Sleep and youth suicidal behavior: a neglected field

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Purpose of review

Sleep undergoes substantial changes during adolescence and suicide risk begins to increase during this period as well. This review focuses on recent literature on the relationship between sleep and suicidal behavior and proposes directions for future research.

Recent findings

Adolescent sleep is characterized by widespread sleep restriction, irregular sleep schedules, daytime sleepiness, and elevated risk for sleep disturbances. More research on adolescent sleep and psychosocial impairment, psychiatric disorders, and suicidal behavior has been conducted. Suicidal psychiatric patients had more sleep disturbances including insomnia, hypersomnia, or nightmares than nonsuicidal patients. Shorter rapid eye movement latency and increased rapid eye movement activity have been noted to be a marker of suicidality in psychiatric patients. Epidemiological studies have demonstrated that insomnia, nightmares, and sleep insufficiency are associated with elevated risk for suicide. Although the link between insomnia and suicidal behavior appears to be mediated by depression, existing data suggest an independent predictive role of nightmares in future suicidal behavior.

Summary

Sleep loss or disturbances are likely to signal an increased risk of future suicidal action in adolescents. Large-scale prospective studies and neurobiological studies are needed for a better understanding of the complex relationship between sleep, psychopathology, and youth suicidal behavior.

Keywords

adolescence, insomnia, nightmares, sleep loss, suicidal behavior

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Abbreviations

EEG	electroencephalography
5-HIAA	5-hydroxyindoleacetic acid
OR	odds ratio
REM	rapid eye movement
SWS	slow-wave sleep

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Introduction

Suicide is a leading cause of death in young people [1]. In addition, young people engage in numerous nonlethal suicidal behaviors. A recent review of 128 studies noted that 9.7% of adolescents reported a lifetime history of suicide attempts and that 29.9% had suicidal ideation at some point [2•]. Suicide is rare in childhood, increases markedly in the late teens and continues to rise until the early twenties [2•,3,4]. Suicidal behavior in adolescence is associated with multiple biological, psychological, social, and cultural factors [3,5–8,9•]. Although a number of risk factors have been identified, curriculum-based suicide prevention programs have been less successful than expected [3,10]. On identifying specific risk domains in adolescence, progress in suicide research, treatment, and prevention hinges is, therefore, under way [10].

One of the possible risk factors that may contribute to the increase in suicide risk in adolescence is sleep changes, characterized by delayed bedtime, irregular sleep schedules, sleep restriction, and increased risk for sleep disturbances [11]. Clinical and epidemiological studies have suggested the potential link between sleep disturbances and youth suicidal behavior [12,13•,14••,15••]. In this review, we discuss recently published research on sleep characteristics and their associations with suicidality and propose directions for future research.

Characteristics of sleep in adolescents

Adolescence is a crucial period from childhood to young adulthood, accompanied by tremendous changes in biological, cognitive, and psychosocial growth and development. Marked sleep changes occurring in adolescence include going to bed later (phase delay), getting up earlier, tendencies to develop irregular sleep patterns and to not get enough sleep, and increased daytime sleepiness [11,16••,17•,18]. As adolescents mature, they get considerably less sleep than they did in preadolescence despite the fact that physiological sleep requirement does not decrease during adolescence [11,19,20]. Wolfson and Carskadon [21] reported that average sleep duration in a sample of 3120 American high-school students was 7.3 h on weeknights. Liu *et al.* [22] reported that average sleep duration in Chinese adolescents was 7.6 h on weeknights. Ohida *et al.* [23] noted that 30% of Japanese high-school students slept less than 6 h a night. Marked decline in sleep makes it difficult for adolescents to be fully alert and not to feel sleepy during the day [20,24•]. Some of these changes may be related to biological changes associated with the onset of puberty, such

as a lengthening and phase delay of endogenous circadian rhythms [11,17•,18]. Psychosocial factors also play a role, including decrease in parental monitoring and increase in time spent with peers, homework, extracurricular activities, job commitments, overuse of the Internet, earlier school start times, and life stress [11,19,22].

Adolescents are also vulnerable to sleep disturbances such as insomnia, excessive daytime sleepiness, chronic nightmares, and circadian sleep disorders [25–27]. Epidemiological studies have estimated that 14–33% of adolescents have sleep disturbances [28••] and that 10–40% of high-school students experience moderate or transient sleep deprivation [29]. In their large-scale epidemiological studies, for example, Roberts *et al.* [27, 30] reported that sleep symptoms were common among adolescents, with 17% reporting nonrestorative sleep, 6% difficulty in initiating sleep, 7% daytime fatigue, 5% daytime sleepiness almost everyday in the previous month, and 12.4% meeting symptom criteria for insomnia almost everyday.

Adverse effects of sleep loss or disturbances

Adolescents' sleep patterns and sleep disturbances are associated with negative effects on their ability to think and concentrate in school, school performance, behavior and mood during daytime hours, increased risk for injuries and accidents, major depression, drugs and alcohol use [20,24•,28••,31]. For instance, Wolfson and Carskadon [21] found that high-school students, who obtained less sleep on school nights or had greater discrepancies between school night and weekend night bedtimes, were more likely to suffer from depressed mood. Fredriksen *et al.* [16••] examined the influence of the sleep patterns of 2259 students, aged 11–14 years, on mental health longitudinally and reported that students who obtained less sleep over time reported heightened levels of depressive symptoms and decreased self-esteem. Breslau *et al.* [32] reported that individuals with insomnia were significantly more likely than those without insomnia to experience the onset of major depression [odds ratio (OR) = 4.0], any anxiety (OR = 2.0), drug abuse (OR = 7.2), and nicotine dependence (OR = 2.4) over a 3.5-year period among a cohort of young adults. Wong *et al.* [33••] found that early childhood sleep problems as reported by parents were a robust predictor for substance use in adolescence. A recent longitudinal study [34] reported that respondents with sleep disturbances because of worry at the time of the baseline interview had a twofold higher risk for developing an alcohol-related problem 12–15 years later than those without these sleep disturbances.

Experimental studies have also demonstrated the negative effects of sleep restriction on psychosocial functioning in youth. Leotta *et al.* [35] found that sleep-deprived participants aged 10–15 years reported significantly higher levels of anger, sadness, and fear toward negative slides. Sadeh and colleagues [36] investigated 77 children aged 9–12 years with extension or restriction of their sleep by an hour on three consecutive nights and reported that sleep restriction had significant adverse effects on neurobehavioral functioning but sleep extension had positive effects. In a recent experimental study of the effects of sleep restriction on a child's school performance and behavior, Fallone *et al.* [37••] reported that 1-week sleep restriction of school-aged children had a direct effect on their academic performance and attention as rated by the teachers.

Clinical and epidemiological studies on sleep disturbances and suicidal behavior

Several clinical studies have demonstrated that insomnia, poor sleep quality, and hypersomnia are associated with suicidal behavior in major depression [38–40]. Insomnia has been noted to be a clinical indicator of acute suicide risk in depressed adults [40]. A recent study of depressed children and adolescents showed that insomnia was more frequent in suicidal patients than in nonsuicidal patients (72.1 vs. 45.6%, OR = 3.03) [13•]. Frequent nightmares have also been noted to be related to suicidality in depressed patients, particularly women [41]. Notably, Bernert *et al.* [14••] reported a significant association between insomnia and suicidality in 176 psychiatric outpatients, but the significance of association disappeared after controlling for depression and sex.

Three epidemiological studies [42–44] in adult populations have examined the association between disturbed sleep and suicide. In a 20-year prospective, follow-up study of adults aged 25–64 years at baseline, Tanskanen *et al.* [42] found that frequent nightmares were a significant predictor of suicide after controlling for a number of covariates including demographics, life stress, insomnia symptoms, and depression. The relative risk increased with frequency of nightmares. In a 10-year prospective, community-based study of the aged population, Turvey *et al.* [43] reported that poor sleep quality was a significant predictor of late-life suicide. A recent cohort study of over 14 years of follow-up in 15 597 Japanese adults found that difficulty in maintaining sleep was a significant predictor of suicide (OR = 2.4) after controlling for stress and demographics [44].

Five epidemiological studies [15••,45–48] among adolescents have examined sleep problems and suicidal behavior. Choquet and Menke [45] found that those adolescents who had suicidal ideation had more insomnia symptoms and nightmares. Of those who often had nightmares, 40% reported having suicidal thought compared to 13% of those who did not have nightmares. Choquet *et al.* [46] analyzed data from two epidemiological surveys of

suicidal ideation and reported that adolescents with suicidal ideation reported more sleep difficulties than those without suicidal thoughts. Vignau *et al.* [47] reported that suicidal behaviors were more prevalent among high-school students with poor sleep than among those without sleep complaints (suicidal ideation 15 vs. 38%, suicide attempts 1 vs. 9%, $P < 0.001$, for both). Roberts *et al.* [48] examined the association of suicidal ideation with sleep disturbances with a large sample of high-school students ($n = 5423$) and found significant association of suicidal ideation with insomnia (OR = 3.4) and hypersomnia (OR = 2.8). The insomnia–suicidal ideation association remained significant although it was attenuated after controlling for other symptoms including mood disturbance (OR = 1.5). The authors concluded that sleep disturbance may be a marker not only for depression but for suicide risk. A recent study [15••] examined the association between inadequate sleep and suicidal behavior in Chinese adolescents. Results indicated that nightmares were associated with increased risk for suicidal ideation and attempts, and sleeping less than 8 h a night was associated with increased prevalence of suicide attempts after adjustment for demographics and depressive symptoms. Insomnia was associated with increased risk for suicidal behavior, but the association disappeared after controlling for depression. The author noted that the role of insomnia in suicide may be mediated through depression and that sleeping less than 8 h a night might be a cutoff for suicide risk in adolescents. All five studies described above were, however, cross-sectional and their results are not entirely consistent, possibly due to differences in sample characteristics, sleep and suicidality assessment instruments used, and covariates considered in statistical models. Clearly, there is a need for longitudinal studies that examine the occurrence of future suicidal behavior in those with and without sleep disturbances at baseline.

Electroencephalographic sleep, plasma cortisol peri-sleep-onset, and suicidal behavior

Electroencephalographic (EEG) studies have documented abnormalities in sleep patterns in psychiatric patients with suicidal behavior, including longer sleep latency, increased rapid eye movement (REM) time and increased phasic REM activity. Sabo *et al.* [49] compared sleep EEG characteristics of adult depressives with and without a history of suicide attempts and noted that suicide attempters had more REM time and phasic activity in the second REM period but less delta wave counts in the fourth non-REM period. Another study [50] conducted at the same laboratory replicated the findings with psychotic patients. On the basis of two studies, the authors [50] suggest that the association between REM sleep and suicidality may cut across diagnostic boundaries and that sleep EEG changes may have a predictive value for future suicidal behavior. REM sleep changes were later replicated by other studies in suicidal schizophrenia [51] and depression [52].

Three cross-sectional studies examined the relationship between sleep EEG and suicidality in depressed adolescents. Dahl *et al.* [53] compared sleep EEG between depressed suicidal group, depressed nonsuicidal group, and normal controls. Their results indicated that suicidal depressed patients had significantly prolonged sleep latency and increased REM phasic activity with a trend for reduced REM latency compared to both nonsuicidal depressed and control groups. Goetz *et al.* [54] and McCracken *et al.* [55] replicated the finding of greater REM density among depressive suicidal adolescents.

Two clinical follow-up studies have examined the predictive value of sleep EEG for suicidality in depressed adolescents. In a 6–8-year follow-up study, Rao *et al.* [56] failed to find any differences in sleep EEG variables between depressed patients who were suicidal over the follow-up period ($n = 6$) and those individuals without suicidality ($n = 13$). Goetz *et al.* [57] examined the predictive value of polysomnographic sleep characteristics recorded during adolescence and suicidality 10–15 years later. Multiple logistic regression analysis indicated that increased stages 3 and 4 (ST34) combined sleep and an interaction term for ST34 sleep and REM latency significantly predicted lifetime suicidality. Unfortunately, the sample sizes of all of the sleep EEG studies are small. Therefore, the findings should be viewed cautiously and further studies are warranted.

Two studies have examined the relationship between the secretion of plasma cortisol presleep and postsleep onset and suicide attempts in depressed adolescents. In a study of the 24-h cortisol secretory pattern in depressed adolescents and normal controls [58], suicidality was related to increased cortisol secretion during evening nadir period prior to sleep onset. A recent clinical follow-up study with 42 depressed adolescents and 35 normal control participants [59] compared depressed individuals who did not make suicide attempts and control participants with depressed adolescents who made suicide attempts during follow-ups. The suicidal group displayed higher levels of cortisol presleep but lower levels of cortisol approximately 2–4 h after sleep onset at initial assessment. The authors hypothesized that dysregulation of the hypothalamic–pituitary–adrenal axis, combined with dysfunction of sleep-onset mechanisms, might confer vulnerability for disorder recurrence and future suicide attempts.

Potential pathways to suicidal behavior

The combined evidence from clinical and epidemiological studies leads to a reasonable hypothesis that sleep deprivation or disturbances are associated with increased

risk for adolescent suicidal behavior. Sleep disturbances, however, are very common whereas suicidal action, especially completed suicide, is rare among adolescents. Most individuals who suffer from sleep disturbances do not take suicidal action. This may be explained by an accumulative model in which childhood adversity, mental disorders, personality factors, and exposure to acute and chronic life stressors work together and lead to suicidal behavior [2•,3,5,6]. Therefore, whether sleep deprivation or disturbances lead to suicidal behavior depends on a number of additional vulnerability and resiliency factors. We speculated that sleep disturbances may be associated with adolescent suicidal behavior by three potential pathways. First, sleep deprivation or disturbances are stressors that may increase suicide risk through independent mechanisms, perhaps by impairing cognitive judgment or impulse control, or by increasing irritability, lowering threshold for negative emotional responses, or perhaps by increasing somatic problems, fatigue, or isolation. Second, sleep deprivation or disturbances may increase risk for suicidal behavior by increasing the individual's susceptibility to psychopathology or exacerbating preexisting psychopathology. Psychopathology such as major depression, in turn, leads to suicidal behavior, especially in the setting of high stress. Third, sleep insufficiency or disturbances may interact with a number of underlying vulnerable moderators (such as hopelessness, impulsivity) and make a subset of adolescents more likely to take suicidal action.

Potential neurobiological mechanisms

Sleep disturbances and suicidal behavior may share neurobiological mechanism, particularly in regard to decreased serotonin functioning. The serotonergic system has been thought to be the most plausible biologic system implicated in suicidality [60]. Research has demonstrated reduced serotonergic activities in suicide victims independent of psychiatric diagnosis [60,61]. Postmortem studies have found lower concentrations of serotonin (5-HT) levels in the brainstems of suicide victims [60]. Some studies have indicated that low cerebrospinal fluid (CSF) 5-hydroxyindoleacetic acid (5-HIAA, the principal metabolite of 5-HT) is associated with suicide attempts or completed suicide in psychiatric patients [62]. Positron emission tomography (PET) of the brain has indicated that prefrontal localized hypofunction and impaired serotonergic responsiveness were proportional to the lethality of suicide attempts [63]. A decreased 5-HIAA is also noted to be a biological marker of a lowered threshold for impulsive, aggressive, and violent behaviors [64]. Recent studies have scrutinized the serotonin transporter (SERT) as a potential substrate for the pathophysiology of suicide even though results are not unequivocal [65].

Serotonin is also involved in regulating the sleep–wake cycle [66]. Specifically, 5-HT is thought to facilitate the onset of sleep, to contain REM sleep within discrete periods, and to contribute to the maintenance of slow-wave sleep (SWS). Firing rates of serotonergic neurons are closely related to sleep–wakefulness states, being highest during waking, reduced during SWS, and minimal during REM sleep [66,67]. The measures of SWS were correlated with CSF 5-HIAA in patients with major depression and schizophrenia [68,69]. Administration of serotonin agonist suppresses REM sleep and markedly increases SWS in healthy participants [70], suggesting that reduced serotonergic activities may cause increased REM time and activity as observed in suicidal patients. Sleep disturbances or loss may also cause alterations in the serotonergic system. In a recent study of sleep restriction with rats, Roman *et al.* [71••] reported that after 8 days of sleep restriction, the sensitivity of the 5-HT1A receptor system was desensitized, independent of stress and forced activity. In addition, the authors found that the desensitization of the 5-HT1A system persisted for many days even with unlimited recovery sleep.

Recent neuroimaging studies using [^{18}F]-fluoro-deoxyglucose positron emission tomography (FDG PET) may shed further light on the neurobiology of sleep, depression, and suicidality. Results indicate that non-REM sleep in depression and insomnia is characterized by a relative 'hyperarousal', or failure to decrease activity in cortical, paralimbic, and subcortical arousal centers during sleep [72••,73••,74]. Insomnia has been suggested to be a marker of altered regional brain activity that impacts upon frontal–limbic interactions and thus may be linked to depression and suicidality [75]. Larger REM sleep-related increases in midbrain reticular formation, anterior paralimbic cortex, and dorsolateral prefrontal cortex among depressed patients compared to controls, consistent with the hypothesis of increased limbic activation during REM [76]. Limbic activity during REM sleep may relate to the hypothesized abnormalities of cholinergic and serotonin metabolism in suicidal depressive people.

Conclusion

Clinical and epidemiological studies suggest that sleep loss or disturbances are likely to signal an increased risk of future suicidal action in adolescents. Several cross-sectional studies have, however, yielded inconsistent results, possibly due to methodological differences. Sample sizes of all clinical follow-up and sleep EEG studies are rather small. No longitudinal studies in the general adolescent population are available. The relative paucity of information addressing these important concepts of sleep and youth suicidal behavior warrants more systematic and prospective studies that would help to understand the psychological and neurobiological mechanisms of suicidal behavior in a better way. Such studies could lead to innovative strategies for intervention and

prevention of suicidal behavior in adolescence. In addition, studies should be undertaken to determine the effects of adequate sleep and sleep-hygiene promotion on youth's mental health and suicidal behavior. These intervention studies may help us learn more about the fundamental role of sleep dynamics in youth depression and suicidality.

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