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Original article

Variable School Start Times and Middle School Student's Sleep Health and Academic Performance

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A B S T R A C T

Purpose: Improving sleep health among adolescents is a national health priority and implementing healthy school start times (SSTs) is an important strategy to achieve these goals. This study leveraged the differences in middle school SST in a large district to evaluate associations between SST, sleep health, and academic performance.
Methods: This cross-sectional study draws data from a county-wide surveillance survey. Participants were three cohorts of eighth graders (n = 26,440). The school district is unique because SST ranged from 7:20 A.M. to 8:10 A.M. Path analysis and probit regression were used to analyze associations between SST and self-report measures of weekday sleep duration, grades, and homework controlling for demographic variables (sex, race, and socioeconomic status). The independent contributions of SST and sleep duration to academic performance were also analyzed.
Results: Earlier SST was associated with decreased sleep duration ($\chi^2 = 173$, $p < .0001$) and deficient sleep (≤7 hours) among 45% of students. Students with SST before 7:45 A.M. were at increased risk of decreased sleep duration, academic performance, and academic effort. Path analysis models demonstrated the independent contributions of sleep duration, SST, and variable effects for demographic variables.
Conclusions: This is the first study to evaluate the independent contributions of SST and sleep to academic performance in a large sample of middle school students. Deficient sleep was prevalent, and the earliest SST was associated with decrements in sleep and academics. These findings support the prioritization of policy initiatives to implement healthy SST for younger adolescents and highlight the importance of sleep health education disparities among race and gender groups.

IMPLICATIONS AND CONTRIBUTION

In this study of multiple demographic variables, school start time and sleep duration had independent contributions to academic performance and effort. Understanding these relative contributions may help to prioritize sleep duration when a school district considers changes to start time.

Insufficient sleep is endemic and has become a focus of public health initiatives. Studies in all age groups show that deficient sleep duration and timing of the sleep period contribute to increased risk of cardiometabolic and immune diseases, obesity, injury, and automobile accidents, as well as decrements in quality of life and neurobehavioral function [1,2].

Conflicts of Interest: The authors have no conflicts of interest to disclose.

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Adolescents are particularly at risk for insufficient sleep due to puberty-linked shifts in biologically regulated circadian rhythms resulting in a high sleep drive and later bed (optimally after 10:30 P.M.) and later wake times (optimally after 7:30 A.M.). This biological drive conflicts with academic, social, and lifestyle demands and choices [3]. Increased use of electronic media [4] and caffeine and early SSTs represent particular challenges but are all modifiable [5,6].

While the National Institute of Health and American Academy of Pediatrics recommend adolescent sleep duration of 9–10 hours and 8–9.5 hours, respectively [7,8], approximately, 60% of sixth–eighth grade students report weeknight sleep duration of less than 9 hours and only 7% of high school students report an optimal sleep duration of 9 hours or more [9]. Consequently, adolescent sleep health is identified as a national health priority in the Healthy People 2020 initiative to increase the proportion of adolescents sleeping 8.5 or more hours. The American Academy of Pediatrics addresses deficient sleep in recent recommendations that middle and high school start times (SSTs) should be 8:30 A.M. or later [10]. This was followed by a Centers for Disease Control (CDC) report estimating that 82% of middle and high schools begin before 8:30 A.M., the average start time in 42 states was 8:03 A.M., and emphasizing the importance of prioritizing these changes [11].

Several observational studies have demonstrated the benefits of later SST, but the vast majority of studies have focused on high school students, and only a few studies have included sixth–eighth graders or focused exclusively on this younger group. Paksarian et al. [12] analyzed a national adolescent surveillance data set and demonstrated that total sleep time on weekdays increased approximately 22 minutes for each hour delay in SST, with smaller benefits for urban boys. Variable results from other studies demonstrate that an hour delay in SST results in increased sleep duration ranging from 25 minutes in a sample of 15- to 17-year-olds, 34 minutes in a sample of 12- to 19-year-olds [13], and a 45-minute delay in SST yielded 20 minutes of additional sleep and healthier sleep schedules, but gains were not maintained after at 12-month follow-up [14].

Several studies have found that specific mental and physical health risks are associated with early SST. Earlier SST and shorter sleep duration are linked to increased rates of automobile accidents [2,15], suicidal ideation and attempts [16], depression, and increased daytime somnolence [13]. Furthermore, several studies have demonstrated that delaying SST by at least 1 hour results in better performance on measures of attention and fewer tardies [17,18].

While grades are a notoriously complex outcome variable given inconsistencies across teachers and subjects and ceiling effects for high performers, academic outcomes are important for school districts particularly when there is an investment in SST change. In one of just a few studies of middle school students, Lufi et al. [17] reported that a 1-hour SST delay yielded 55 minutes of additional sleep and better performance on measures of attention and mathematics. Similarly, Wolfson et al. [18] reported 50 minutes of increased sleep duration in schools within a district that started at 7:15 A.M. versus 8:37 A.M. All the studies evaluating younger adolescents have involved small samples, and the power to consider individual school, socioeconomic status (SES), gender, and race effects has been limited. This study is one of only a few to evaluate SST in middle school students. We are aware of no other studies that have examined the independent association of SST and sleep duration on academic performance. The study is also unique as it uses a large sample of eighth graders with an exceptionally high response rate of 85%–90% attending schools in which SST varied by 50 minutes. We predicted that students with earlier SST would report shorter sleep duration and that longer sleep duration and later SST would be associated with improved academic performance. Given our large sample, we were also able to test the mediational hypotheses that sleep and SST have unique contributions to academic outcomes. These findings are intended to increase the evidence of effects of SST on middle school students' sleep health and academic performance to inform policy decisions at the school district and at national level to improve adolescent health.

Methods

These data were derived from a publicly available data set from a demographically diverse school district with an enrollment of ~165,000 students. The study leverages variability in SST among eighth grade students (7:20 A.M.–8:10 A.M.). Sleep and academic questions were drawn from a modified version of the CDC's Youth Risk Behavior Survey that has been administered annually in this school district to eighth, 10th, and 12th graders since 2001. Beginning in 2008, a single sleep question was added: "how many hours of sleep do you get on weeknights?" with possible answers: <4, 5, 6, 7, 8, or >/+ 9 hours. This study included all eighth grade students in years 2008 (n = 6,936), 2010 (n = 11,991), and 2012 (n = 10,768) who answered the sleep question. Missing data resulted in a 4.7% reduction of the total sample. To facilitate analyses, the sample was divided into three SST groups across 26 schools: "earliest" (7:20 A.M.–7:30 A.M.); "early" (7:40 A.M.–7:55 A.M.); and "latest" (8:00 A.M.–8:10 A.M.). Data and approval for analyses were provided by the school district and an institutional review board waiver.

The key outcomes under study are students' weeknight sleep duration and academic performance and effort. Self-reported weeknight sleep duration was grouped as <7 hours, 7 hours, 8 hours, and ≥9 hours. Academic performance was self-reported grades: "Do you get mainly A's, B's, C's, D's, or F's (D's and F's were combined yielding a four-level categorical outcome). Academic effort was self-reported homework completion: "How often did you not finish your homework?" with possible responses of "never," "sometimes," or "usually."

The association between student sleep duration and academic performance (grades) was first examined with the chi-square statistics and subsequently with path analysis with probit regression [19], in which the underlying latent continuous response variable y^*_{Grades} of the observed ordinal measure of grades (1: F/D, 2: C, 3: -B, and 4: A) was the dependent variable, and the latent continuous response variable y^*_{Sleep} of the observed ordinal measures of sleep duration (1: <7 hours, 2: 7 hours, 3: 8 hours, and 4: ≥9) was a mediator. Covariates at both student level (e.g., age cohort, gender, and race) and school level (e.g., free lunch status, a proxy measure of SES) were controlled in the model. As the data were hierarchically structured (i.e., students nested within schools), school effects were adjusted in modeling to account for intraclass correlations. The Sobel test [20] assessed the indirect effect of SSTs on student's academic performance (grades) and effort (homework). Finally, chi-square tests were used to determine the distribution of race and SES across schools to assure that there were no systematic differences in SST.

Descriptive and binary statistics were estimated using SAS 9.2 (SAS Institute, Cary, NC), and models were estimated using the statistical package Mplus.