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A quasi-experimental study of the impact of school start time changes on adolescent sleep

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ABSTRACT

Objective: To determine whether simultaneous school start time changes (delay for some schools; advance for others) impact adolescents' sleep.
Design: Quasi-experimental study using cross-sectional surveys before and after changes to school start times in September 2015.
Setting: Eight middle (grades 7-8), 3 secondary (grades 7-12), and 8 high (grades 9-12) schools in Fairfax County (Virginia) public schools.
Participants: A total of 2017 (6% of ~34,900) students were surveyed before start time changes, and 1180 (3% of ~35,300) were surveyed after.
Intervention: A 50-minute delay (7:20 to 8:10 AM) in start time for high schools and secondary schools and a 30-minute advance (8:00 to 7:30 AM) for middle schools.
Measurements: Differences before and after start time changes in self-reported sleep duration and daytime sleepiness.
Results: Among respondents, 57.5% were non-Hispanic white, and 10.3% received free or reduced-priced school meals. Before start time changes, high/secondary and middle school students slept a mean (SD) of 7.4 (1.2) and 8.4 (1.0) hours on school nights, respectively, and had a prevalence of daytime sleepiness of 78.4% and 57.2%, respectively. Adjusted for potential confounders, students with a 50-minute delay slept 30.1 minutes longer (95% confidence interval [CI], 24.3-36.0) on school nights and had less daytime sleepiness (−4.8%; 95% CI, −8.5% to −1.1%), whereas students with a 30-minute advance slept 14.8 minutes less (95% CI, −21.6 to −8.0) and had more daytime sleepiness (8.0%; 95% CI, 2.5%-13.5%).
Conclusions: Both advances and delays in school start times are associated with changes in adolescents' school-night sleep duration and daytime sleepiness. Larger changes might occur with later start times.

Introduction

Leading medical and public health organizations, including the American Medical Association,[1] the American Academy of Pediatrics,[2] and the US Department of Health and Human Services,[3] recognize that chronic sleep loss is at epidemic levels among US adolescents and have documented how sleep loss impacts health, the likelihood of engaging in risk-taking behaviors, safety, and academic achievement. Early school start times (SSTs) (ie, before 8:30 AM) have been identified as a major contributor to deficient sleep in teens[2] due to a combination of associated insufficient sleep duration and circadian misalignment that reflects the conflict between school schedules and biologically based pubertal changes in circadian rhythms. Previous research suggests not only that early SSTs for both middle and high school students are associated with diverse and serious adverse sleep, health, safety, and education outcomes but that delaying SSTs may mitigate the impact of negative consequences, such as higher rates of self-reported depression,[4,5] increased car crash rates,[6–9] more school absences and higher dropout rates,[10] lower graduation rates,[11] deficits in attention[12] and vigilance,[13] poorer grades, and lower standardized test scores.[9,14–17]

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Although SSTs have emerged as one of the key potential remediable factors in addressing a growing health crisis, a number of critical knowledge gaps remain.[18] Examining the impact of SSTs requires a comprehensive and detailed approach to assessing sleep outcomes. For example, impacts on sleep duration, sleep timing, and daytime sleepiness are important to assess because they are the primary mechanisms that likely mediate the potential impacts of start time changes on health, safety, and educational outcomes. However, the methodologies used, extent of start time change, populations examined, and scope of sleep parameters assessed vary across studies, leading to some inconsistencies in the findings.[18] For example, only a handful of studies have demonstrated the positive impact of later SSTs using a prospective pre-post quasi-experimental design,[4,5,19] and the generalizability of the findings from these studies may be limited because all involved homogeneous student populations in small independent or public high schools. The only evaluation of SST change in a large, diverse public school district (Minneapolis, MN) lacked baseline data on sleep and other health outcomes and compared students with those in another district with a later start time, potentially confounding effects of SST with other individual, school, or community factors.[10,20] Not all studies have assessed differences in weekday/weekend sleep patterns, which can serve as indicators of both sleep debt and circadian misalignment. Moreover, although most studies have included some measure of daytime sleepiness,[4,5] few have included data regarding napping as a strategy to offset chronic sleep loss. Finally, although many school districts that have delayed high SSTs have used an approach involving a simultaneous advance in either middle or elementary SSTs, no study has assessed the impact on sleep of this multipronged strategy.

This study addresses a critical gap in the literature by prospectively examining key outcomes related to adolescent sleep in one of the largest public school districts in the US before and after SST changes. The purpose of this study was to determine whether 2 simultaneous SST changes—a 50-minute delay in high/secondary schools and a 30-minute advance in middle schools—impacted adolescents' sleep duration, sleep timing and schedule regularity, daytime sleepiness, napping, and satisfaction with sleep. Given these relatively modest changes in start times and a delayed high SST that was still before the recommended time of 8:30 AM or later,[2] we hypothesized that the delay and advance in start times would be associated with, respectively, modest positive and negative changes in sleep duration, timing, and regularity; daytime sleepiness and napping; and satisfaction with sleep.

Participants and methods

Using a quasi-experimental design with repeated cross-sectional school surveys, we evaluated the impacts of changes in SST in Fairfax County (Virginia) public schools, the 10th largest US school district.[21] In September 2015, 2 district-wide changes were implemented[22]: (1) a 50-minute delay, from 7:20 to 8:10 AM, in the 24 high schools (grades 9-12, including 22 traditional high schools and 2 alternative high schools) and 3 secondary schools (grades 7-12) and (2) a 30-minute advance, from 8:00 to 7:30 AM, in the 23 middle schools (grades 7-8). Between March and June of 2015, before SST changes went into effect, we conducted an online survey of students and their parents in 8 middle schools, 8 high schools, and all 3 secondary schools. These 19 schools were selected to be representative of the entire district with regard to student race/ethnicity and family income. Between March and June of 2016, after implementation of the SST changes, another online survey of students and their parents was conducted in the same 19 schools. Using self-report data from these cross-sectional surveys, we examined the impact of 2 simultaneous SST changes—a 50-minute delay and a 30-minute advance—on students' sleep and sleep-related outcomes.

Survey design

The questionnaires and survey administration protocols were identical in each cross-sectional assessment. The survey protocols were designed, by school-district request, to protect class time (no in-class administration), minimize disruptions (no direct e-mail or cell phone contact with students by the research team), and obtain parental consent. We attempted to make the surveys available to all students in the sampled 19 schools. Parents (or primary caregivers) at each school received an invitation to participate in the study by way of a district-sponsored e-mail, followed by 3 reminder e-mails. Parents were asked to complete an online survey and to grant electronic consent for their child to complete a survey. Students with parental consent were sent a link via e-mail to a separate online student survey. Upon completion of the survey, students were provided a $5 Amazon gift card.

Of the students enrolled in the 19 schools, we received complete surveys from 2020 before the SST changes (6% of ~34,900) and from 1182 after the SST changes (3% of ~35,300). We excluded from our analysis 2 students aged <12.0 years and 3 students >19.0 years, leaving final samples of 2017 before SST changes and 1180 after SST changes. Compared with the overall population of students in grades 7-12 in the district, those in our survey samples were more often non-Hispanic white (before changes, 60.7% vs 42.1%; after changes, 52.0% vs 41.0%) and less often received free or reduced-price school meals (before changes, 8.1% vs 27.4%; after changes, 14.0% vs 27.6%). Study procedures were approved by the school district's Research Screening Committee and the Institutional Review Boards at the Children's National Medical Center and Temple University.

Measures

Sleep duration, timing, and schedule regularity

Sleep duration was based on student responses to separate questions about usual bedtime on school nights and wake time on school days (school-night sleep duration) and usual bedtime on nights preceding non–school days and wake time on non–school days (weekend sleep duration).[23] Sleep duration was calculated as the difference in hours between these times after excluding 35 cases with implausible school-night bedtimes (<7 PM or >3 AM), wake times (<3 AM or >8:30 AM), or calculated duration (<4 or >12 hours) and 23 cases with implausible weekend bedtimes (<7 PM or >5 AM), wake times (<3 AM or >4 PM), or calculated duration (<4 or >15 hours). Weekend oversleep was calculated as the difference in hours between weekend sleep duration and school-night sleep duration.[23] Weekend delay was calculated as the difference in hours between weekend bedtime and school-night bedtime.[23] All sleep measures had statistically normal distributions and were used in our analysis as continuous variables.

Daytime sleepiness, napping, and sleep satisfaction

Daytime sleepiness was self-reported using a modified version[24] of the 10-item Sleepiness Scale in the Sleep Habits Survey.[23,25,26] Students were asked if they had "struggled to stay awake or fallen asleep" in 10 situations during the last 2 weeks. Response options included "never" (0), "Yes, I struggled to stay awake" (1), and "Yes, I fell asleep" (2), and students also indicated if a situation did not apply to them. A score between 0 and 2 was calculated by summing across the situations and dividing the number of situations that applied to the student, with higher scores indicating greater daytime sleepiness. The Cronbach α of the modified scale was .78. Because scores were skewed toward low sleepiness (28.3% had a score of 0), a binary measure was developed for daytime sleepiness: no daytime sleepiness (sleepiness score = 0); daytime sleepiness (sleepiness score > 0).

Students were asked to report the number of school days during the past 2 weeks that they took a planned or scheduled nap. A binary

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