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School start time changes and sleep patterns in elementary school students

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ABSTRACT

Objectives: Research finds significant sleep deprivation among adolescents with early school start times. This study surveyed sleep patterns in elementary school students before and after a district-wide change to earlier start times.

Design: Students in grades 3-5 completed a self-administered sleep survey in the spring of 2009 (third grade, n = 216; fourth grade, n = 214; fifth grade, n = 259; total, n = 689) and again in 2010 (third grade, n = 168; fourth grade, n = 194; fifth grade, n = 263; total, n = 625), after the school start time switched from 8:20 AM to 7:45 AM in the Fall of 2009. Students entering grade 3 experienced a larger shift from 9:10 AM to 7:45 AM, due to moving from the kindergarten-second-grade building to the third-to-fifth-grade building. Descriptive statistics quantified responses by grade.

Results: Prechange, wake time across all grades was similar; postchange, fourth and fifth graders woke on average 30-40 minutes earlier than children in those grades the year before, and third graders woke on average 8 minutes later. Compared to prechange, third graders reported longer average total sleep times (24 minutes); fourth and fifth graders reported average sleep times 4 and 9 minutes shorter, respectively, than students in those grades the previous year. The percentage of students in each grade reporting later weekend wake and bed times decreased postchange. Reports of sleepiness somewhat increased for fifth graders postchange.

Conclusions: School start time change did not decrease total amount of sleep. This is the first study of its kind to report on the effects of a start time change in elementary school students.

Introduction

While the developmental process during childhood and adolescence is defined by biological change, daily life is often structured by the school schedule. Logistical and financial factors influence school start times, with many districts having their high schools start the earliest. Empirical data find that adolescents' total reported sleep time declines from 10 hours in middle childhood to less than 7.5-8 hours by age 16 years.[1-5] Early school start times may exacerbate the challenge of adolescents obtaining the needed amount of sleep on school nights.[4] The American Academy of Pediatrics recently recognized the importance of insufficient sleep in adolescence as an important public health issue and endorsed the scientific rationale for later school start times.[6,7] Specifically, by 12th grade, 75% of adolescents are not obtaining the recommended 8+ hours of sleep per night.[6,7]

While social and environmental factors including most recently the use of technology are important contributors, biological changes also play a role in the problem of adolescent sleep deprivation. Pubertal changes alter melatonin levels, the underlying mechanism regulating sleep-wake cycles, and lead to a "delayed sleep phase" creating a biological barrier to adolescents falling asleep earlier.[8-10]

Schools delaying start times for their adolescent students have offset the consequences of chronic sleep deprivation, including poorer cognitive functioning, disruptive sleep patterns, and alterations in physical and mental health ([4,11-18]). Modest delays of 1 hour or less find students attaining more total sleep (29-45 minutes[19-22]), reporting less daytime sleepiness overall and in class[19-22] and schools reporting increased student attendance and better academic performance.[19] Reduction in adolescent risky behaviors, such as drowsy driving and juvenile delinquency, has also been correlated with later start times, although these findings are based on cross-sectional study designs and warrant further prospective work to determine a causal link.[23-25]

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Decisions to delay high school start times, however, often involve changing to earlier start time for younger students to accommodate logistics, such as tiered bus systems, leading to concerns of early start time effects on younger students. One question is whether this switch simply transfers the problem of sleep deprivation from the older students to the younger ones.

Sleep research on younger school-aged children largely focuses on sleep-related behavior problems[26] such as sleep walking, bed wetting,[26,27] and nightmares[26]–all shown to lead to shorter sleep durations and sleep deprivation.[28-30] We lack research on the sleep needs of young children without clinical sleep issues, and these handful of studies are limited by small sample sizes and wide age ranges (eg, 5-12).[29,30] The purpose of this study is to determine whether a switch to an earlier start time for elementary school students significantly affects their sleep patterns.

Participants and methods

Participants

Participants included third to fifth graders enrolled in a public northeastern elementary school during the 2008-2009 and 2009-2010 academic years. The superintendent granted permission to publish the findings as long as the school system's identity remained anonymous. The community from which the student population was drawn is predominantly white (97.8%), and 82.2% of housing units were owner occupied (reference excluded to retain anonymity of school). Because this was a school-initiated survey and the data were deidentified, the Boston University Institutional Review Board determined that institutional review board approval was not required.

Instruments

The measures were modified from the Sleep Habits Survey used in previous adolescent sleep studies conducted by Wolfson and Carskadon ([3,31,32]). The survey included 16 questions containing open-ended, multiple choice, and Likert-scaled questions focusing on sleep-wake schedules and bedtime and wake routines. Dr Amy Wolfson advised the school on modifications of the survey for appropriateness for grades 3-5, which was also reviewed by teachers from the school.

Procedure

Deidentified surveys were administered on the same day by classroom teachers in grades 3-5. Teachers used scripted instructions during survey administration. Completed surveys were returned to the school's administrative offices and copied for data entry use.

Before the change in school start times (eg, prechange), students in grades 3-5 completed self-administered surveys that included questions on sleep duration at the end of the 2008-2009 academic year (Spring 2009) (third grade, n = 216; fourth grade, n = 214; fifth grade, n = 259; total, n = 689). In the next academic year (Fall 2009), students in third grade moved from a previous start time of 9:10 AM to 7:45 AM, whereas students in grades 4-5 switched from a start time of 8:20 AM to 7:45 AM to accommodate a switch in the start time for middle and high school students from 7:30 AM to 8:15 AM. At the end of this academic year (Spring 2010; postchange), students from grades 3-5 completed the same set of self-administered questionnaires (third grade, n = 168; fourth grade, n = 194; fifth grade, n = 263; total, n = 625). Students surveyed in grade 3 after the change had experienced a greater shift to earlier start times when they moved into the elementary school (9:10 AM to 7:45 AM, 85-minute difference), whereas those in grades 4 and 5 had experienced a 35-minute shift in start time (8:20 AM to 7:45 AM).

Community outcry necessitated that the data collection process involved no student identifying information except grade level, preventing direct longitudinal comparison. However, more than 90% of students from each grade during the first survey administration attended the next grade in the same school system for the second survey administration. Thus, a large subset of students who took the initial prechange survey comprised the student sample that took the second postchange survey the following year.

Data analysis

Data from the survey were entered and analyzed using SPSS and rechecked for data entry accuracy. Descriptive statistics included means, bar graphs, correlations and comparisons between grades, SDs, and percentages of each question were used to quantify responses by grade level.

Results

Students were queried via a multiple-choice question as to their method of getting to school. Both before and after the change, at least 79% of students in each grade used school-provided buses as their primary transportation. Between 1.2% and 3.7% of students reported walking to school, and 8.4% to 16% reported being driven. These percentages were consistent across both presurvey and postsurvey time points.

Results from the 2 cross-sectional surveys indicated that before the change in start times, weekday wake times across grades 3-5 were relatively similar. Postchange, fourth and fifth graders woke up on average 30-40 minutes earlier than children in those grades the year before, whereas third graders woke up on average 8 minutes later. Before and after the change, mean school night bedtimes became later with increasing grade level. Postchange, students in grades 3-5 had earlier average bedtimes. When compared with prechange data, third graders reported longer total sleep times (24 minutes), whereas fourth and fifth graders exhibited sleep times 4 and 9 minutes shorter, respectively, than students in those grades the previous prechange year (Table 1).

Students were queried as to whether their bedtimes and wake times were later on weekends compared with weeknights in a multiple-choice question format. Before the change in school start times, 60.6% of third graders, 64.0% of fourth graders, and 78.4% of

Table 1
Summary of wake times, bed times, and total sleep times for students in grades 3-5 before and after the change in school start times.

	2009 (prechange)	2010 (postchange)	
Grade	Average wake up time (SD, min)	Average wake up time (SD, min)	Difference
3	6:49 (31)	6:57 (51)	+8 min
4	6:56 (41)	6:22 (28)	−34 min
5	6:59 (26)	6:23 (31)	−36 min
Grade	Average bed time (SD, min)	Average bed time (SD, min)	Difference
3	8:37 (42)	8:22 (53)	+15 min
4	8:52 (43)	8:22 (41)	+30 min
5	9:10 (37)	8:43 (40)	+27 min
Grade	Average total sleep time (SD, min)	Average total sleep time (SD, min)	Difference
3	10:11 (45)	10:35 (68)	+24 min
4	10:03 (52)	9:59 (49)	−4 min
5	9:49 (41)	9:40 (45)	−9 min

fifth graders reported waking up later on weekend mornings than weekday mornings. In addition, 83.3% of third graders, 83.2% of fourth graders, and 88.0% of fifth graders reported later weekend bedtimes compared to weeknight bedtimes. Postchange, 53.0% of third graders, 62.4% of fourth graders, and 66.9% of fifth graders reported waking up later on weekend mornings than weekday mornings. In addition, 79.8% of third graders, 79.4% of fourth graders, and 86.3% of fifth graders reported later weekend bed times after the change in the school start times (Figs. 1 and 2).

Surveys addressed sleepiness experienced both at school and after school with a multiple-choice question. Before the change in school start times, 14.4% of third graders, 15.0% of fourth graders, and 11.2% of fifth graders reported that they "never" felt sleepy at school; postchange, 19.6% of third graders, 17.0% of fourth graders, and 9.1% of fifth graders endorsed the same feelings. When asked about after school, 34.7% of third graders, 36.0% of fourth graders, and 44.2% of fifth graders reported that they "never" felt sleepy after school before the start time change, whereas 33.9% of third graders, 37.6% of fourth graders, and 31.6% of fifth graders endorsed the same postchange (Figs. 3 and 4).

Discussion

Results indicated that this district-wide change in school start times did not decrease the total amount of sleep reported by elementary school students. Survey data collected before and after the change indicated that students were able to implement earlier bedtimes to accommodate the earlier start times. The altered bed and wake times led to 4- and 9-minute decreases in average total sleep time for fourth and fifth graders, respectively, and a 24-minute average increase in total sleep time for third graders. The increased amount of sleep reported by third graders is particularly notable given that students in that grade experienced the largest shift in school start time, suggesting that they were able to obtain a sufficient amount of sleep despite the earlier start time.

Data examining student wake and bed times on weekends both before and after the change indicated that while the majority of students in all grades report later bed and wake times on weekends, the percentages endorsing later weekend bed and wake times were smaller after the change in school start times. Because later weekend wake times examined in adolescents indicate attempts to attenuate "sleep debt" accrued during the week ([4,33-35]), results from this study suggest a change to earlier start times did not increase sleep debt in young elementary school students.

Daytime sleepiness is an unexplored area in healthy young children without sleep disorders. In our two survey questions addressing sleepiness, the majority of students in each grade endorsed at least some sleepiness after school, and an even greater majority endorsed at least some sleepiness while at school. For sleepiness at school, percentages were nearly equivalent before and after the change for all grades; for sleepiness after school, percentages were similar for third and fourth graders, whereas there was a small increase in the endorsement of sleepiness for fifth graders after the change. Future research should further examine daytime sleepiness in this population, particularly using objective measures such as cognitive performance and actigraphy.

Although speculative, heightened community awareness of how school start times affect sleep durations may account for why third graders reported longer sleep durations after the change, even when faced with earlier school start times. Because this group of students also switched school buildings, they experienced the largest shift in school start times, leading to greater vocally expressed concerns by their parents of the potential negative impact of this change. This may have led to greater monitoring and vigilance from affected parents. Importantly, results suggest that wake and bed times are malleable in this age group, allowing modification to accommodate changing start times without affecting the overall amount of sleep obtained. This is important initial evidence that can aid the various stakeholders involved in making policy decisions regarding school times for students of all ages.

Limitations

This study had several significant limitations. Parental demands against using student ID numbers during the initial survey prevented direct longitudinal comparison of sleep times pre and post school start time change. Instead, results refer to a comparison of each cohort on average at the 2 time points; however, because of the significant retention of students within the district from 1 year to the next (>90%), we are confident the results obtained are informative and representative of the examined grades.

Another limitation was that although there is much consensus on the benefits of delayed high school start times,[6,7] analyses are based on self-reported surveys, which carry inherent response bias. This study relied on student self-report because of the significant resistance parents voiced before and after the change, creating concerns that their survey responses would be highly biased. However, research suggests that children as young as 8 years old (the same

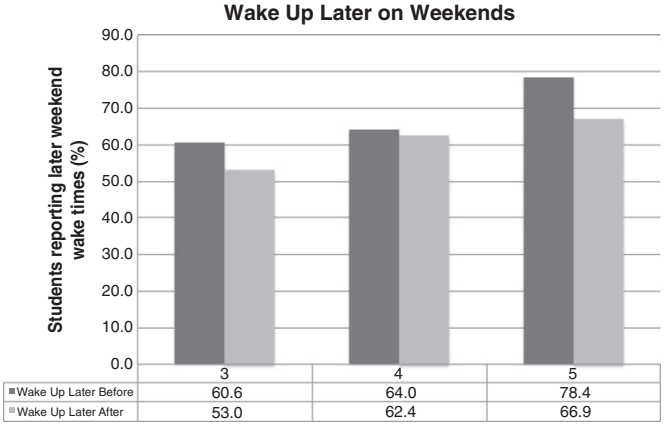

Fig. 1. Percentage of students in grades 3-5 reporting later wake times on weekends compared with weekdays before and after the change in school start times. Before the change, 131/216 third graders, 137/214 fourth graders, and 203/259 fifth graders reported later weekend wake-ups. After the change, 89/168 third graders, 121/194 fourth graders, and 176/263 fifth graders reported later weekend wake-ups.

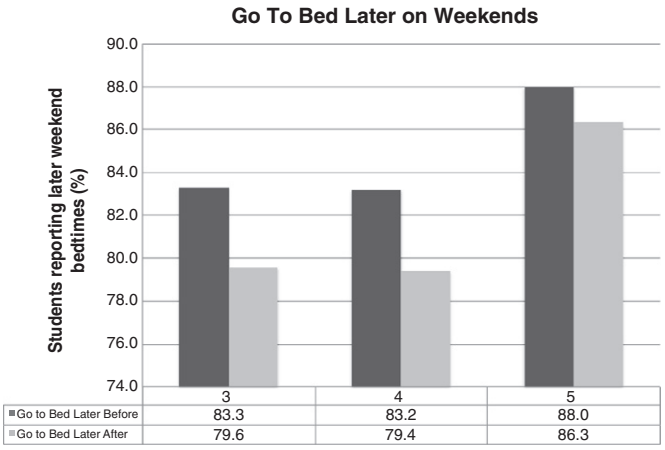

Fig. 2. Percentage of students in grades 3-5 reporting later bed times on weekends compared with weekdays before and after the change in school start times. Before the change, 180/216 third graders, 178/214 fourth graders, and 228/259 fifth graders reported later weekend bed times. After the change, 134/168 third graders, 154/194 fourth graders, and 227/263 fifth graders reported later weekend bed times.

average age of third graders in our study) can provide reliable and valid self-report information about their health.[36,37] In particular, one recent study validated a self-report questionnaire on sleep patterns in 8- to 12-year-olds and found that the children provided valid information about their sleep, including information that might not otherwise be captured if relying only on parental report.[38] The volatile nature of this issue makes longitudinal studies difficult to conduct. Lack of parental and school cooperation, scalability, and costs were also barriers to more objective assessments, such as academic performance or cognitive performance on neuropsychological tests.

This study involved examination of a largely white, wealthy community; additional research should examine ethnically and economically diverse populations to generalize findings across varying demographics. More work should be done to examine variables in addition to sleep times including measures of academic and emotional functioning. Using technology such as actigraphy will obtain more objective measures of sleep variables, including documenting sleep behaviors longitudinally as they experience a shift in school start times. Having identifying information to link prechange and postchange measures would permit true longitudinal analysis, and extending beyond a single year of follow-up will document longer term effects, particularly if measured after the high emotional tenor in the community has abated. Despite these limitations, this study provides initial data suggesting that changing to earlier school start times will not negatively impact younger students.

Conclusions

In summary, a change to an earlier school start time did not decrease the total amount of sleep reported by elementary school students. Furthermore, it did not increase sleep debt as evidenced by weekend bed and wake times or self-reported sleepiness during and after school. Importantly, this study was the first, to our knowledge, to report on the effects of a start time change on elementary school students. Our results provide evidence that earlier start times did not significantly decrease the total amount of sleep obtained by young children. Younger students were able to move their bedtimes forward to compensate for the earlier wake times needed to get to school for the earlier start time, which research has been shown to be biologically difficult in older adolescents. Future studies are needed to replicate this finding using direct longitudinal comparison and more economically and ethnically diverse study samples.

A number of financial and logistical factors are involved in determining school start times, but empirical data often play an underrepresented role, despite growing evidence that sleep patterns can be modified with deliberate changes to school schedules. Those attempting to enact change often encounter significant fiscal, logistical, and psychological challenges in addition to emotional volatility within the school system and the associated community. There is a paucity of research on how start time changes affect young children whose school day may be moved forward to accommodate later

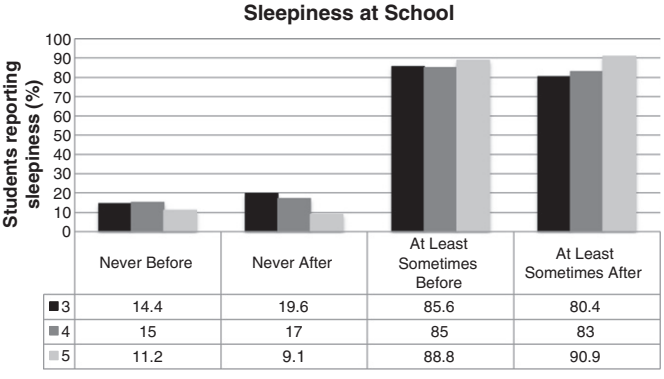

Fig. 3. Percentage of students in grades 3-5 reporting that they "never" or at least sometimes ("sometimes," "a lot of the time," or "all the time") feel sleepy at school before and after the change in school start times. Before the change, 31/216 third graders, 32/214 fourth graders, and 29/259 fifth graders reported that they "never" felt sleepy at school. After the change, 33/168 third graders, 33/194 fourth graders, and 24/263 fifth graders reported that they "never" felt sleepy at school.

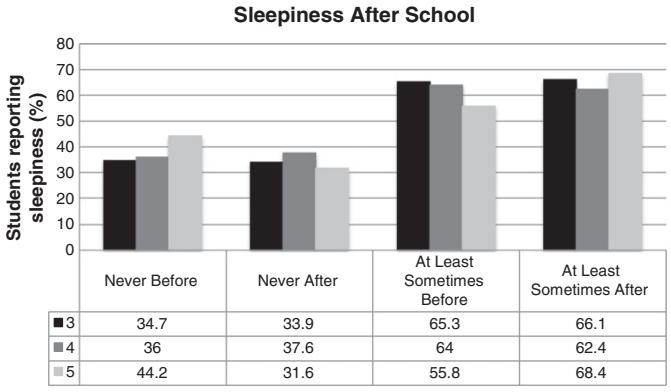

Fig. 4. Percentage of students in grades 3-5 reporting that they "never" or at least sometimes ("sometimes," "a lot of the time," or "all the time") feel sleepy after school before and after the change in school start times. Before the change, 75/216 third graders, 77/214 fourth graders, and 114/259 fifth graders reported that they "never" felt sleepy after school. After the change, 57/168 third graders, 73/194 fourth graders, and 83/263 fifth graders reported that they "never" felt sleepy after school.

start times for sleep-deprived adolescents. The goal of this research was to investigate the effects of a switch to an early start time for elementary school students and provide evidence that young students could maintain an adequate amount of sleep after a change to earlier start times.

Understanding the impact of school start times on sleep patterns will assist parents, health care providers, and educators in promoting sleep hygiene in school-aged children and enable informed decision making regarding start times. Obtaining adequate amounts of sleep is important to maintaining physical and mental health for students of all ages. Getting students and parents to understand how school start times may be impacting their ability to get proper amounts of sleep is just one step. More broadly, it is important for parents to understand that across the developmental continuum, various factors may impact their children's sleep patterns and needs. Thus, it is necessary to remain vigilant in monitoring that their children obtain adequate amounts of sleep, regardless of their age. Teaching students proper day and bedtime practices that promote sufficient quantities of quality sleep and encouraging parents to help their child, even during the teenage years, establish and maintain good sleep hygiene practices can lead to lifelong positive benefits, even in the absence of a change in school start times.

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Conflict of interest

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