Effects of school start time on students' sleep duration, daytime sleepiness, and attendance: a meta-analysis

Jennifer M. Bowers, MA *, Anne Moyer, PhD

Stony Brook University

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ABSTRACT

Research conducted over the past three decades finds that many children and adolescents do not meet recommended sleep guidelines. Lack of sleep is a predictor of a number of consequences, including issues at school such as sleepiness and tardiness. Considering the severity of this public health issue, it is essential to understand more about the factors that may compromise children's and adolescents' sleep. This meta-analysis examined the effects of school start time (SST) on sleep duration of students by aggregating the results of five longitudinal studies and 15 cross-sectional comparison group studies. Results indicated that later starting school times are associated with longer sleep durations. Additionally, later start times were associated with less daytime sleepiness (7 studies) and tardiness to school (3 studies). However, methodological considerations, such as a need for more longitudinal primary research, lead to a cautious interpretation. Overall, this systematic analysis of SST studies suggests that delaying SST is associated with benefits for students' sleep and, thus, their general well-being.

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The amount of sleep needed for optimal functioning varies widely across the lifespan; the National Sleep Foundation recommends newborns sleep for 14 to 17 hours per night, whereas an older adult requires approximately 7 to 8 hours.[1] Although adolescence is a time of transition to adult lifestyle and responsibilities, an adolescent between the ages of 14 and 17 needs more sleep than the average adult: 8 to 10 hours[2]; 12- and 13-year-old children should sleep for 9 to 11 hours per night for optimal functioning.[1] In actuality, studies measuring adolescent nightly sleep estimate that between 66% and 92% of adolescents in the United States do not meet these nightly sleep requirements.[3–5]

The importance of sufficient sleep

Students need to be mentally alert to sufficiently learn during school. Diminished reasoning and verbal skills have been associated with sleep deprivation in middle and high school students.[6] Insufficient sleep interferes with the memorization process, with specific negative effects observed for working memory and the memory consolidation processes, both essential for learning in the classroom.[7–9]

Furthermore, lack of sleep has been associated with increased tardiness to class and disciplinary actions.[10*]

The mental alertness gained from sleep is also essential for safe motor vehicle operation. Fine motor skills and reaction times suffer in sleep-deprived adolescent populations.[11] Rates of car crashes have been demonstrably higher in districts in which schools start earlier in the day, along with fewer recorded total minutes of sleep.[12*–14]

Lack of sleep during adolescence may result in symptoms of mental health diagnoses, including depression and anxiety.[15] Inadequate sleep duration may lead to poor health behavior decisions, including overeating; skipping exercise; or misusing drugs such as caffeine, nicotine, or other stimulants.[16,17] Serious physical symptoms such as increased heart rate and blood pressure can result from prolonged sleep deprivation.[18] Sleep disorders may also develop as a result of poor sleep habits, including insomnia, restless leg syndrome, and sleep apnea.[19] Lack of sleep can lead to insulin resistance and changes in hormones which may lead to obesity or diabetes.[20] In summary, sleep is critical for the well-being of children and adolescents.

School start time

During puberty, circadian rhythms, or sleep-wake cycles, shift toward preference for late-morning wake times and late-onset sleep times.[5] Chronotype is an individual's preference for sleep timing[21], and older, more developed adolescents demonstrate a greater

* Corresponding author at: Department of Psychology, Stony Brook University, Stony Brook, NY 11794-2500.
E-mail address: jennifer.bowers@stonybrook.edu (J.M. Bowers).

evening preference chronotype.[22] Both behavioral and intrinsic biological factors appear to be involved in chronotype determination.[22] Early school start time (SST) is believed to directly interfere with the natural sleep-wake cycle and homeostatic sleep regulation process of the typical adolescent.[23] Teens have difficulties falling asleep earlier than 11:00 PM[23] yet still require 8 to 10 hours of sleep. The American Academy of Pediatrics recommends that middle and high schools begin no earlier than 8:30 AM to accommodate the sleep needs of students.[24] Criticisms of shifting SST include logistical and financial concerns, as well as suspicions that students will not use the time to maximize their sleep[12*,25,26]; however, some school districts report increased flexibility and cost-savings for transportation following SST change,[27,28] and studies have demonstrated that increased sleep from SST delay can be attributed to later wake times because bedtimes remain stable.[29*,30*,31*]

The current meta-analytic review

Studies measuring SST and adolescent sleep have been accumulating over approximately 25 years. Few previous systematic reviews have been conducted. One review examined only published longitudinal studies.[17] A review confined to high school student samples[32] had high theoretical validity given the literature on adolescent circadian rhythms; however, one drawback to this approach was the inevitable exclusion of other studies from the SST literature in non–high school samples. A recent extensive systematic review[33] examined a broad array of outcome variables from studies implementing SST delay for students aged 13 to 19, noting positive findings in primary studies examining sleep duration. However, these authors provided arguments for primary study weaknesses, deeming the quality of the current studies on SST too low for any definitive conclusions. Although a large number of studies were included in the review, few studies were included for quantitative synthesis (ie, meta-analysis) because of the authors' evaluation of study design differences among the set of included reports; only 3 studies were meta-analyzed for the outcome of sleep duration.

The primary goal of the current meta-analytic review is to comprehensively, systematically, and quantitatively summarize the evidence from investigations testing whether delayed morning SSTs result in more sleep compared with earlier start times. Three secondary outcome variables were identified in the primary studies: daytime sleepiness, absences from school, and tardiness to school. A priori moderators of interest for the primary outcome variable are outlined below.

Delay of SST in minutes

Although there is a policy movement toward delaying SST, it is not clearly evident how many minutes a school should shift its starting time to achieve potential benefits for students. Delays as short as 15 minutes have been investigated as well as delays of 60 minutes or more. The number of minutes delayed was included as a potential moderating variable to understand whether longer delays produced greater benefits.

Clock time of the later SST

The clock time of the "later" SST was extracted as a second method for measuring potential differences by starting time. This variable was extracted by converting the starting time into the number of minutes past midnight (for example, 8:00 AM is equal to 480 minutes past midnight).

Before and after 8:30 AM SST

Studies were coded categorically for whether the later starting time was before or after/at 8:30 AM, corresponding to the recommendation from the American Academy of Pediatrics.[24]

Student grade in school

Most primary studies have focused on high school and middle school populations because of the fact that circadian rhythms shift with puberty. However, a small number of studies have tested the effects of an SST delay in elementary school students. Given that shifting high schools to later starting times may involve younger children starting school earlier in the day (for logistical reasons such as bus availability), it is important to explore the potential effects of SST on elementary school students. Studies examining the effects of earlier SSTs on elementary school students, although their focus is different, provide relevant data to the question at hand and were thus included in the review to allow for a comprehensive analysis of the literature on SST. Synthesizing research on this population may aid in understanding the optimal SST for elementary school students and the timing of the circadian rhythm shift. The grade in school was included as a moderator to determine whether potential effects differed based on the grade level of the participants, and a sensitivity analysis was included to determine whether findings were any different with these studies excluded.

Time elapsed between assessments before vs after an SST delay

Longitudinal studies reported the amount of time that elapsed between measurements of sleep before (time 1) vs after (time 2) implementation of an SST delay. This variable was included as a potential moderator to determine whether any potential effects on sleep depended on the length of time following the implementation of the SST delay.

Publication status

A search of the gray literature was conducted in an attempt to mitigate against the effects of any potential publication biases. In addition to peer-reviewed published articles, conference abstracts were retrieved and publication status was coded as a moderator.

Methods

Search strategy and inclusion process

The search strategy to identify relevant articles assessing SST and sleep duration included database searches (PsycINFO, PubMed, Scopus, and ProQuest) and manual searches for citations in recently published reviews of the literature.[17,34] The following search terms were used for database searching: *school start time, students, school, education, sleep, sleep deprivation, sleep restriction, circadian rhythm, adolescent,* and *sleep pattern.* Date restrictions were not applied. The search was conducted in September 2016 and updated in March 2017.

The initial database and backwards searches yielded a total of 163 articles. After applying filters that only included records written in the English language and peer-reviewed journal articles (except in ProQuest, a dissertation database), 88 total articles were collected from the databases and manual backwards searches. These 88 articles were imported into a citation manager (Endnote X7). Duplicates were removed, and 57 articles remained to be screened.

Titles and abstracts were screened for the following inclusion criteria: (1) 2 different morning SSTs (eg, 8:15 AM compared with 7:30 AM) were compared; (2) total sleep duration measured in