ORIGINAL ARTICLE

Trajectories of sleep problems in childhood: associations with mental health in adolescence

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Abstract

Study Objectives: We examined initial levels (intercepts) of sleep–wake problems in childhood and changes in sleep–wake problems across late childhood (slopes) as predictors of externalizing behavior problems, depressive symptoms, and anxiety in adolescence. To ascertain the unique effects of childhood sleep problems on adolescent mental health, we controlled for both childhood mental health and adolescent sleep problems.

Methods: Participants were 199 youth (52% boys; 65% White/European American, 35% Black/African American). Sleep–wake problems (e.g. difficulty sleeping and waking up in the morning) were assessed during three time points in late childhood (ages 9, 10, and 11) with self-reports on the well-established School Sleep Habits Survey. At age 18, multiple domains of mental health (externalizing behavior problems, depressive symptoms, and anxiety) and sleep–wake problems were assessed.

Results: Latent growth curve modeling revealed that children with higher levels of sleep–wake problems at age 9 had consistently higher levels of such problems between ages 9 and 11. The initial level of sleep–wake problems at age 9 predicted externalizing behaviors, depressive symptoms, and anxiety at age 18, controlling for mental health in childhood and concurrent sleep–wake problems in adolescence. The slope of sleep–wake problems from ages 9 to 11 did not predict age 18 mental health.

Conclusions: Youth who had higher sleep–wake problems during late childhood had higher levels of mental health problems in adolescence even after controlling for childhood mental health and concurrent sleep–wake problems. Findings illustrate that childhood sleep problems may persist and predict adolescent mental health even when potentially confounding variables are rigorously controlled.

Statement of Significance

Long-term associations between sleep problems and mental health across childhood and adolescence are poorly understood. The present study assessed interindividual differences in initial level (intercept) and change (slope) in sleep–wake problems over childhood and their associations with mental health in adolescence. Findings demonstrate that higher sleep–wake problems in childhood predict poorer mental health in adolescence after controlling for early mental health and concurrent sleep–wake problems, highlighting the potential long-term implications of persistent sleep problems in childhood and the importance of early screening and treatment of sleep difficulties.

Key words: sleep problems; childhood; adolescence; adjustment; mental health

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Introduction

Sleep problems in childhood and adolescence are prevalent [1–3]. Short sleep duration and poor sleep quality may compromise youths' mental health, consistent with a growing body of evidence demonstrating relations between sleep problems and depressive symptoms [4], anxiety [5], and externalizing behaviors [6, 7]. The evidence is based largely on the results of cross-sectional and short-term longitudinal studies [8, 9], although a smaller number of experimental studies examining sleep extension or restriction and mood disturbances provide additional, compelling evidence [10, 11].

Long-term associations between sleep problems and mental health across childhood and adolescence are poorly understood. Several studies suggest that childhood sleep problems predict later emotional and behavioral problems. For example, a prospective longitudinal study showed that greater sleep problems at age 4 were related to higher levels of depressive symptoms, anxiety, and aggression in mid-adolescence (ages 13–15) [12]. Another study reported that individuals who had persistent sleep problems in childhood, defined as having sleep problems during at least one of two time points during early childhood (age 5 or 7) and during late childhood (age 9), showed higher odds of anxiety disorders in young adulthood [13].

Despite some exceptions, few studies have addressed relations between sleep problems and mental health over longer developmental periods (e.g. more than 2 years) or examined trajectories of increasing or decreasing sleep problems over time as predictors of later mental health difficulties. Children may experience stable good sleep, stable sleep problems, emergent sleep problems that increase over time, or dissipating sleep problems that decrease over time. Such variability in the initial levels and change over time in sleep problems may predict later mental health outcomes.

Two existing studies demonstrate the importance of examining trajectories of sleep problems over time as predictors of behavioral and mental health. In one study, a trajectory of persistently high sleep problems from ages 5 to 14 was associated with relatively high levels of aggressive behaviors at age 17 [14]. In another study, a trajectory of higher initial sleep problems at 18 months and increases in sleep problems across four waves from 18 months to 7 years predicted higher levels of internalizing and externalizing problems at age 11 [15]. Given that significant changes in sleep occur from late childhood through adolescence [16–18], and that associations between early sleep problems and later mental health problems may be heightened during adolescence [19], examining longitudinal relations between sleep and mental health across developmental periods of childhood and adolescence is important [20, 21].

Current study

The primary objective of the current study was to examine associations between sleep problems and growth in sleep problems across late childhood (ages 9, 10, and 11 years) as predictors of mental health (externalizing behavior, depressive symptoms, and anxiety) in adolescence (age 18) among a sample of youth from small towns and semirural communities. Sleep problems were assessed with the well-established Sleep–Wake Problems scale of the School Sleep Habits Survey (SSHS) [22], which

measures various dimensions of sleep including difficulty with falling asleep and waking up in the morning.

We used growth curve modeling to examine initial levels of sleep problems (intercepts, age 9) and changes in sleep problems between ages 9 and 11 years (slopes) as predictors of mental health in late adolescence (age 18). Existing longitudinal studies of relations between childhood sleep problems and later mental health outcomes have not examined associations across developmental periods and included both early mental health problems and concurrent sleep problems as covariates [13, 15]. Extending prior work, we accounted for the effects of childhood mental health problems and concurrent sleep problems in adolescence to ascertain the unique effects of childhood sleep problems on later mental health. We expected that individual differences in sleep problems in childhood would predict mental health problems in adolescence, with greater sleep problems at age 9 (intercept effects) or increases in sleep problems from ages 9 to 11 (slope effects) predicting higher levels of externalizing behavior problems, depressive symptoms, and anxiety at age 18. Conversely, we expected that lower levels of sleep problems at age 9, or decreases in sleep problems between ages 9 and 11, would predict lower levels of mental health problems in adolescence.

Methods

Participants

The analytic sample included 199 adolescents who participated in the Auburn University Sleep Study, a longitudinal investigation of sleep and health disparities among White/European American and Black/African American youth living in small towns and semirural communities in the southeastern United States. During the first assessment (age 9), children were recruited from public elementary schools; letters detailing the study were distributed to be sent home with the children. Exclusion criteria at the time of recruitment included a diagnosis of a sleep disorder (e.g. sleep apnea) or an intellectual disability, as reported by parents.

At T1 of the larger investigation, 282 children participated (51.8% male; 64.9% White/European American, 35.1% Black/African American; $M_{\text{age}} = 9.44$ years, $SD = 0.71$). There were 1-year intervals between T1 and T2 and between T2 and T3; there was a 6-year interval between T3 and T4. Data collection occurred in 2009–2012 for T1–T3 and in 2017–2018 for T4. Of the children who participated at T1, 227 (80.5%) participated at T2, and an additional 54 children were recruited at T2 to compensate for attrition, resulting in a total sample of 281 children (54.8% male; 63.3% White, 36.7% Black; $M_{\text{age}} = 10.41$ years, $SD = 0.67$). Of the children who participated at T2, 275 (97.9%) participated at T3 (53.5% male; 62.2% White, 37.8% Black; $M_{\text{age}} = 11.35$ years, $SD = 0.68$). Of youth who participated at T1, T2, or T3, 199 (59.2%) participated at T4 (51.8% male; $M_{\text{age}} = 17.65$ years, $SD = 0.78$). For clarity, we refer to mean participant ages across the waves of the study (9, 10, 11, and 18 years old, respectively) rather than study wave number.

The final analytic sample consisted of 199 adolescents (96 girls and 103 boys) who participated at least once at ages 9, 10, or 11 and also at age 18; most of the analytic sample ($n = 170$; 85%) were part of the original cohort who participated at age 9, and 29 youth participated for the first time

at age 10. The majority of participants (65.3%) were White/European American; about a third of participants (32.2%) were Black/African American and 2.5% were biracial (coded as Black in analyses), which is representative of the community. According to their income-to-needs ratio [23], families were from a wide range of socioeconomic backgrounds with a relatively high concentration of lower socioeconomic status (SES). Specifically, at each of the first three time points (ages 9–11), 26%–32% of families were living in poverty (income-to-needs ratio ≤ 1), 31%–37% were near the poverty line (ratio > 1 and ≤ 2), 24%–31% were considered lower middle-class (ratio > 2 and < 3), and 11%–13% reported incomes reflecting middle-class status (ratio ≥ 3). At the fourth time point (age 18), 19% of families were living below the poverty line, 21% near the poverty line, 17% were lower middle-class, and 43% were middle-class or higher.

Procedure

The study was approved by the university's Institutional Review Board. Parents consented and youth assented to participation. At each time point, participants visited the laboratory to complete questionnaires.

Measures

Sleep–wake problems (ages 9, 10, 11, and 18)

Youth completed the sleep–wake problems scale of the SSHS [22], which has demonstrated excellent reliability and validity [24, 25] and has been used successfully with youth of similar ages to study participants [26, 27]. There are advantages and disadvantages for all methodologies used to examine sleep [28], and subjective reports based on psychometrically sound measures are an effective means of assessing individual variability in sleep quality [29, 30]. The sleep–wake problems scale consists of 10 items that assess the frequency of difficulties with initiating and maintaining sleep at night and waking in the morning over the past 2 weeks (e.g. “had an extremely hard time falling asleep,” “fallen asleep in a morning class,” “slept in past noon,” and “stayed up all night”). Responses were scored on a 5-point scale (1 = *never* to 5 = *every day*), giving the scale a possible range of 10 (no sleep–wake problems) to 50 (daily experience of each sleep–wake problem). Internal consistency was fair across waves (α s = 0.63, 0.68, 0.71, and 0.83 at age 9, 10, 11, and 18, respectively).

Externalizing behaviors (age 18)

Adolescents reported on their externalizing behaviors over the past 6 months using the Youth Self-Report (YSR), a well-validated instrument used frequently in research and clinical settings [31]. The externalizing scale is composed of 32 items examining rule-breaking and aggressive behaviors (e.g. “I lie or cheat,” “I get in many fights,” and “I break rules at home, school, or elsewhere”). Responses were scored on a 3-point scale (0 = *not true* to 2 = *very true or often true*), and internal consistency was good (α = 0.85). Raw scores were converted to T scores, which have a possible range of 0–100. The T scores are normed for age and sex and indicate that 16.1% of the sample met criteria for borderline or clinical level for externalizing problems (T score ≥ 60) [31].

Externalizing behaviors (ages 9–11)

Mothers reported on children's externalizing behaviors using the Personality Inventory for Children (PIC) [32] at each of the first three time points, since parents' reports of children's externalizing problems are generally more reliable than children's reports [33]. The externalizing scale assesses symptoms of impulsivity, disruptive behavior, delinquent behavior, and noncompliance. Mothers rated items as true or false about the child; internal consistency was good (α = 0.83, 0.83, and 0.84 at ages 9–11, respectively). True responses were summed and converted to T scores, which indicated that 12.9%, 8.9%, and 8.6% of participants met criteria for borderline or clinical level (T ≥ 60) for externalizing problems at age 9–11, respectively. Scores were strongly correlated across ages 9–11 (r s = 0.62–0.79, p s < 0.001) and were averaged to form an externalizing behaviors composite. The mother-reported PIC externalizing composite (ages 9–11) was significantly correlated with adolescent-reported YSR externalizing behaviors (age 18), $r = 0.18$, $p < 0.05$. In analytic models examining externalizing behavior in adolescence, mother-reported externalizing problems in childhood were covaried to provide a more stringent assessment of relations between childhood sleep problems and adolescent externalizing behaviors.

Depressive symptoms (ages 9, 10, 11, and 18)

Across the four study waves, youth completed the well-established Child Depression Inventory (CDI) [34]. Children are better reporters of internalizing symptoms than are parents [33, 35], and the CDI is a reliable and valid measure of depressive symptoms among children and adolescents [36]. The CDI consists of 27 items assessing symptoms of depression over the past 2 weeks on a 3-point scale (e.g. 0 = “Things will work out for me O.K.” to 2 = “Nothing will ever work out for me”). One item concerning suicidal ideation was excluded, and two items relating to sleep disturbances were excluded from analyses; scores could range from 0 to 48. The CDI was internally consistent (α = 0.87, 0.83, 0.81, and 0.88 at age 9, 10, 11, and 18, respectively). Clinically significant levels of depression (scores ≥ 18 ; cutoff score adjusted due to exclusion of three items) [34] were reported by 10.4%, 1.1%, 1.1%, and 12.9% of participants at ages 9, 10, 11, and 18, respectively. Depressive symptoms scores were correlated across ages 9, 10, and 11 (r s = 0.23–0.57, p s < 0.01); these scores were averaged to form a childhood depressive symptoms composite, and the composite was used as a covariate in analyses. Depressive symptoms at age 18 was examined as a primary outcome.

Anxiety symptoms (ages 9, 10, 11, and 18)

Youth also completed the well-established Revised Children's Manifest Anxiety Scale (RCMAS-2) [37] at each time point. The Total Anxiety scale of the RCMAS includes 45 items surveying three dimensions of anxiety: physiology (e.g. “Often I feel sick in my stomach”), worry (e.g. “I worry a lot of the time”), and social anxiety (e.g. “I fear other people will laugh at me”). Youth indicated whether they agreed (coded 1) or disagreed (coded 0) with each statement. Five items pertaining to sleep problems were excluded, producing a modified scale with excellent reliability (α = 0.91, 0.93, 0.85, and 0.94 at age 9, 10, 11, and 18, respectively); scores could range from 0 to 40. High levels of anxiety symptoms (≥ 2 SD above the mean) were reported by 3.7%, 8.1%, 7.5%, and

2.6% of youth at age 9, 10, 11, and 18, respectively. Anxiety scores were correlated across ages 9, 10, and 11 ($r_s = 0.45$ to 0.62 , $p_s < 0.001$) and were averaged to form a childhood anxiety composite that was covaried in analyses assessing anxiety symptoms at age 18.

Covariates

Parents reported on children's race, sex, and age at each time point. Family SES was indexed by the family's income-to-needs ratio, calculated from parental report of family income and the number of people living in the household [23]. Children's standardized body mass index (zBMI) was obtained during each laboratory session through a measurement of weight using a Tanita digital weight scale (Model BC-418) and wall-mounted stadiometer. Family SES was strongly correlated across the four time points (r_s ranged from 0.59 to 0.80 , $p_s < 0.001$), as was zBMI (r_s ranged from 0.68 to 0.94 , $p_s < 0.001$). Thus, to improve model fit, SES, age, and zBMI each were averaged across ages 9 through 18 and used as time-invariant controls, along with child race, sex, and childhood mental health (i.e. externalizing behaviors, depressive symptoms, or anxiety at age 9 through 11). Sleep-wake problems at age 18 were also covaried when predicting mental health at age 18.

Statistical analysis

Latent growth curve modeling analyses were used to examine sleep problems in childhood and their relations to mental health in adolescence. First, to determine whether there was significant growth in children's sleep-wake problems in childhood (age 9, 10, and 11), we fit an unconditional growth curve model and selected the form of a growth trajectory (no-growth or linear growth). Residuals of the repeated measures of childhood sleep-wake problems were constrained to be equal across time to ensure measurement invariance over time [38, 39]. Per established procedures, for the no-growth model, the slope was constrained to be 0 for all individuals, indicating that the growth trajectory did not increase or decrease over time. For the linear model, factor loadings were fixed at 0, 1, and 2 to denote linearity. When negative variances of the latent factors or nonpositive definite covariance matrixes of latent variables were detected, we first examined whether the intercept-slope covariance was significant. If not significant, it was fixed to zero; if significant, the variance of the latent factor having a negative value was fixed to zero. The best-fitting trajectory was selected using delta chi-square tests [40, 41]. We then assessed individual differences in the trajectory of childhood sleep-wake problems by inspecting the intercept and the slope variances. Significant variance around the mean slope indicates that there are individual differences in the rate of change in sleep-wake problems from ages 9 to 11. For example, some children may experience rapidly increasing problems, others more gradually increasing problems, while still others may have unchanging or decreasing problems over time. In contrast, a nonsignificant slope variance suggests that participants are experiencing the same rate of change in sleep-wake problems over time. In such a case, the growth trajectories of sleep-wake problems would be parallel lines that are separated only by differences in the intercept (assuming that there is significant variance around the mean intercept), and in this sense children have persistently higher or lower

sleep-wake problems than other children. Next, to test whether sleep-wake problems in childhood (age 9, 10, and 11) predicted mental health in adolescence (age 18), we utilized the intercept and slope of childhood sleep-wake problems obtained in the unconditional growth curve model to predict externalizing behaviors, depressive symptoms, and anxiety at age 18.

Three models were fit to examine the relations between the trajectory of sleep-wake problems in childhood and mental health in adolescence. In each model, one outcome variable was included in the model to reduce multicollinearity. For rigorous assessment of the research questions, the effects of covariates (SES, and adolescents' race, sex, age, and zBMI) were included when predicting both of the latent growth factors (intercept and slope) of sleep-wake problems across ages 9 through 11 and the outcome at age 18 (Figure 1). To ascertain the unique effects of childhood sleep-wake problems on mental health in adolescence, childhood mental health as well as concurrent sleep-wake problems at age 18 were also included as covariates. Across all models (see Figure 1 for an example), the childhood mental health variable (e.g. depressive symptoms) was linked to both the latent growth factors (intercept and slope) and the mental health variable at age 18; sleep-wake problems at age 18 was linked only to the outcome to represent temporal precedence, but was covaried with the latent growth factors (Figure 1). All control variables were allowed to covary.

Analyses were conducted in Mplus Version 8 [42], and utilized maximum likelihood (ML) estimation to handle missing data, which is superior to other missing value estimation methods such as listwise or pairwise deletion [43, 44]. Missingness for study variables ranged from 0% to 17%, which is within the acceptable range for use of ML [45]. Data that exceeded 4 SD were winsorized for sleep-wake problems from ages 9 to 18 (4–7 cases) and externalizing behaviors at age 18 (3 cases), and recoded as the score corresponding to 4 SD [46]. Skewness values were less than 2.0 for all variables, suggesting that they were relatively normally distributed. Acceptable model fit included meeting at least two of the following three criteria: $\chi^2/df < 3$, comparative fit index (CFI) > 0.90 , and root mean square error of approximation (RMSEA) < 0.08 [47]. All models in the present study satisfied this criterion.

Results

Preliminary analyses

Table 1 presents correlations, means, and standard deviations for sleep-wake problems, mental health variables, and the covariates. Moderate cross-time associations emerged for sleep-wake problems across childhood (age 9, 10, and 11) through adolescence (age 18). In addition, sleep-wake problems at age 9, 10, and 11 were each positively associated with externalizing behaviors, depression symptoms, and anxiety at age 18. Sleep-wake problems at age 18 were also concurrently associated with all mental health outcomes at age 18. Paired samples *t*-tests showed that the mean levels of childhood sleep-wake problems ($t = -6.90$, $p < 0.001$), externalizing behaviors ($t = -1.76$, $p < 0.10$ marginal), depressive symptoms ($t = -6.57$, $p < 0.001$), anxiety ($t = -2.08$, $p < 0.05$) that were averaged across ages 9 and 11 were significantly lower than the mean levels of these variables at age 18.

Figure 1. The analytic model used to examine the associations between a trajectory of sleep–wake problems in childhood and mental health in adolescence. SWP, sleep–wake problems. Mental health = externalizing behaviors, depression symptoms, or anxiety. Race was coded as 0 = White, 1 = Black; sex was coded as 0 = female, 1 = male. SES, socioeconomic status (income-to-needs ratio); zBMI, standardized body mass index.

Trajectories of sleep–wake problems in childhood

An unconditional growth model was fit to the data to examine the trajectory of sleep–wake problems across ages 9–11. We fit two unconditional growth curve models (no-growth and linear growth) and selected the best-fitting growth trajectory using delta chi-square tests. Table 2 presents parameter estimates for means (fixed effects, μ), variances and covariance (σ^2) of the intercept and the slope, and fit indices (χ^2/df , RMSEA, and CFI).

The results of the linear growth model indicated that a covariance matrix of the latent variable was not positive definite, and that the intercept-slope covariance was not significant (Table 2, under linear). Therefore, the intercept-slope covariance was fixed to zero, and the model was reanalyzed (Table 2, under linear 2). The delta chi-square test showed that the linear growth model, in which the intercept-slope covariance was fixed to zero, fit better than the no-growth model (Table 2: $\Delta\chi^2$).

A significant negative fixed effect of the linear slope (μ_s) emerged (Table 2). A significant intercept variance (σ_i^2) was also detected, while the slope variance (σ_s^2) was not significant (Table 2). This indicates that, on average, sleep–wake problems declined over childhood ($\mu_s = -0.75$, $p < 0.001$), and that there were not significant interindividual differences in the patterns of change in sleep–wake problems ($\sigma_s^2 = 0.65$, N.S.: Figure 2). The mean-level decline in sleep–wake problems reflects discontinuity (rather than continuity of mean level) [48]. The nonsignificant slope variance reflects stability of sleep–wake problems (i.e. maintenance of rank order over time) [48]; in other words, youth who had the highest levels of sleep–wake problems at age 9 persistently had higher levels of such problems across ages 9 through 11, whereas youth with the lowest levels of sleep problems at age 9 had the lowest levels of such problems across ages 9 through 11 (Figure 2).

Associations between sleep–wake problems in childhood and mental health in adolescence¹

To test whether sleep–wake problems in childhood predicted mental health in adolescence, the growth model for sleep–wake problems across ages 9–11 that was obtained in the unconditional growth model was utilized to predict mental health at age 18. Because a nonsignificant slope variance was detected in the unconditional growth model, we respecified our analytic model (Figure 3), following guidelines established for structural equation modeling and growth modeling [49, 50]: (1) the intercept, but not the slope, of childhood sleep–wake problems predicted the outcome and (2) all covariates were linked to the intercept and the outcome, but not to the slope.

The first model examined whether the initial levels of sleep–wake problems at age 9 predicted externalizing behaviors at age 18. A significant positive association emerged between the intercept of childhood sleep–wake problems (age 9) and externalizing behaviors in adolescence ($B = 0.83$, $p < 0.01$; $R^2 = 0.13$, effect size = 0.15 [medium]; Table 3), independent of the levels of externalizing behaviors in childhood. Thus, adolescents who had higher sleep–wake problems at age 9 had greater externalizing behavior problems at age 18. Indicative of stability, all individuals maintained their relative positions in sleep–wake problems across ages 9–11. Furthermore, in contrast to the results of the bivariate correlation (Table 1), sleep–wake problems at age 18 were not associated with externalizing behaviors at age 18.

The second model examined whether the initial levels of sleep–wake problems at age 9 predicted depressive symptoms at age 18. Similar to findings observed for externalizing behaviors, the intercept of childhood sleep–wake problems was significantly and positively associated with depressive symptoms in adolescence ($B = 0.85$, $p < 0.001$; $R^2 = 0.22$, effect size = 0.28).

Table 1. Correlations, means, and standard deviations for sleep-wake problems, mental health, and covariates

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Sleep-wake problems, age 9	1.00														
2. Sleep-wake problems, age 10	0.35***	1.00													
3. Sleep-wake problems, age 11	0.43***	0.47***	1.00												
4. Sleep-wake problems, age 18	0.27***	0.22**	0.32***	1.00											
5. Race	0.24**	0.15*	0.30***	0.17*	1.00										
6. Sex	-0.01	-0.01	0.08	-0.04	0.05	1.00									
7. SES	-0.14	-0.05	-0.20**	-0.17*	-0.36***	0.19**	1.00								
8. Age	0.04	0.03	0.08	0.09	0.02	0.01	-0.09	1.00							
9. zBMI	0.60	0.01	0.12	0.08	0.12	-0.05	-0.13	-0.01	1.00						
10. Externalizing, ages 9–11	0.09	0.09	0.06	0.20**	0.11	-0.06	-0.31***	0.04	0.12	1.00					
11. Depression, ages 9–11	0.20**	0.25***	0.30***	0.12	0.10	-0.02	-0.09	-0.05	0.05	0.21**	1.00				
12. Anxiety, ages 9–11	0.33***	0.45***	0.38**	0.18**	0.10	-0.12	-0.07	0.02	0.10	0.09	0.58***	1.00			
13. Externalizing, age 18	0.24**	0.16*	0.23**	0.41***	-0.10	0.04	-0.11	0.06	0.08	0.18*	0.25***	0.21**	1.00		
14. Depressive Symptoms, Age 18	0.31***	0.18*	0.21**	0.46***	-0.15*	-0.26***	-0.10	0.04	0.00	0.17*	0.24***	0.25***	0.41***	1.00	
15. Anxiety, age 18	0.16*	0.24**	0.15*	0.30***	-0.25***	-0.30***	0.02	0.03	-0.09	0.09	0.18**	0.26***	0.26***	0.76***	1.00
M	18.40	17.82	16.88	21.54	–	–	2.05	12.50	0.69	48.77	4.89	8.63	50.20	8.70	10.18
SD	4.98	5.09	5.23	7.53	–	–	1.16	0.91	1.13	7.75	3.99	6.46	9.22	7.63	8.82

Race was coded as 0 = White, 1 = Black; sex was coded as 0 = female, 1 = male. SES, socioeconomic status; zBMI, standardized body mass index.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

[medium]; Table 3), with individuals maintaining their rank order in sleep-wake problems across ages 9–11. In addition, sleep-wake problems at age 18 were not concurrently associated with depressive symptoms at age 18.

The last model examined whether the initial levels of sleep-wake problems at age 9 predicted anxiety at age 18. Similar to the aforementioned findings for externalizing behaviors and depressive symptoms, a significant positive association was detected between the intercept of childhood sleep-wake problems and anxiety in adolescence ($B = 1.07$, $p < 0.01$; $R^2 = 0.41$, effect size = 0.69 [large]; Table 3), and individuals maintained their relative position in sleep-wake problems across ages 9–11. In addition, sleep problems at age 18 were not related to concurrent anxiety symptoms at age 18.

Additional analysis

Our findings indicate that the initial levels of sleep-wake problems at age 9 (i.e. intercept) predicted externalizing behavior problems, depressive symptoms, and anxiety at age 18 (Table 3). At the same time, results of the unconditional model, which showed that youth maintained their rank order in sleep-wake problems across ages 9–11 (Figure 2), suggest that persistently higher levels of sleep-wake problems from age 9 to 11 may predict mental health problems at age 18. To probe this possibility, we examined whether the same results hold if the intercept

of sleep-wake problems were rescaled at other time points in childhood. In two additional models, we rescaled the initial levels of sleep-wake problems by centering the intercept at age 10 and at age 11. Results indicated that relations between the rescaled intercepts (at age 10 and 11) and mental health outcomes at age 18 remained significant: individual differences in the levels of sleep-wake problems at age 10 ($B = 0.80$ for externalizing; $B = 0.80$ for depressive symptoms; $B = 1.00$ for anxiety; $ps < 0.01$) and at age 11 ($B = 0.80$ for externalizing; $B = 0.80$ for depressive symptoms; $B = 1.01$ for anxiety; $ps < 0.01$) predicted all the outcome variables at age 18, though the parameter estimates changed slightly (Supplemental Material, Tables S1 and S2). These results showed robust intercept effects and suggest that adolescents who had persistently higher sleep-wake problems across ages 9–11 had higher levels of externalizing behavior problems, depressive symptoms, and anxiety at age 18.

Discussion

We investigated whether sleep-wake problems in late childhood predicted poorer mental health in adolescence. We fit latent growth curve models to examine interindividual differences in the initial level and change in sleep-wake problems across ages 9–11 as well as their predictive associations with mental health at age 18. Importantly, we controlled for the effects of mental health problems in childhood (ages 9–11) and concurrent sleep

Table 2. Parameter estimates for means, variances, and fit indices for the unconditional growth models of sleep–wake problems in childhood (age 9, 10, and 11)

	No-growth	Linear (nonpositive definite)	Linear 2
Means (μ)			
Intercept (μ_i)	17.75***	18.52***	18.51***
Slope (μ_s)		−0.76***	−0.75***
Variances and covariance (σ^2)			
Intercept (σ^2_i)	11.70***	10.02***	11.43***
Slope (σ^2_s)		0.05	0.65
Intercept with slope (σ^2_{is})		0.92	0.00
Fit indices			
χ^2	15.68**	1.54	1.97***
df	6	3	4
χ^2/df	2.61	0.51	0.49
RMSEA	0.09	0.00	0.00
CFI	0.88	1.00	1.00
$\Delta\chi^2$	No-growth vs. Linear 2 $\Delta\chi^2 (2) = 13.71***$		

Unstandardized parameter estimates. i, intercept; s, slope. The intercept-slope covariance = 0.00 under the Linear 2 column indicates that it was fixed to zero due to the non-positive definite covariance matrix of the latent factor found in the previous model (see the Linear column). Significant $\Delta\chi^2$ indicates that the linear model fits better, whereas nonsignificant $\Delta\chi^2$ indicates that the no-growth model fits better. Bold indicates the results of the final model.

Figure 2. Estimated prototypical and individual growth derived from the unconditional growth models. Nonsignificant slope variances were constrained to zero for easier interpretation of the results. Red line is a prototypical growth for the full sample; gray lines is individuals' growth.

problems in adolescence (at age 18). Sleep–wake problems were stable throughout childhood, and individual differences in the level (i.e. intercept) of sleep–wake problems at age 9, 10, and 11 each predicted higher levels of externalizing behavior problems, depressive symptoms, and anxiety at age 18. Collectively, our results suggest that sleep problems at age 9 are influential for mental health outcomes at age 18, and that adolescents who persistently had higher sleep–wake problems across age 9–11 had greater levels of externalizing behavior problems, depressive symptoms, and anxiety at age 18.

On average, sleep–wake problems decreased during late childhood, reflecting discontinuity in sleep–wake problems, but youth with higher levels of sleep problems at age 9 continued to report relatively high levels of sleep problems over time, representing stability in interindividual differences in late childhood (i.e. maintenance of rank order [48]). Results of the present study are consistent with some prior findings that mean levels of sleep problems decrease through childhood [12, 14, 15, 51], although some studies have found interindividual differences in the trajectory of sleep problems from childhood to mid-adolescence [14, 51]. Developmental changes in sleep are known to occur between childhood and adolescence [17]. Thus, discrepant findings about variability in the trajectory of sleep may be related to age differences across studies. Indeed, several studies assessed change in sleep problems from earlier childhood (age 4–5) to mid-adolescence (age 14–16) and demonstrated a quadratic trajectory of sleep problems, with a notable shift emerging at age 10 [14, 51]. When sleep is examined over a wider developmental period, greater variability in trajectories of sleep may emerge.

In the present study, youth who reported higher sleep–wake problems during late childhood also reported higher levels of externalizing behaviors, depressive symptoms, and anxiety in late adolescence. These results corroborate other studies which also found that early sleep problems forecast later mental health problems [13–15]. Whether adolescent mental health is predicted by sleep problems that emerge around age 9 specifically or earlier in development cannot be determined by the present study (sleep was not measured prior to age 9) and should be examined in future studies. Although the mechanism through which childhood sleep problems predict adolescent mental health was not tested in the present study, one potential explanation is that childhood sleep problems undermine emotion regulation [10, 21, 52]. Indeed, sleep problems disrupt processes mediated in the prefrontal cortex (PFC), including executive functioning needed for emotion regulation [53, 54]. Emotion dysregulation, in turn, is a transdiagnostic risk factor associated with externalizing problems, depressive symptoms, and anxiety in youth [55]. Emotion dysregulation may trigger negative developmental cascades [56], creating difficulties across multiple domains of development (e.g. family, peer, and school) that ultimately contribute to externalizing problems, depressive symptoms, and anxiety in adolescence.

The present study advances the existing literature on sleep and mental health in several ways. First, we performed rigorous analyses that examined the unique effects of childhood sleep problems on adolescent mental health outcomes by controlling for both childhood mental health problems and concurrent adolescent sleep problems. One prior study examined the relations between early sleep problems and later externalizing and internalizing problems [15], but neither early mental health problems nor later sleep quality was covaried. Another study examined the predictive relations between sleep problems in childhood and anxiety and depressive symptoms in early adulthood [13]. Childhood internalizing problems were covaried, yet the effects of concurrent sleep problems in early adulthood were not [13], such that concurrent sleep problems may have accounted for some of the effects of earlier sleep problems on mental health in early adulthood. Building on these prior studies, we demonstrated the unique effects of sleep problems in late childhood on multiple domains of mental health in adolescence, providing compelling evidence that childhood sleep

Figure 3. The respecified model used to examine the associations between the intercept of sleep–wake problems in childhood and mental health in adolescence. SWP, sleep–wake problems. Mental Health = externalizing behaviors, depressive symptoms, or anxiety. Race was coded as 0 = White, 1 = Black; sex was coded as 0 = female, 1 = male. SES, socioeconomic status (income-to-needs ratio); zBMI, standardized body mass index.

problems increase risk for future mental health difficulties, beyond the effects of mental health in childhood and concurrent sleep problems in adolescence.

Second, expanding upon prior studies that have examined between-individual or between-group differences in early sleep to predict later mental health outcomes [13, 14], we examined individual variability in the initial level and change in sleep problems in childhood and their associations with mental health in adolescence. Gregory et al. assessed children’s sleep problems at age 5, 7, and 9 as a binary category (0 = no sign of a problem; 1 = sign of problem) [13]. Children with persistent sleep problems (i.e. classified as having a sleep problem at age 5 and/or 7 in addition to age 9) had higher odds of anxiety disorders at 21 and 26 years than their counterparts. In another study, Wang et al. assessed children’s sleep problems at age 5, 8, 10, and 14, and identified two latent trajectory groups: normal sleepers and troubled sleepers [14]. Troubled sleepers had higher mean scores on aggressive behaviors than normal sleepers. The present study examined how individuals differ in their initial level and rate of change over time [57, 58] and how such variability in the initial level or change is associated with developmental outcomes [15]. Utilizing the individual-level approach, our findings suggest that persistently higher sleep problems during late childhood predict poorer mental health in adolescence and demonstrate the importance of examining individual patterns of sleep problems as a predictor of future adjustment difficulties.

The present study has strengths and limitations. Strengths include an age span that encompasses developmental changes in sleep and mental health, as well as rigorous analytic models that assess stability and change and control

for both earlier mental health and concurrent sleep. Indeed, mean levels of sleep–wake problems declined from ages 9 through 11, and both sleep–wake problems and mental health problems were higher at age 18 than during late childhood. Another strength is the socioeconomically and ethnically diverse sample, which advances existing research on this topic with more homogenous, middle-class samples. Specifically, at the first three time points, over half of the participating families reported incomes below or near the poverty line and only 11%–13% reported incomes reflecting middle-class status, although it should be noted that SES increased for most participants by the age 18 assessment. However, participants consisted of youth living in small towns and semirural communities in the southeastern United States. This may limit generalizability of results to populations in other geographical locations or urban settings. Findings should also be interpreted based on the age range and sleep assessment utilized in the present study. The lack of interindividual variability in the trajectory of sleep–wake problems across childhood may be due to the narrow age range (age 9–11) over which the slope was calculated. Furthermore, associations between sleep and mental health were found in analyses with reliable and valid subjective ratings of sleep–wake problems; further research will be needed to explain differences in the effects of other sleep parameters obtained through various methodologies. Nonetheless, results of the present study indicate that childhood sleep problems may be stable and increase risk for poorer mental health in adolescence. Our findings suggest that early screening of sleep problems is crucial, and that intervention efforts and public policies for facilitating good sleep in late childhood may improve well-being in adolescence.

Table 3. Parameter estimates for associations between sleep–wake problems in childhood (age 9 through 11) and mental health in adolescence (age 18)

	Externalizing	Depression	Anxiety
Intercept (childhood sleep–wake problem at age 9) on			
Race	2.17***	1.87**	1.71**
Sex	0.18	0.27	0.63
SES	−0.14	−0.21	−0.25
Age	0.31	0.31	0.20
zBMI	0.13	0.11	−0.04
Childhood mental health	0.04	0.27***	0.27***
Outcome (externalizing, depression, or anxiety) on			
Intercept	0.83**	0.85***	1.07**
(Childhood Sleep–Wake Problem at Age 9)			
Race	−5.38***	−4.93***	−6.89***
Sex	1.17	−3.63***	−5.10***
SES	−0.88	−0.54	0.01
Age	0.33	−0.30	−0.56
zBMI	0.18	−0.17	−0.82
Childhood mental health	0.20*	0.21	0.04
Sleep at age 18	0.17	0.23	0.22
Means (μ)			
Intercept	18.58***	18.51***	18.50***
Slope	−0.78***	−0.74***	−0.73***
Variances (σ^2)			
Intercept	10.00***	8.70***	6.41***
Slope	0.41	0.49	0.37
Fit indices			
χ^2	14.84	21.43	20.65
df	25	25	25
χ^2/df	0.59	0.85	0.83
RMSEA	0.00	0.00	0.00
CFI	1.00	1.00	1.00
R^2 (f^2)	0.13* (0.15)	0.22*** (0.28)	0.41*** (0.69)

Unstandardized parameter estimates. Intercept, the intercept of sleep–wake problems at age 9. Race was coded as 0 = White, 1 = Black; sex was coded as 0 = female, 1 = male. SES, socioeconomic status; zBMI, standardized body mass index; Childhood Mental Health, averaged scores on externalizing behaviors, depressive symptoms, or anxiety from age 9 to 11. Adolescents' race, sex, age, and body mass index, family SES, childhood mental health from age 9 to 11, and sleep–wake problems at age 18 were included in the model as covariates. RMSEA, root mean square error of approximation; CFI, comparative fit index. f^2 , Cohen's effect size: $f^2 \geq 0.02$ (small), $f^2 \geq 0.15$ (medium), and $f^2 \geq 0.35$ (large). Bold indicates the coefficients of the associations that pertain to our hypotheses.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

Supplementary Material

Supplementary material is available at SLEEP online.

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¹On average, 7.57% of 199 children had ADHD and 19.06% were taking medication across study waves. We conducted sensitivity analyses by comparing the results of the model that included children's ADHD and medication status, which were averaged across ages 9 through 18, as covariates with the model where these regression paths were omitted. Results indicate that the intercept of childhood sleep–wake problems significantly predicted externalizing problems, depressive symptoms, and anxiety at age 18 regardless of whether ADHD and medication status were included in the models. Further, ADHD and medication status were not significantly associated with the intercept of childhood sleep–wake problems or mental health problems in adolescence.

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