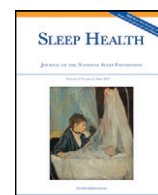




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## Relationships between school start time, sleep duration, and adolescent behaviors

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### ABSTRACT

**Objectives:** The objectives were 2-fold: (1) to examine how high school start times relate to adolescent sleep duration, and (2) to test associations between sleep duration and mental health- and substance use-related issues and behaviors in teens.

**Design:** This study examines selected questions from survey data collected between 2010 and 2013 high school students.

**Setting:** Respondents included more than 9000 students in grades 9 to 12 in 8 high schools in 5 school districts across the United States.

**Measurements:** The survey instrument is the 97-item *Teen Sleep Habits Survey*. Logistic regression models were used to calculate adjusted odds ratios and 95% confidence intervals. Because of clustering within schools and the use of repeated measures, generalized estimating equations were used to account for variance inflation.

**Results:** Greater sleep duration was associated with fewer reports of various mental health- and substance use-related issues and behaviors (all *P* values <.01). For instance, for each additional hour of sleep reported, there was a 28% reduction in the adjusted odds of a participant reporting that he or she felt "unhappy, sad, or depressed." Later wake-up times were associated with a reduction in risk for some, but not all factors. Later start times were significantly associated with greater sleep duration.

**Conclusions:** Given that later start times allow for greater sleep duration and that adequate sleep duration is associated with more favorable mental health- and substance use-related issues and behaviors, it is important that school districts prioritize exploring and implementing policies, such as delayed start times, that may increase the amount of sleep of adolescent students, which is needed for their optimal development.

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### Introduction

Adolescent mental health concerns and risky behaviors including substance use (nicotine, alcohol, and other drug use) are immediate causes of substantial morbidity, mortality, and social problems for youth. In addition, these types of adolescent issues can set the stage for chronic lifelong health issues. Many of these risk factors are common among adolescents. For instance, in the 2015 Youth Risk Behavior Surveillance System, 32.3% of high school students reported ever trying a cigarette, 32.8% reported using alcohol in the past 30 days, and 21.7% reported using marijuana in the past 30 days.<sup>1</sup> Mental

health concerns are also prevalent among adolescents, with 8.3% of 12- to 17-year-olds reporting 14 or more mentally unhealthy days in the past month in the 2005–2010 National Health and Nutrition Examination Survey.<sup>2</sup> In the National Survey of Children's Health, 7.1% of parents reported that their child aged 12–17 years had ever received a diagnosis of depression<sup>2</sup> which may be an underestimate of true prevalence, as some depression is undiagnosed.

In recent years, sleep deficiency has received increasing attention as being a potential component cause in the development of both substance use and mental/behavioral health concerns among youth. A likely pathway for this connection is that lack of sleep is known to diminish teens' executive cognitive functioning and emotional regulation.<sup>3</sup> In the area of substance use, a recent analysis from the cross-sectional Monitoring the Future study demonstrated that the frequency of obtaining 7 or more hours of sleep per night was associated with a reduced risk of using cigarettes, alcohol, marijuana, and

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amphetamines,<sup>4</sup> which echoes other cross-sectional reports on sleep deficiencies and substance use.<sup>5–9</sup>

With regard to mental well-being, shorter sleep duration among adolescents is associated with lower self-esteem,<sup>10</sup> a more negative attitude toward life,<sup>11</sup> greater difficulty with emotional regulation,<sup>12</sup> higher rates of mood disorders,<sup>8,9,13–16</sup> and more thoughts of suicide.<sup>9,16–18</sup> This association between sleep issues and mental health persists into young adulthood. Sleep disorders have been correlated with lower working memory capacity and poorer mental health among emerging adults.<sup>19,20</sup> There is also evidence that week-day/weekend discrepancies in sleep duration and timing relate to poorer mental health and behavioral outcomes as well.<sup>8,9</sup> Short sleep duration in adolescents has further been cross-sectionally correlated with unsafe behaviors that are expressions of mental health and substance use problems such as weapon carrying, fighting, and drunk driving.<sup>15,21,22</sup>

There is an epidemic of short sleep duration among American adolescents.<sup>23</sup> High school students often seem to stay up too late at night and then have difficulty getting out of bed the next morning. Although an estimated 9 hours 15 minutes of sleep may be optimal for adolescents,<sup>24</sup> results from many studies have found that, on average, most adolescents report sleeping less than 8 hours on school nights.<sup>25–28</sup> Although there are social and environmental factors that influence adolescents' sleep behavior, such as peer pressure, homework, and screenuse, research on the sleep-wake cycle of teens over the past 30 years has identified changes in specific biological processes that occur with the onset of puberty. These biological changes unique to adolescents cause them to feel sleepy at a later time in the evening, as compared with the sleep-wake patterns of younger children.<sup>29</sup> Given this biological obstacle to adolescents being able to successfully fall asleep at earlier hours, having an inflexible early wake-up time, such as the time that school starts each morning, limits teens' sleep duration. Thus, early-start high schools have been identified as an important external condition that likely affects the amount of sleep teens obtain on school nights.<sup>30,31</sup> The accumulation of evidence showing the detrimental effects of early high school start times on adolescents' sleep duration, performance in school, and safety led the American Academy of Pediatrics to issue a policy statement in 2014 recommending that all high schools start no earlier than 8:30 AM.<sup>32</sup> However, as recently as 2011/2012 (the most recent year for which national data are available), fewer than 15% of US high schools were in line with this recommendation.<sup>33,34</sup>

Given previous research on outcomes for students attending high schools with later start times,<sup>25,29,30</sup> in this study we sought to test how school start times related to both adolescent sleep duration and wake-up times. We also aimed to test how these 2 factors of sleep duration and wake-up times related to mental health- and substance use-related behaviors. We hypothesized that later start times would be associated with greater sleep and later wake-up times. Furthermore, we posited that more sleep would be associated with fewer mental health and substance use risks.

## Participants and methods

### Participants

From 2010 to 2013, 9089 attendees in grades 9 to 12 of 8 comprehensive high schools in 5 school districts across the United States were invited to take a paper-and-pencil survey, administered in school, on sleep and selected health, academic, and behavioral issues. Table 1 displays the 8 schools that were included in this study, their start times, and when the data were collected. Students in Jackson Hole (WY) High School were surveyed twice, once in 2012, and a second time in 2013 after the school had made a start time change. All other schools

were surveyed just once, during the 2010/2011 school year. Detailed methodology of this study has been previously reported.<sup>30</sup>

### Measures

Participants were administered the 97-item *Teen Sleep Habits Survey*, which was based on the *School Sleep Habits Survey*.<sup>35</sup> The survey asked participants to write in their usual school-night bedtime and school-day wake-up time. For this analysis, "sleep duration" was calculated by counting the number of hours between self-reported school-night bedtime and self-reported wake-up time. Given that participants may fall asleep somewhat after their bedtime and/or may wake once or more during the night, and/or may "snooze" even after their school day wake-up time, our measure of sleep duration is an estimate, with some likely inherent error. A study by Wolfson et al<sup>36</sup> found that subjective data using student self-report of sleep and wake times on a survey are sufficiently aligned with objective measures of sleep using actigraphy. Hence, we are confident that the sleep duration data we obtained are a valid measure for this large population.

We examined mental health and substance use factors in relation to sleep. Mental health-related issues were assessed using 8 items, each of which questioned participants how frequently in the previous 2 weeks they were "bothered or troubled" by (1) feeling too tired to do things; (2) having trouble going to sleep or staying asleep; (3) feeling unhappy, sad, or depressed; (4) feeling hopeless about the future; (5) feeling nervous or tense; (6) worrying too much about things; (7) bad nightmares or bad dreams during the night; and (8) done dangerous things without thinking. Response options for each of these outcomes were "never," "once," "twice," "several times," and "every day/night." We dichotomized participant responses for each question into those who reported "twice" or less vs those who responded "several times" or more.

Substance use was assessed through participant self-report. Five separate questions about a range of substances were asked, using the same response set for each question. Participants were asked if they had done the following in the past 2 weeks: (1) drank a beverage with caffeine (Coke, Pepsi, Monster, Mountain Dew, Red Bull), (2) drank coffee or tea with caffeine, (3) used tobacco (cigarettes, cigars, chewing tobacco, etc), (4) drank alcohol, and (5) used drugs. Response options for each question were "never," "once or twice a week," "once a day," and "several times a day." For purposes of analysis, for the tobacco, alcohol, and drugs items, we dichotomized the responses, such that only participants who reported "never" were categorized as nonusers; those reporting "once or twice a week" or more were categorized as users. For the analysis of caffeine use, we combined the 2 caffeinated beverage items and dichotomized persons into those who reported drinking any caffeine beverage "never" or "once or twice a week" vs "once a day" or more.

### Statistical analysis

Logistic regression models were used to compute the association and 95% confidence intervals between the school start time that participants experienced and their school-day wake-up time, as well as school-night sleep duration. We also tested and quantified the association between sleep variables (sleep duration and wake-up time) and the mental health- and substance use-related items. To address variance inflation due to clustering by school, school district, and repeated measures on some individual students (specifically Jackson Hole High, the one high school surveyed in 2 consecutive years), we used generalized estimating equations. All models were adjusted for the following individual-level confounders: grade level, gender, racial/ethnic background, usual academic letter grades, and use of medication to help with concentration or a learning disability. We also adjusted for the potential school-level confounder: percentage

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