



Sleep in infancy and childhood: implications for emotional and behavioral difficulties in adolescence and beyond

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Purpose of review

Extensive scientific efforts have been made in an attempt to identify early markers of behavioral and emotional problems. In this context, sleep has received considerable research attention, as it appears to be closely linked to developmental psychopathology. The present review synthesizes some of the most recent findings regarding the concurrent and longitudinal associations between psychopathology and behavioral manifestations of sleep in childhood and adolescence.

Recent findings

Recent evidence suggests that compromised sleep is associated with both internalizing and externalizing problems in childhood and adolescence. Moreover, sleep problems have been shown to predict the development of various emotional and behavioral problems, including depression, anxiety, attention-deficit hyperactivity disorder, risk-taking and aggression. Yet, inconsistencies are apparent, particularly among findings that are based on objective sleep measurement.

Summary

Taken together, most recent findings suggest that poor sleep in childhood and adolescence constitutes a risk factor for psychopathological symptoms. Accordingly, the importance of early detection and intervention should be a primary goal in clinical settings. In the research domain, the underlying mechanism of these associations should receive future research attention, in an attempt to broaden the understanding of the relationship between sleep and psychopathology.

Keywords

behavior problems, child, development, psychopathology, sleep

INTRODUCTION

During the first years of life, sleep patterns undergo rapid and conspicuous maturational processes. Significant maturational changes occur in sleep architecture [i.e., electroencephalography (EEG)-based sleep stages or spectral density] and in localization of different brain waves during different sleep stages. These changes were the focus of a recent *Current Opinion* review [1^{***}]. The focus of our current review is mainly on the behavioral manifestation of sleep, including sleep schedule, sleep duration, sleep continuity and fragmentation in infants, children and adolescents and how these aspects of sleep are related to developmental psychopathology.

The most noticeable sleep-related process in early childhood is the consolidation of sleep during the nocturnal hours and the reduction in the number of episodes and duration of daytime sleep. Sleep consolidation during the night is a rapid process

occurring most dramatically during the first 6 months [2,3]. In spite of the rapid sleep consolidation process during early childhood, many infants and children continue to suffer from fragmented sleep manifested by multiple and prolonged night wakings [4,5]. Another important developmental change is the reduction in total sleep time throughout childhood and adolescence [6–9]. The reduction in sleep duration is mostly driven by the delay in sleep onset time. This delay appears to be

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KEY POINTS

- Poor sleep quality and insufficient sleep are very prevalent problems in child development and they are closely linked to behavioral and emotional problems in children.
- Although the links between sleep and psychopathology appear to be bidirectional, the more established causal direction is that inadequate sleep may lead (or exacerbate) to compromised emotional and behavioral regulation, and thus increase the risk for psychopathology.
- Brief and effective intervention for childhood sleep problems has been developed and established. Considering the ongoing stress associated with sleep problems in early childhood and the risk for later psychopathology, early sleep problems should be identified and treated.
- Future research should focus on using both objective and subjective sleep measures in assessing sleep and its links to psychopathology; using longitudinal designs to assess the long-term impact of sleep problems and interventions aimed at resolving these problems and further identifying mediators and moderators for the associations between sleep and psychopathology.

accelerated in early adolescence and is linked to the growing prevalence of delayed sleep-phase syndrome, which is characterized by inability to fall asleep at appropriate hours, extremely late sleep onset time, difficulty waking up in the mornings (for regular school or work activities) and the associated daytime sleepiness [10]. Furthermore, research suggests that children's sleep duration is gradually decreasing over decades, such that 100 years ago children slept an average of over an hour more than children sleep today [11]. This could be attributed mainly to the rapid technological evolution introducing, electricity, artificial light and modern social media, as well as other social activities competing with sleep time. It has been estimated that close to 25% of children (ages 6–11 years) and 39% of adolescents (ages 12–17 years) in the United States suffer from insufficient sleep and its adverse correlates [12].

SLEEP AND PSYCHOPATHOLOGY IN CHILDREN AND ADOLESCENTS

Childhood psychopathology is considered a major risk factor for psychopathology in adolescence and adulthood [13–22]. Adolescence has been defined as a vulnerable period for the onset of psychopathology, and brain and hormonal changes occurring during this period have been implicated in this

growing vulnerability [23–26]. Therefore, it is crucial to identify, and if possible to treat, every risk factor that increases the vulnerability of the child or the adolescent to psychopathology. Sleep is one of the key factors that have been associated with developmental psychopathology [25,27,28^{***}, 29–32,33^{***},34,35]. The following sections will present the most recent findings regarding the associations between sleep and internalizing and externalizing problems.

SLEEP AND INTERNALIZING DISORDERS

During the last decade, there has been a growing interest in the relationships between childhood sleep problems and internalizing disorders, with many studies demonstrating that these disorders are strongly associated [27,36–40]. Most of these studies have focused on the links between sleep disturbances and depression, but other internalizing disorders and symptoms, such as anxiety [41–43], loneliness [44,45], suicidal ideation and completion [46–48], have also been the focus of research. More recent publications of cross-sectional and longitudinal studies have extended these findings and have provided substantial support for strong bidirectional links between sleep and internalizing disorders, particularly when the assessment of sleep is based on subjective measures [1^{**},28^{**}, 33^{**},49–51,52^{**},53,54].

Recent large-scale cross-sectional studies have reported associations between different facets of children's sleep, such as sleep quality, quantity and timing and between internalizing symptoms. Poor reported sleep quality (i.e., insomnia symptoms) and eveningness circadian chronotype were significantly associated with depressive symptoms in two different cross-sectional studies of the Australian adolescents [55^{*},56]. In a large survey of 10 220 adolescents, those with insomnia and who slept less than 6 h at night had an increased risk to suffer from depressive symptoms [50]. Further on, in a large cohort study of 11 788 adolescents from 11 different European countries, shorter sleep duration was associated with emotional and peer-related problems, as well as with anxiety and suicidal ideation [33^{**}]. Suicidal ideation was also strongly associated with reported sleep problems in a nonclinical sample of the Croatian adolescents [57], and in a clinical sample of adolescents admitted to a psychiatric inpatient unit [58].

Studies comparing sleep problems in children at risk for psychopathology or clinical samples and controls yielded mixed results [13,59^{*},60]. In a study of children and adolescents at high risk for depression, high-risk adolescents showed poorer sleep

[polysomnography (PSG) measures] in comparison to controls [59[■]]. However, PSG measures were not significantly different between high-risk children and controls. Children at high risk for a bipolar disorder were reported to have an increased risk of a variety of psychiatric disorders, including sleep disorders [13]. Conversely, in a recent study comparing sleep of adolescents with social anxiety disorder to controls, no significant differences were observed in actigraphic or subjective sleep measures [60]. A recent meta-analysis found only modest differences between children and adolescents with major depressive disorder and controls for both sleep microarchitecture (e.g., detailed analysis of EEG frequencies detected by PSG during sleep) and macroarchitecture features [e.g., total sleep time, sleep latency, sleep efficiency, awake time, stage 1, stage 2, stage 3, stage 4, rapid eye movement (REM) latency and REM sleep] [61[■]]. The strongest difference was found in sleep latency, with 31% of adolescents with major depressive disorder showing increased sleep latency. Because 63–99% of depressed youth had similar sleep macroarchitecture to controls, the authors concluded that the differences in sleep could not be considered as specific biological markers for depression. Similar findings of longer sleep latency and lower sleep efficiency in depressed adolescents in comparison with controls were reported in another meta-analysis [52[■]].

A central question, which has been the focus of many recent studies, is whether it would be possible to identify a directional relationship between sleep disorders and internalizing disorders in children. Indeed, recent reviews have concluded that sleep problems probably predict the onset of internalizing disorders [1[■],55[■]]. A recent meta-analysis, based on longitudinal and treatment studies, has demonstrated that sleep disturbances precede the development of depression, but there was no support for a predictive role of depression in the development of sleep disturbance [52[■]]. Longitudinal studies published in the last 2 years further support these findings [32,62[■],63,64[■]]. In addition to depression, recent studies have also focused on the links between sleep problems and self-injury. In one of these studies, difficulties initiating sleep and early morning waking were associated with increased risk of subsequent hospitalization for self-harm. However, these associations could mainly be explained by coexistent symptoms of anxiety and depression [65].

Longitudinal studies following school-aged children into adolescence have also reported significant predictive associations between sleep and internalizing symptoms. In a community-based sample of 1420 children assessed 4–7 times between ages

9 and 16 years, bidirectional predictive relationships were found between reported child sleep problems and higher prevalence of generalized anxiety disorder and depression symptoms [66]. Likewise, Perfect *et al.* [67] found that insomnia symptoms as reported by the child and parental-reported excessive daytime sleepiness were the sleep parameters most consistently predictive of reported depressive and anxiety symptoms.

Only a few studies have recently focused on sleep and internalizing symptoms of preschool children [30,68,69[■],70]. In a study of 5-year old children, poor sleep assessed objectively by EEG [69[■]] and actigraphy [70] was a significant predictor of parental-reported internalizing problems 1 year later.

In summary, accumulating evidence demonstrates strong bidirectional links between disturbed sleep and internalizing disorders in children and adolescents, and suggests that sleep disorders may precede the development of various emotional problems, particularly depression.

SLEEP AND EXTERNALIZING DISORDERS

Externalizing behaviors, such as aggression, conduct problems and risk-taking in children and adolescents, are a serious concern because of their high prevalence rates and associations with adverse outcomes and later psychopathology [71–73]. The links between sleep and externalizing problems have been the focus of several recent investigations.

Considering concurrent links, childhood behavioral problems have been found to be positively correlated with different aspects of poor sleep, including the number of night-wakings [74] and short sleep duration [75–77]. A recent large cohort study indicated that preschool children with shorter night-time sleep duration had higher odds of parent-reported overactivity, anger, aggression, impulsivity, tantrums and annoying behaviors than their peers, even after controlling for many relevant covariates [34]. Similarly, actigraphy-measured sleep duration was recently found to be inversely associated with aggression at age 5 years [78].

The associations between sleep and attention deficit hyperactivity disorder (ADHD) have drawn extensive scientific attention in the past decades. This topic has been addressed in recent years in a number of reviews and meta-analyses [79–82], and therefore only a summary of recent findings is included here.

Reported sleep problems have been significantly associated with ADHD [83,84]. It has been shown that 30% of children with ADHD have reported sleep difficulties [81]. When objective measures of

sleep are considered, the findings are less consistent. One meta-analysis found no consistent significant differences between PSG sleep measures in children with ADHD versus controls, with the exception of periodic limb movements in sleep [79]; whereas, a second meta-analysis reported that children with ADHD have lower sleep efficiencies, more sleep stage shifts and increased apnea–hypopnea index as presented in PSG studies [80]. Recent actigraphic studies have pointed to the associations between ADHD and longer sleep latency, shorter sleep duration and lower sleep efficiency [84,85].

In adolescence, sleep problems have been linked to risk-taking behaviors, such as cigarette smoking, drug abuse, risky driving and delinquency [28^{***},86]. A recent study of healthy adolescents showed that even normative levels of self-reported poor sleep quality were related to more risk-related behavior [87]. Interestingly, the authors suggest that poor sleep is associated with greater arousal to rewards and a potential lack of motivation to engage in cognitive control, which may account for their riskier behavior. With regards to more specific aspects of sleep, short sleep duration in adolescence has recently been associated with several risk-taking behaviors, such as smoking and snuffing [35]. Interestingly, a recent study found longitudinal predictive links between sleep movements at age 4.5 years and ADHD at age 18 years, but failed to find associations between childhood insomnia and elevated ADHD symptomology in adolescence [88^{*}].

Evidence from longitudinal studies suggests that childhood sleep problems are also associated with later externalizing behaviors [76,89–91]. In a recent prospective study, two specific parent-reported sleep difficulties in childhood were found predictive of later externalizing behaviors. First, sleep-movement persistence (from ages 4.5 to 9 years) was associated with externalizing at age 9 years. Second, insomnia, especially persistent insomnia, was associated with externalizing at ages 9 and 18 years [88^{*}]. Similar results were recently found concerning general sleep problems reported by parents at preschool age, which predicted school-aged externalizing problems [68]. Correspondingly, parent-reported and self-reported sleep problems in older children (assessed repeatedly between ages 9 and 16 years) predicted an increase in the prevalence of oppositional defiant disorder, even when adjusting for comorbidity and relevant covariates [66]. In contrast, a recent investigation failed to detect longitudinal links between poor sleep reported in infancy (ages 12 and 18 months) and aggression at age 5 years [78]. Nevertheless, sleep characteristics from as early as the fetal stage have been found to predict the degree of self-regulation (effortful control) both

at 8–9 years and at 14–15 years [92]. Furthermore, it has recently been proposed that measuring individual developmental trajectories in sleep patterns, as opposed to cross-sectional assessment, may be more indicative of later ADHD [93^{*}].

In adolescence, the negative consequences of sleep loss and disruptions seem to include a future tendency toward risk-taking behaviors. A recent review presented ample evidence from prospective studies, suggesting that poorer or shorter sleep predicts more alcohol and drug use, driving while intoxicated, unprotected sexual activity, multiple unintentional injuries and other health-risk behaviors [28^{***}]. Correspondingly, in a recent large cohort study, short sleep duration in adolescence was identified as a marker of delinquency in adulthood, and its effects were partially mediated by sensation-seeking and impulse control [94]. The issue of mediators and moderators of these longitudinal associations has been relatively neglected, yet several investigations have identified relevant factors, such as sex [86], socioeconomic status [95] and maternal characteristics [77,78]. Further research is warranted regarding possible mediation and moderation trajectories in this domain.

UNDERLYING MECHANISMS

Different underlying mechanisms have been proposed to explain the ubiquitous bidirectional and predictive links between sleep and behavioral and emotional problems. For instance, the interpretation that insufficient or poor sleep is the cause (or exacerbating factor) for psychopathology gains support from experimental studies on sleep restriction and extension in children. Overall, these studies lend some support to the claim that insufficient sleep can lead to compromised neurobehavioral functioning, emotion regulation, mood and other outcomes that are related to psychopathology [96^{***},97^{***},98–103].

Recently, Baum *et al.* [96^{***}] showed that following a mild sleep restriction protocol of 6.5 h in bed per night for five consecutive nights adolescents were more irritable, angry, oppositional, tense and prone to emotional outbursts according to parent-reports and self-reports, compared with a healthy sleep duration schedule (10 h sleep opportunity for five consecutive nights). Another recent study, which examined the influence of gradual sleep extension in a group of adolescents with chronic sleep reduction, found a significant decrease in depressive symptom severity at the end of the sleep extension period [97^{***}]. Davis *et al.* [99] found that sleep restriction to 4 h for one night led to riskier pedestrian behavior (e.g., impulsive road behavior)

in a virtual reality setting, in comparison with adequate sleep (8.5 h) in healthy adolescents. Thus, it seems that sleep restriction may compromise safety and well-being and lead to a variety of poor psychological outcomes in youth.

Evidence regarding the negative impact of sleep manipulations on psychopathology-related outcomes underscores the need to identify the processes responsible for this impact. One such mechanism is related to the links between sleep and emotions and emotion regulation that also address the impact of insufficient sleep on brain functions that are related to executive control and emotional information processing [104,105]. Other suggested mechanisms include overlapping genetic features [27,106] and shared family and parenting factors [107] that influence both sleep and psychopathology.

CONCLUSION

Poor (or insufficient) sleep is very common during infancy, childhood and adolescence. It appears to be a risk factor for developing psychopathology or exacerbating it during development. Both poor sleep and childhood psychopathology are precursors of adult adjustment problems and psychopathology. Poor sleep can be identified in early development and effective interventions are available [108]; therefore, the importance of early detection and treatment should be a primary goal for clinicians in the field.

Our review reveals that most studies leading to these conclusions are based on reported measures and on correlational designs. The few studies, which are based on objective measurement of sleep, have reached less conclusive findings regarding the links between sleep problems and internalizing disorders. This issues should be further explored to identify to what extent these links are mainly in the subjective domain (e.g., negative bias in depression or shared-method variance) and to what extent the objective sleep measures fail to document some meaningful aspects of reported sleep. Notwithstanding methodological issues, bidirectional links have been identified between sleep and psychopathology. Longitudinal studies suggest that sleep is a more reliable predictor of psychopathology than the opposite prediction.

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Conflicts of interest

The authors have no conflict of interest.

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