anxiety may be aware of their sleep problems but simply fail to report them. Methodologically, the magnitude of

discrepancy between objective and subjective sleep measures in this clinical sample underscores the importance of considering how these domains of sleep measures can yield very different results.[38]

From a developmental perspective, we found the typical pattern of sleep changes associated with the pubertal transition. The fairly wide age range, including both children and adolescents, allowed us to examine both developmental effects and interactions of development with diagnostic group. There were not significant interactions between development and diagnosis in objective or subjective sleep measures, and the inclusion of age as a covariate did not appear to influence the results.

The limitations of the study include the methodological complexities of comparing objective and subjective measures of sleep, the diagnostic overlap between affective disorders and sleep problems, and the shared method variance of symptom reports and subjective sleep problems. The advantages of assessing sleep in a uniform environment are accompanied by the drawbacks of being unable to assess sleep in a typical environment and having missing data for some participants (which may influence night-specific findings). The cross-sectional design of the study limited our ability to understand the interplay of sleep problems, anxiety, and depression over time. Also, the relatively small anxiety group made it difficult to compare “pure” MDD, “pure” anxiety, and comorbid depression and anxiety. However, the strength of the findings, which generally did not change when the comorbid subgroup was excluded, suggests that anxiety has an association with sleep independently of depression. Although we did not find that sex moderated the relation between depression and sleep, it is still possible that it exerted an undetected influence. An important next step will be to use multiple measures to examine the mechanisms by which anxiety and sleep problems may be related. For example, it is difficult to determine without actigraphy data whether the notably long sleep latency that we observed in the anxiety group reflects typical sleep or anxiety associated with sleeping in the laboratory.

The psychiatric characteristics of the sample created additional limitations. First, the co-occurrence of depressive and anxiety symptoms in both clinical groups, although not atypical, presents challenges to separating the unique contributions of depression and anxiety to sleep problems. We hypothesize, based on findings when the comorbid group was excluded, that clinically and functionally meaningful anxiety is a key factor in objective sleep difficulties, so that anxiety symptom levels alone are not sufficient to disrupt sleep. Second, our exclusion criteria created limitations in the generalizability of findings to the larger population of young people with affective disorders. In particular, exclusion based on drug or alcohol use could have attenuated the relationship between MDD and sleep problems, given the high co-occurrence of MDD and substance use disorders.[39]

Given the comorbidity of depression and anxiety in young people,[17] the different patterns of sleep disturbance in the MDD and anxiety groups raise compelling questions about ways in which these disorders may differ and about new opportunities for early intervention. For instance, a psychosocial treatment for anxiety may be more effective if it is augmented with an intervention to target specific symptoms such as vigilance and worry at bedtime. Targeting sleep problems that are especially responsive to treatment may have particular value for reducing anxiety. Similarly, specific treatments for anxiety may improve sleep quality in young people. Given that MDD was not associated with objective sleep problems, it could be useful to educate young people with depression about perceived sleep quality and to address their cognitive distortions about the consequences of poor sleep. Finally, given the sharply increased rate of onset of depressive disorders during adolescence[40] and the tendency for anxiety to precede depression in young people,[41] it may be especially critical to intervene at an earlier point in childhood, before anxiety and sleep problems have a chance to develop into more serious pathology.

Acknowledgements

This study was supported by the National Institute of Mental Health (P01 MH41712, Neal D. Ryan; K01 MH74769, Erika E. Forbes) and the National Alliance for Research on Schizophrenia and Depression (Young Investigator Award, Erika E. Forbes). The authors are grateful to Laura Trubnick for coordinating the Child and Adolescent Sleep Laboratory at Western Psychiatric Institute and Clinic, Ian Kane for assisting with data management, and the participants and their families.

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TABLE 1

Sample Characteristics

	Control (*n* = 101)	Anxiety (*n* = 24)	MDD (*n* = 128)
Age	10.9 (2.2)	12.2 (3.1)	12.0 (2.3)
Sex, % female	46.5	58.3	45.3
Race, %			
European American	95.9	81.8	79.2
African American	3.1	13.6	18.4
Latino	1.0	4.5	0.8
Asian			0.8
Native American			0.8
Pubertal status			
Child (Tanner stage <3)	74	10	74
Adolescent (Tanner stage≥3)	27	14	54
SES	47.7 (11.9)	43.7 (9.6)	38.6 (13.0)
BMI	18.9 (4.1)	21.5 (4.3)	20.5 (4.1)
Depressive symptoms (BDI/CDI)	3.6 (4.1)	16.4 (27.4)[a]	13.5 (21.8)
Anxiety symptoms (SCARED)			
Child rated			
Total	8.3 (9.3)	36.1 (14.2)	25.8 (16.0)
Panic	1.8 (2.4)	8.7 (4.4)	5.0 (5.1)
Generalized anxiety	1.5 (2.1)	11.5 (4.4)	8.4 (5.3)
Separation anxiety	1.3 (2.2)	5.8 (3.9)	3.7 (3.6)
Social phobia	2.1 (2.1)	5.3 (2.6)	3.7 (3.1)
School phobia	1.6 (1.8)	6.8 (3.5)	5.0 (3.1)
Parent rated			
Total	5.0 (4.0)	33.9 (13.6)	25.0 (15.5)
Panic	0.5 (.7)	5.5 (4.6)	3.4 (3.9)
Generalized anxiety	1.4 (1.8)	11.2 (4.2)	8.6 (5.6)
Separation anxiety	0.4 (.8)	5.6 (3.1)	3.5 (3.5)
Social phobia	1.5 (1.3)	4.5 (3.1)	3.9 (2.5)
School phobia	1.2 (1.3)	7.1 (3.7)	5.7 (3.7)

Note: Values are mean (SD) unless reported as a percentage. Participants were classified as children if they were Tanner stage <3 and as adolescent if they were Tanner stage ≥3. MDD = major depressive disorder; SES = socioeconomic status, measured by Hollings-head Index; CDI = Child Depression Inventory[27]; BMI = body mass index; BDI = Beck Depression Inventory[28]; SCARED = Screen for Childhood Anxiety and Related Disorders.[26]

[a]Value = 2.70 (36.03) when excluding participants with co-morbid MDD.

TABLE 2

Mean (SD) and Effects for Diagnostic Group, Night, and Group × Night for Objective Sleep Quality Variables

	Night 1			Night 2					
Variable	**Control**	**ANX**	**MDD**	**Control**	**ANX**	**MDD**	**Group**	**Night**	**Group × Night**
Total sleep time (min)	538.3 (34.9)	529.9 (85.6)	524.5 (35.5)	558.0 (33.9)	525.3 (45.2)	546.0 (38.8)	2.11	1.70	0.80
Awakenings	5.8 (2.8)	8.3 (4.0)	5.4 (3.2)	6.1 (3.1)	6.4 (3.4)	5.2 (3.6)	3.08**	0.19	0.59
Time awake (min)	44.6 (38.3)	27.7 (27.9)	28.9 (27.7)	26.6 (28.2)	13.3 (14.0)	19.2 (22.6)	4.86**	0.47	0.32
Sleep latency (min)	25.6 (15.4)	35.7 (36.7)	30.0 (18.5)	19.4 (15.7)	41.3 (28.7)	21.9 (11.7)	3.96**	6.65**	2.10
Total REM time (min)	90.4 (23.2)	101.1 (33.1)	93.7 (27.7)	113.9 (22.0)	106.0 (19.8)	112.0 (25.0)	0.32	8.62***	1.82
REM latency (min)	144.6 (47.4)	113.2 (49.8)	134.8 (55.5)	118.3 (48.0)	128.0 (55.9)	111.5 (43.3)	0.88	0.86	2.60*
REM density	1.4 (0.5)	1.3 (0.4)	1.4 (0.5)	1.5 (.5)	1.2 (0.3)	1.4 (0.5)	1.62	11.88***	0.99
Stage 1 sleep (min)	24.5 (15.9)	27.8 (13.4)	20.7 (12.6)	24.7 (15.2)	27.4 (9.9)	20.7 (12.1)	4.01**	0.15	0.44
Stage 2 sleep (min)	262.9 (50.6)	298.9 (61.6)	261.8 (40.3)	275.8 (40.9)	292.4 (20.8)	277.0 (39.8)	3.02**	0.48	1.19
Stage 3 sleep (min)	40.8 (20.6)	36.6 (14.8)	39.4 (19.9)	40.3 (15.4)	33.0 (11.9)	38.8 (18.8)	0.05	0.64	0.32
Stage 4 sleep (min)	74.9 (32.5)	41.8 (35.8)	80.0 (31.8)	76.6 (33.7)	53.3 (33.1)	78.2 (34.9)	6.84***	0.04	0.64
Slow-wave sleep (min)	115.7 (40.1)	78.4 (37.9)	119.4 (37.3)	117.0 (36.8)	86.3 (29.4)	116.9 (35.9)	6.23***	0.40	0.42

Note: Values for group, night, group × night are *F*. Slow-wave sleep = stage 3 + stage 4. For rapid eye movement (REM) variables, *df* = 1,171 for night and 2,171 for group and group × night. For all others, *df* = 1,172 for night and 2,172 for group and group × night. All of the variables except total REM time, stage 2 sleep, stage 4 sleep, and slow-wave sleep were log-transformed before analyses.

* $p < .10$;

** $p \leq .05$;

*** $p < .005$.

TABLE 3

Mean (SD) and Effects for Diagnostic Group, Night, and Group × Night for Subjective Sleep Quality Variables

	Night 1			Night 2					
Variable	**Control**	**ANX**	**MDD**	**Control**	**ANX**	**MDD**	**Group**	**Night**	**Group × Night**
Sleep quality	69.05 (23.08)	59.86 (29.15)	55.06 (26.40)	81.86 (19.33)	65.35 (21.28)	73.41 (24.62)	2.26	1.94	0.30
Ease of waking	84.78 (20.40)	70.59 (28.25)	76.53 (23.92)	77.95 (25.50)	58.60 (30.09)	70.06 (29.14)	1.27	0.03	0.59
Awakenings	1.61 (1.28)	2.18 (1.71)	2.13 (1.47)	0.86 (1.08)	1.30 (1.66)	1.21 (1.25)	1.61	0.18	0.46
Minutes awake	11.98 (15.12)	13.41 (32.01)	17.62 (32.66)	4.71 (7.94)	3.47 (4.54)	7.20 (12.03)	0.64	0.04	0.97
Sleep latency	17.96 (14.38)	22.41 (27.03)	24.31 (18.92)	12.43 (9.90)	44.60 (108.01)	15.47 (12.26)	2.79*	0.09	4.73**

Note: Values for group, night, and group × night are *F*. Numerator $df = 1$ for night and 2 for group and group × night; denominator $df = 156$ for sleep quality, 154 for ease of waking, 150 for awakenings, 131 for minutes awake, and 146 for sleep latency. All of the variables were log-transformed before analyses.

* $p < .10$;

** $p \leq .05$.