Changes in School Start Time have a Significant Effect in the Amount of Sleep and Reported Grade Point Average of Students

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Abstract

Later or delayed secondary school start times have been widely investigated in the past few decades given their promising student physical and mental health outcomes. However, robust research investigations regarding later school start times and their associations with academic outcomes are minimal in number. In this study, the association between school start times and academic outcomes as well as whether students obtained the recommended hours of sleep were examined. Multiple regression results from a sample of students from grades 5, 8, 9, and 11 (n = 38,019) from the Minnesota Student Survey 2016 and 2019 administrations show that later school start times are positively associated with higher grade point averages and higher proportions of students getting the recommended number of hours of sleep.

Background

Across the country, the topic of school start times (SST) is debated, both on a national level and on local levels. According to the Centers for Disease Control and Prevention (CDC), the average SST in the U.S. was 8:03 a.m. in the 2011–2012 school year (Wheaton et al., 2015). The majority of schools (76%) had an SST between 7:30 a.m. and 8:29 a.m. with only 18% of schools having an SST after 8:30 a.m. This start time is important as it is the time the American Pediatrics Association recommends as the ideal SST (Owens, 2014). The start times vary widely by district and by state based on local regulations. Louisiana had the earliest average SST (7:40 a.m.) as well as the highest percentage of schools with an SST before 7:30 a.m. (30%). Additionally, few states had no schools with an SST at or after the ideal time of 8:30 a.m. (Hawaii, Mississippi, and Wyoming). North Dakota and Alaska had the latest average start times (8:31 a.m. and 8:34 a.m.) along with the highest percentage of schools starting at 8:30 a.m. or later (79% and 77%, respectively).

Researchers reported that from the 2017–2018 school year, the overall SSTs did not change by much, in fact there were a smaller percentage of schools with SST at or after 8:30 a.m. (17%; Sawyer & Taie, 2020). During this time, although the overall average SST remained the same, multiple states pushed back their average SST. For example, Minnesota, Virginia, and South Carolina pushed their average SST by 4, 10, and 30 minutes, respectively. This also does not make note of the individual districts that decided it would be best to have later SST.

There is currently a large push across the country from researchers and public health experts for later SST. For decades, researchers have shown that the biological circadian rhythms of students govern when children, and especially teenagers, fall asleep (Dunster et al., 2018). Largely due to this, the time at which students go to sleep cannot be controlled, but the time when they wake up, and proposedly the amount of time spent asleep, could be adjusted depending on the time students need to be at school. Minges and Redker (2016) showed in a systematic review that delaying SSTs increased daily sleep between 25 to 77 minutes per night across the studies reviewed. Getting more sleep at night results in reduced daytime sleepiness, improved motor functioning, improved reaction time, and better mental health in regard to depression and anxiety (Bowers & Mower, 2016; Crowley et al., 2018; Hafner et al., 2017;

Wahlstrom & Owens, 2017). However, there is limited research on the effects of delaying SST on academic outcomes. In this study, we examined the associations of moving to a later SST and academic outcomes as well as the impact on the recommended hours of sleep.

Perspective

There is a great deal of research on the positive and negative health impacts of the amount of sleep students get at night, but there are only a few studies about the impact of sleep on academic outcomes, and of those studies, the results have been mixed. For example, in a study of elementary schools in Wayzata Public Schools in the state of Minnesota, Dupuis (2015) found that delayed start times were associated with increased reading and mathematics scores; however, the effect sizes were small, and the increase was not seen for all students. Researchers on another study (Sabia et al., 2017) found that one additional hour of sleep was estimated to increase the probability of high school graduation by about 8.6% on average and college attendance rate by 13.4%. Similarly, Dunster and colleagues (2018) found a positive impact on grades with a 4.5% increase in the median grades of students, less tardiness, and fewer absences a year after a later SST was introduced; this effect was only found for one of the schools in the study.

Researchers studying high schools have found that later SSTs lead to more sleep (Nahmod et al., 2017; Patte et al., 2017) as well as other health benefits including lower daily depressive/anxiety symptoms and a decline in falling asleep in class (Peltz et al., 2017; Wheton et al., 2016). On the other hand, high schools that moved to earlier SSTs have experienced some detrimental effects on absenteeism, tardiness, as well as higher rates of dropouts (Lenard, 2020). In one of the more robust studies on the effects of earlier SSTs on academic outcomes to date, Lenard (2020) found no difference in test scores, but definitely worse non-cognitive outcomes in his quasi-experimental study.

Regarding SST changes in middle schools, Wahlstrom and Owens (2017) and Edwards (2012) reported similar results for academic success due to delayed SST as those for high schools. Wahlstrom and colleagues used a survey of delayed SST districts and found increased self-reported test scores and grades. However, there was no distinction between responses from elementary, middle, and high schools. On the other hand, Edwards found that a later SST of one hour led to a three-percentile point gain on average in both math and reading standardized test scores for middle school students, representing 14% of the White-Black achievement gap. These results are promising for middle school students, where they gain to benefit from a later SST.

Elementary schools have rarely been studied regarding SST as they typically start earlier than middle and high schools due to logistic and economic constraints. Moreover, school districts often balance their high school and middle school later start time changes by pushing elementary schools to earlier start times (Whalstrom & Owens, 2017). Keller et al. (2015) examined elementary schools that set earlier SST and found lower standardized test scores. However, in another study, Keller et al. (2017) found that earlier start times in elementary schools were associated with more behavioral issues but found no differences in test scores. Appleman et al. (2015) examined an elementary school with an earlier start time and found no difference in the amount of sleep obtained by students. The research findings for elementary school students are minimal in nature and, as noted, mixed.

Overall, these researchers showed there may be differences in the effects of SST changes on academic success based on school level; however, there is minimal research with comparison

(control) schools. Previously, researchers also typically used nonexperimental designs without comparison groups, with the bulk of reports written as reactions to school district changes due to other policy or economic initiatives. Due to this, many studies were opportunistic and did not have comparative groups, and thus the SST-associated effects could be due to other factors.

In the present study, we examined the effects of changes in SST for elementary, middle, and high schools with matched schools in proportions of race/ethnicity, English learner status, special education participation, and free- or reduced-priced lunch status for comparison. The schools and grades were compared in terms of meeting the recommended amounts of sleep and academic outcomes. We hypothesized that both grade point average and recommended hours of sleep would be higher for students who attended schools with a change to a later SST.

Methodology

Data

A secondary data analysis of the Minnesota Student Survey (MSS) data was performed. The MSS, managed by a state interagency team, is administered every three years to students in public schools in grades 5, 8, 9, and 11 (Minnesota Department of Education, 2016). In 2016, a total of 168,733 students participated in the survey, and in 2019, the number of participants increased slightly to 170,128. Four school districts were identified as transitioning from an early SST to a later SST after the 2016 administration and before the 2019 administration, herein referred to as Later Start Time School Districts (LSDs). These four districts transitioned from early SSTs of 7:25 a.m., 7:30 a.m., 7:33 a.m., and 8:10 a.m., to later SSTs of 8:35 a.m., 8:20 a.m., 8:00 a.m., and 8:30 a.m., respectively. Four other school districts with early SSTs were identified that closely matched LSDs on proportions of race/ethnicity, English learner status, special education participation, and free- or reduced-priced lunch status, herein referred to as Early Start Time School Districts (ESDs); these districts did not change their SST during this period. An additional variable used in the analyzes was a factor called Commitment to Learning (CTL), a composite scale measure composed of caring about doing well in school, paying attention in class, going to class prepared, interested in learning, finding school learning useful, and being a student is an important part of who I am (Rodriguez , 2017). The total number of students from these eight school districts totaled 38,019 students.

Procedure

In order to estimate the associations between SST, likelihood of obtaining the recommended amount of sleep, and academic achievement of students, multiple regression analyses were performed. The majority of students in the data were White (54.7%), with 12.4% Latino, 8.8% Black, 8.6% Asian, 4.9% Multiracial, 3.6% Somali, 3.1% American Indian, and 2.1% Hmong. About half of the students were female (49.2%). Grades were relatively evenly distributed (i.e., 25.6% grade 5, 27.3% grade 8, and 26.1% grade 9), with slightly fewer in grade 11 (20.9%). The mean of CTL score was 12.15 with a standard deviation of 1.5 (ranging from about 5 to 15 points). Descriptive statistics by year and start time are presented in Table 1.

Table 1
Descriptive Statistics for the 2016 and 2019 MSS Data

	2016		2019	
	Control	Treatment	Control	Treatment
	%	%	%	%
Control Variables				
Race/Ethnicity				
African American	8.5	7.6	10.6	8.1
American Indian	3.8	3.1	2.6	2.5
Asian	5.9	9.5	7.4	12.6
Hispanic/Latino	11.1	14.0	12.1	13.0
Hmong	2.8	1.2	2.9	0.9
Multiracial	5.7	5.1	4.2	4.3
Somali	3.1	3.8	3.4	4.4
White	58.0	54.2	54.5	51.6
Grade				
5	27.4	20.2	28.0	25.8
8	26.5	28.3	28.1	26.6
9	25.9	29.4	24.6	25.3
Gender				
Female	49.1	48.9	49.6	49.3
FRL				
No	74.9	70.8	60.5	60.7
CtL				
Mean	12.3	12.3	12.0	12.0
SD	1.6	1.5	1.5	1.5
Dependent Variables				
Sleep				
Recommended	33.3	30.3	32.5	34.8
GPA				
Mean	3.2	3.2	3.2	3.3
SD	0.9	0.9	1.0	0.9
n	10866	8041	10047	9065

Note. FRL = Free- and reduced-priced lunch status; CtL = Commitment to learning scale; Sleep-Recommended = percent of student obtaining the recommended amount of sleep on a school night.

Dependent Variables

There were two dependent variables that were investigated in this study, including self-reported grades typically achieved in school classes (used to estimate GPA) and whether students typically obtained the recommended amount of sleep during school nights. Student GPA was estimated by from a MSS item where students reported the grades they typically received during their current school year (e.g., *Mostly As*, *Mostly Bs*, etc.). The responses were converted to values on a 4.0 scale ($M = 3.2$, $SD = 0.9$). The sleep variable was dichotomized from a MSS item with seven options, where students reported the amount of sleep they typically obtain on a school night, ranging from *4 or less hours of sleep* to *10 or more hours of sleep*, into whether students met the recommended 9 hours or more (28.2%) for students in grades 5 and 8, and 8 hours or more (36.6%) for students in grades 9 and 11. Sleep recommendations followed guidance from the National Sleep Foundation (Hirshkowitz et al., 2015) and the American Academy of Sleep Medicine (Paruthi et al., 2016).

Regression Analyses

Two multiple regression analyses were conducted with the *R* 4.0.2 statistical software (R Core Team, 2020). The first multiple regression model was fitted to the data to test the hypothesis regarding the association between student academic performance and the decision of their school district to move to a later start time, controlling for race/ethnicity, FRL, gender, and CTL. Additionally, the grade of the student along with interaction effects between grade and LST were included as covariates as well as an interaction between year and LSD. A three-way interaction between the variables of LSD, grade, and year was considered but it was removed when it was determined not be statistically significant. This model was

$$\begin{aligned}\widehat{\text{GPA}} = {} & \beta_0 + \beta_1(\text{FRL}) + \beta_2(\text{Race / Ethnicity}) + \beta_3(\text{Gender}) + \\ & \beta_4(\text{CtL}) + \beta_5(\text{Grade}) + \beta_6(\text{Year}) + \beta_7(\text{LSD}) + \\ & \beta_8(\text{LSD x Grade}) + \beta_9(\text{LSD x Year})\end{aligned}$$

The second model was a logistic regression model due to the binary nature of the dependent variable. This multiple logistic regression model was fit to the data to test the hypothesis regarding the association between whether students obtained the recommended hours of sleep and a later start time, controlling for the same variables described above. In a logistic regression model, rather than predict a value for the dependent variable, the model predicts the probability of being in the affirmative condition (coded 1) for the model. Thus, this model predicted the probability of whether a student obtained the recommended amount of sleep. The model implemented the same variables as the previous model and again a three-way interaction was considered then removed due to non-significance. This model was

$$\begin{aligned}\text{Logit}\left(\widehat{\text{Recommended Hours}}\right) = {} & \beta_0 + \beta_1(\text{FRL}) + \beta_2(\text{Race / Ethnicity}) + \\ & \beta_3(\text{Gender}) + \beta_4(\text{CtL}) + \beta_5(\text{Grade}) + \beta_6(\text{Year}) + \\ & \beta_7(\text{LSD}) + \beta_8(\text{LSD x Grade}) + \beta_9(\text{LSD x Year})\end{aligned}$$

Results

Students in school districts that moved to a later start time (LSDs) in 2019, relative to the sample that did not change SST, reported higher grade point averages and higher proportions of meeting the recommended hours of sleep, after controlling for sociodemographic characteristics and Commitment to Learning.

Academic Performance

For academic performance as measured by GPA, there was a significant interaction effect between LSD and year, $B = 0.07$, $p < 0.001$, controlling for FRL, race/ethnicity, gender, and CTL, see Table 2, Model 1, and Figure 1, indicating GPA increased more for LSD relative to ESD students over time. All interaction effects between LSD and grade were also significant; grades 8, 9, and 11 all had positive effects ($B = 0.13$, $SE = 0.03$; $B = 0.11$, $SE = 0.03$; $B = 0.11$, $SE = 0.03$, respectively), indicating GPA increased more in these grades than grade 5 over time. These effects were statistically significant after accounting for the control variables, and they represented the increase in GPA for each grade relative to grade 5.

In all, predicted GPAs increased for all grades for ESDs (0.07); however the increase for each grade for the LSDs was greater, ranging from 0.14 to 0.20 GPA points. Specifically, GPA increased in LSDs above the increase in ESDs by 0.07 in grade 5, 0.13 in grade 8, and 0.11 in grades 9 and 11. See Table 3 for the fitted (predicted) values by grade, year, and group.

Recommended Hours of Sleep

The effects of later start times were similar on the likelihood of students obtaining the recommended hours of sleep. Given that the variable for meeting the recommended hours of sleep was binary (i.e., whether students met the recommended hours of sleep), the effect sizes for the significant interaction and main effects are expressed as odds ratios (see values for exp(B) in Table 2, Model 2). There was a significant effect for the interaction between LSD and year (OR = 1.16, 95% CI [1.05, 1.29]). That is, the odds of meeting the recommended hours of sleep increased by 16% for students in LSDs from 2016 to 2019. For the interaction effects with LSD and grade, the only significant effect was for grade 8 (OR = 1.34).

Specifically, the likelihood of obtaining the recommended hours of sleep did not increase over time in ESDs at statistically significant levels (where they experienced small increases in the likelihood by between 1 and 9 percent), but did so in LSDs, where the likelihood to obtain the recommended hours of sleep increased by 35% in grade 5, 11% in grade 8, 8% in grade 9 and 5% in grade 11 (although only the grade 8 increase was statistically significant). See Table 4 for the fitted (predicted) values by grade, year, and group.

Table 2

Multiple Regression Results for Grade Point Average (Model 1) and Experiencing the Recommended Amount of Sleep (Model 2)

		Model 1		Model 2		
		B	SE(B)	B	SE(B)	exp(B)
Intercept		1.00	0.04	-2.40	0.11	
FRL						
	Yes	-0.39 **	0.01	-0.09 *	0.03	0.91
	Not Sure	-0.31 **	0.02	-0.06	0.05	
Race/Ethnicity (Ref = White)		**				
	African American	-0.35 **	0.02	-0.27 **	0.05	0.76
	American Indian	-0.32 **	0.03	-0.31 **	0.08	0.73
	Asian	0.13 **	0.02	-0.26 **	0.05	0.77
	Hispanic/Latino	-0.40 **	0.01	-0.16 **	0.04	0.85
	Hmong	-0.18 **	0.03	-0.28 *	0.09	0.76
	Multiracial	-0.12 **	0.02	-0.32 **	0.06	0.73
	Somali	-0.25 **	0.03	0.50 **	0.07	1.65
	Missing	-0.11 *	0.04	-0.11	0.10	
Gender (Female)		0.18 **	0.01	-0.30 **	0.03	0.74
CtL		0.19 **	0.00	0.24 **	0.01	1.27
Grade (Ref = Grade 5)						
	Grade 8	-0.05 *	0.02	-2.09 **	0.05	0.12
	Grade 9	-0.03	0.02	-0.96 **	0.04	0.38
	Grade 11	-0.13 **	0.02	-1.69 **	0.05	0.18
Year (2019)		0.07 **	0.01	0.05	0.04	
LSD		-0.07 **	0.02	-0.08	0.05	
LSD*Grade 8		0.13 **	0.03	0.30 **	0.07	1.34
LSD*Grade 9		0.11 **	0.03	0.00	0.06	
LSD*Grade 11		0.11 **	0.03	0.03	0.08	
LSD*Year 2019		0.07 **	0.02	0.15 *	0.05	1.16
		Adj. R^2	0.25	*pseudo* R^2	0.20	

Note. FRL = Free- or reduced-priced lunch status; CtL = Commitment to Learning; LSD = Later Start Time School District; *pseudo* R^2 (Cragg-Uhler).

* $p < .01$; ** $p < .001$

Figure 1

Interaction Plot of Predicted Grade Point Averages by Grade, Year, and Start Time

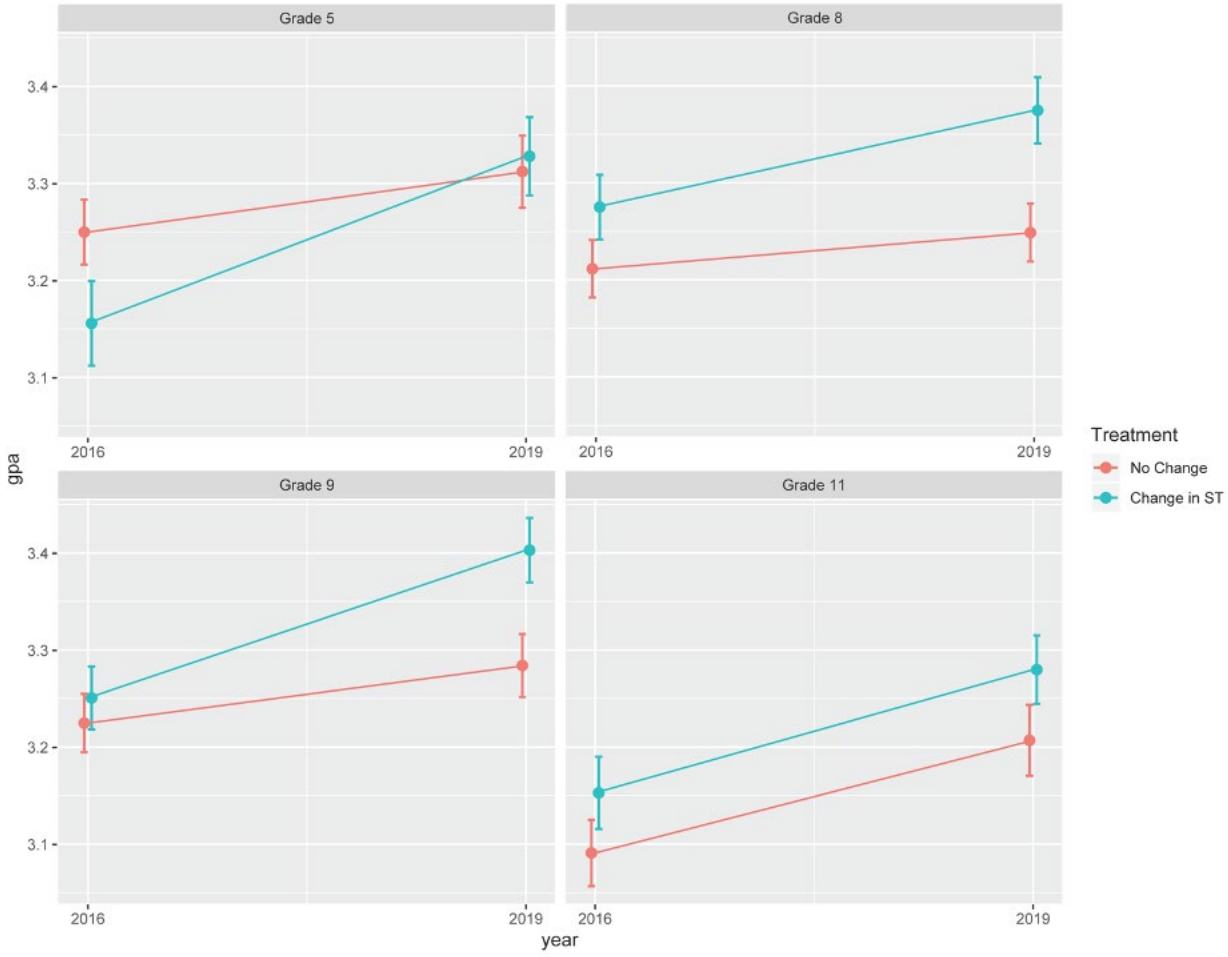

Table 3

GPA Fitted Values for Each Grade, Year, and Group

Group	Grade	2016	2019	Difference between year	Difference between group and year
Early start districts	5th	3.34	3.41	0.07	
	8th	3.29	3.36	0.07	
	9th	3.31	3.38	0.07	
	11th	3.21	3.28	0.07	
Late start districts	5th	3.27	3.41	0.14	0.07
	8th	3.28	3.49	0.20	0.13
	9th	3.31	3.49	0.18	0.11
	11th	3.21	3.39	0.18	0.11

Table 4

Likelihood of Obtaining Recommended Hours of Sleep Fitted Odds Ratios for each Grade, Year, and Group

Group	Grade	2016	2019	Difference between year	Difference between group and year
Early start districts	5	1.74	1.83	0.09	
	8	0.21	0.23	0.01	
	9	0.66	0.70	0.03	
	11	0.32	0.34	0.02	
Late start districts	5	1.60	1.96	0.35	0.27
	8	0.21	0.33	0.11	0.10
	9	0.66	0.75	0.08	0.05
	11	0.32	0.37	0.05	0.04

Discussion

Academic Performance

In the model predicting academic performance, the main effects can only be interpreted with the interaction effects. Considering the interaction effect, we can show the effect that pushing back the SSTs had over the years. This interaction effect is 0.07, showing an additional increase in GPA for students in LSDs beyond that of the ESDs. Although there was a slight increase in GPA for all students across ESDs and LSDs between 2016 and 2019, the increase for LSDs was 0.07 for grade 5, 0.13 for grade 8, and 0.11 for grades 9 and 11. These are relatively small effects, but they are meaningful for every student who's GPAs were improved by only the policy decisions of district leaders.

Recommended Hours of Sleep

Similar to the previous analysis, the main effects will be considered in the context of the interaction effects. However, due to one of the interaction effects only being significant for grade 8 and for year, the effect for LSDs can be considered to be the same for grades 5, 9 and 11 as well as between the years. Since the main effect for year was not significant, there was no change in likelihood for obtaining the recommended hours of sleep for the ESD over time. The only effect detected was the difference between years for the LSDs. The model shows that the students in LSDs in 2019 were 1.16 times more likely than the ESD students in 2016 to get the recommended amount of sleep, with an additional effect for some grades. In fact, the increase in likelihood of obtaining the recommended hours of sleep for LDSs increased for grade 5 an additional 35% and grade 8 an additional 11%. This effect shows that beyond all other variables, pushing back the SSTs makes a difference in the amount of sleep students obtain.

Educational Significance

School districts around the country are still looking for evidence to guide them to make data-driven decisions regarding delayed or later SSTs. The majority of researchers investigating changes in SSTs have focused on health behaviors including the number of additional hours of sleep students get at night, mental health, sleepiness during class, absenteeism, tardiness, and even decreased number of vehicle accidents. Fewer researchers have focused on academic performance, and those that have focused on academic performance have looked at test scores and GPA changes producing both positive results in gains in test scores and GPA, and others finding negligible impact of changes in SST on test scores and GPA. We introduced a control group in order to increase robustness and better gauge the effectiveness of SST changes.

Although the results are positive and significant, the effect sizes of changes to later SSTs were small. However, they still account for some explained variance in GPA and the likelihood of students meeting the recommended amount of sleep. These findings, together with the positive physical health and mental health outcomes found by other colleagues, ought to provide school districts with more data to guide them in making appropriate decisions when encountering discussions regarding SST changes.

At a time where school budgets are tight, educators and stakeholders ought to seek inexpensive options to increase academic outcomes as well as the physical and mental health of students that would be fairly easy to implement. SST changes have been reported to have short-term (Wahlstrom & Owens, 2017) as well as long-term financial savings (Hafner et al., 2017).

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