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High school start times after 8:30 AM are associated with later wake times and longer time in bed among teens in a national urban cohort study

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ABSTRACT

Objectives: High school start times are a key contributor to insufficient sleep. This study investigated associations of high school start times with bedtime, wake time, and time in bed among urban teenagers.
Design: Daily-diary study nested within the prospective Fragile Families and Child Wellbeing Study.
Setting: Twenty US cities.
Participants: Four hundred thirteen teenagers who completed ≥1 daily diary report on a school day.
Measurements: Participating teens were asked to complete daily diaries for 7 consecutive days. School-day daily diaries (3.8 ± 1.6 entries per person) were used in analyses (N = 1555 school days). High school start time, the main predictor, was categorized as 7:00-7:29 AM (15%), 7:30-7:59 AM (22%), 8:00-8:29 AM (35%), and 8:30 AM or later (28%). Multilevel modeling examined the associations of school start times with bedtime, wake time, and time in bed. Models adjusted for age, sex, race/ethnicity, household income, caregiver's education, and school type.
Results: Teens with the earliest high school start times (7:00-7:29 AM) obtained 46 minutes less time in bed on average compared with teens with high school start times at 8:30 AM or later ($P < .001$). Teens exhibited a dose-response relationship between earlier school start times and shorter time in bed, primarily due to earlier wake times ($P < .05$). Start times after 8:30 AM were associated with increased time in bed, extending morning sleep by 27-57 minutes ($P < .05$) when compared with teens with earlier school start times.
Conclusion: Later school start times are associated with later wake times in our large, diverse sample. Teens starting school at 8:30 AM or later are the only group with an average time in bed permitting 8 hours of sleep, the minimum recommended by expert consensus for health and well-being.

Introduction

The majority of teenagers (teens) in the United States (US) of America have insufficient sleep. Data collected from the Youth Risk Behavior Survey in 2015 showed that 73% of high school students reported less than 8 hours of sleep on school nights.[1] The American Academy of Sleep Medicine Consensus Statement and the National Sleep Foundation's Consensus Statement on sleep both recommend that teens obtain 8-10 hours of sleep per night.[2,3]

Melatonin secretion patterns, a reliable indicator of circadian timing, are delayed in both onset and offset relative to the dark/sleep period during puberty, triggering relatively later bedtimes and desired later wake times in teens.[4,5] These physiological changes in circadian timing are incompatible with the daily life contexts of contemporary US teens. Social pressures, schoolwork, employment, familial schedules, extracurricular activities, and electronic devices are all factors that further delay teens' circadian patterns, interfering with sleep.[6,7] Furthermore, early school start times (SSTs) that require early morning wake times may present a temporal obstacle

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to sufficient nighttime sleep. For most teenagers, the ideal sleep/wake patterns would consist of an 11:00 PM bedtime and an 8:00 AM wake time.[8]

Adequate sleep in teens has been linked with overall academic success and improvements in memory, learning, and attention.[9–11] Sufficient sleep in teens has also been linked with improved mood and health[8] and decreased sports-related injuries,[12] motor vehicle accidents,[13] tardiness and school dropouts,[8] and daytime sleepiness.[8] Given the importance of sufficient sleep during this developmental period, the American Academy of Pediatrics recommends that middle and high schools begin after 8:30 AM.[14]

The purpose of this study was to examine the association of SSTs (ie, 7:00-7:29 AM, 7:30-7:59 AM, 8:00-8:29 AM, and 8:30 AM or later) on sleep timing and time in bed. Teen sleep timing and time in bed were measured by daily logs of bedtime, wake time, and SST (daily diaries) over 1 week. We had 2 specific hypotheses in this study. First, we hypothesized that (1) compared with later SSTs (ie, 8:30 AM or later), earlier SSTs would be associated with earlier wake times. Second, we hypothesized that (2) earlier SSTs would be associated with shorter time in bed than later SSTs, which we investigated using a time in bed variable constructed from the reports of bedtime and wake time. We did not expect to find a relationship between earlier SSTs and earlier bedtimes due to the delayed circadian timing of sleep propensity typically seen during adolescence. Finally, to evaluate current consensus and clinical recommendations,[2,3] we examined categorical start times before and after 8:30 AM for their association with bedtime, wake time, and time in bed, hypothesizing that SSTs after 8:30 AM would be associated with later wake times and longer time in bed.

Methods

Data

Prospective data collection included daily diary data from a subsample of the parent study, the Fragile Families and Child Wellbeing Study (www.fragilefamilies.princeton.edu). The parent study follows a longitudinal birth cohort of children born between 1998 and 2000 in 20 US cities, with an oversampling of nonmarital births. The cohort was designed to create a national urban sample, randomly selecting cities with >200,000 people and then sampling hospitals within those cities and then births within those hospitals.[15] Mothers were initially interviewed in the hospital within 2 days of their child's birth (baseline survey), and follow-up interviews were completed by parents (including fathers if available) and primary caregivers when the focal child was ages 1, 3, 5, 9, and 15. Eligibility for the age 15 wave of the study required participation in the original birth cohort and the age 9 wave of data collection. Separate primary caregiver surveys were used to collect information about the teen's age and sex (baseline survey), teen's household income level, primary caregiver education level, and the type of school the teen attends (age 15 wave, primary caregiver survey). Teen's report of race was collected from the age 15 wave survey.

Of the 3055 eligible teens in the age 15 wave, a randomly selected subset of 1021 teens participated in this nested daily diary study. Participants were asked to complete Web-based electronic daily diaries to report their nightly sleep and SSTs.

The final analytic sample of this nested substudy included 413 high school students who provided at least 1 school day of diary data during nonsummer school months and provided complete daily diary data on school attendance, SST, bedtime, and wake time. The analytic sample was reduced because of teens who (1) provided daily diary entries during summer months (June, July, or August) (315 teens); (2) did not provide at least 1 school day of diary data (175 teens); (3) were homeschooled or did not report type of school (9 teens); (4) were in middle school (58 teens); and (5) did not provide data on SST, or both bedtime and wake time, or 1 or more covariate variables (51 teens). The included and excluded teens within the nested study did not differ by sex, ratio of household income to poverty, primary caregiver education level, or school type. However, compared with teens who were excluded from analyses (608 teens), the teens who were included in the final analytic sample (413 teens) were approximately 1 month older ($M = 15.5$ vs $M = 15.4$, $P < .05$), and a lower proportion were white teens (14% vs 19%, $P < .05$).

Compared with the teens in the parent study who did not participate in the nested study, the teens included in our nested substudy sample did not significantly differ with regard to poverty threshold, primary caregiver education level, and school type. Teens included in our nested substudy sample (N = 413) differed with regard to age, sex, and race from the teens who participated in only the age 15 wave of the larger parent study. Teens in our nested substudy sample were younger ($P < .05$) by about 7.5 months, consisted of more females (54% vs 47%, $P < .05$), and had more Hispanic/Latino teens (31% vs 23%, $P < .001$) than those who did not participate in the nested substudy.

Procedure

Teens were asked to complete an online daily diary each evening, beginning after 7:00 PM, during 7 consecutive days, including school days and nonschool days during both the *academic year* and the *summer*, which we defined as September through May and June through August, respectively. On average, the sample completed this diary at 9:31 PM. Most participants completed the daily diary online through a computer, tablet, or smart phone; 6 did not have access to the Internet and used a paper diary. Each diary entry took an average of 9.3 minutes to complete. Variables of interest collected from each diary entry included the previous night's bedtime, the time the teen woke up in the morning, whether or not the teen went to school, and the SST. Among the total diary entries, we used only school-day entries during nonsummer school months (1555 school-day observations). Sociodemographic variables were obtained from primary caregivers (mostly mothers) during field interviews and also from teens at the age 15 survey.

Measures

Predictor

School start time. Each school day, the daily diary asked teens, "What time did your school day begin?" Responses were coded in the hour:minute AM/PM format. The intraclass correlation of the reported SSTs indicated that there were 47 teens with any variation (1 or more instance where the difference between SST and mode SST is nonzero, mean = 0.99 hour, ±1.24 hours) in SST at the individual level (intraclass correlation = 0.44) presumably due to occasional delays (eg, weather, examinations). The SST variable was coded as a continuous variable. Analyses examined SST as a continuous variable and investigated the associations with bedtime, wake time, and time in bed. Next, for ease of interpretation, SSTs were further broken down into categories to compare teens with SSTs before the recommended 8:30 AM start time with teens with SSTs 8:30 AM or later. To further examine the associations of teens' usual range of SSTs during a week, we used the mode of SSTs across school days and created a categorical indicator of SSTs: 7:00 ≤ x < 7:30 AM was coded as 0, 7:30 ≤ x < 8:00 AM was coded as 1, 8:00 ≤ x < 8:30 AM was coded as 2, and x ≥ 8:30 AM was coded as 3. The mode of the SSTs, the most frequently reported SST for each teen, was used to identify the most probable SST without the influence of school delays.

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