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Delayed high school start times later than 8:30 AM and impact on graduation rates and attendance rates

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ABSTRACT

Objectives: The first purpose of this study was to investigate changes in high school graduation rates with a delayed school start time of later than 8:30 AM. The second aim of the study was to analyze the association between a delayed high school start time later than 8:30 AM and attendance rates.
Design: In the current study, a pre-post design using a repeated-measures analysis of variance was used to examine changes in attendance and graduation rates 2 years after a delayed start was implemented.
Setting: Public high schools from 8 school districts (n = 29 high schools) located throughout 7 different states. Schools were identified using previous research from the Children's National Medical Center's Division of Sleep Medicine Research Team.
Participants and measurements: A total membership of more than 30,000 high school students enrolled in the 29 schools identified by the Children's National Medical Center's Research Team. A pre-post design was used for a within-subject design, controlling for any school-to-school difference in the calculation of the response variable. This is the recommended technique for a study that may include data with potential measurement error.
Results: Findings from this study linked a start time of later than 8:30 AM to improved attendance rates and graduation rates.
Conclusions: Attendance rates and graduation rates significantly improved in schools with delayed start times of 8:30 AM or later. School officials need to take special notice that this investigation also raises questions about whether later start times are a mechanism for closing the achievement gap due to improved graduation rates.

Introduction

Sleep experts agree that school start times are not in synchronization with adolescent sleep cycles, affecting learning and overall well-being of students.[1,2] Proven scientifically, the drive to fall asleep and alert from sleep shifts during adolescence.[3,4,5] Previous studies suggest that adolescents need 9 hours or more a night to function at peak performance,[4,6,7] making 8:30 AM or later an ideal start time for adolescent sleep/wake cycles.[8–12] School start times influence wake times but other factors impact bedtimes. Two national convenience samples were studied to compare changes in bedtime and wake time from 1981 and 2003-2006 among adolescent students 15 to 17 years old. Findings from this comparative study indicated that over the span of time, socioeconomic factors and daytime activities predicted weekday bedtime and school start time predicted weekday wake time.[13] If irregular pubertal sleep patterns result in a decreased sleep drive before 11:00 PM because the adolescent body begins to produce melatonin at 11:00 PM and stops at about 8:00 AM,[10,14] then only a small window of time exists to obtain optimum sleep. Using basic math calculations, it is evident that the amount of sleep recommended is difficult if not impossible to obtain based on the majority of existing bell schedules. To date, a concern lingers that a failure to shift start times may lead to chronic sleep deprivation in high school students. A disconnect occurs because the only way to overcome sleep deprivation is to increase nightly sleep time to satisfy biological sleep needs, a solution that is not an option for most adolescents given the existing bell times.[15]

To draw more attention to the commonly accepted practice of setting early bell schedules, on August 6, 2015, the Centers for Disease Control and Prevention released information outlining the school start times of 40,000 middle and high schools.[16] The report indicated that fewer than 20% of middle and high schools start at 8:30 AM or

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later.[16] More specifically, 42 states reported that 75% to 100% of public schools start before 8:30 AM[16] Survey findings raise awareness about the reluctance by school officials to adjust bell schedules to match adolescent sleep patterns.[17] Furthermore, decisions to condone existing start times persist despite politician and physician attempts to urge local district and state leaders to consider scientific evidence before setting bell times.[18–20] Stated clearly in a 2005 study published in *Pediatrics*,[5] physicians concluded boldly that decision makers set students up for failure by endorsing traditional school schedules. The plea to delay start times is not only expressed by physicians but also by politicians that have called for federal oversight to enact public policies that align to the sleep/wake cycle.[19] Reasons to dismiss schedule changes vary; however, one argument against the implementation for later school start times is due to a belief by stakeholders that delayed adolescent sleep onset is a behavioral choice, influenced by factors such as socializing with peers and accommodating late job schedules.[21] This stance seems counterintuitive given that evidence suggests that biological processes of the sleep/wake cycle, and not merely teen preferences, are responsible for the delay in drive for sleep.[4,5]

Consequences of inadequate sleep

An important research finding to consider is that insufficient sleep has been associated with an increase in suicidal attempts, suicidal ideation, substance abuse, and depression in adolescents.[22] Studies showed that inadequate and fragmented sleep impacts student well-being. Winsler and colleagues[22] surveyed adolescents (n = 27,939) and conclude that a shortened duration of sleep by 1 hour increased feelings of hopelessness, doom, suicidal ideations, attempted suicides, and substance abuse. Furthermore, insomnia and major depression were 2 symptoms related to sleep quality and quantity in a 2013 study.[23] The study revealed teens that attempted suicide were found to have higher rates of insomnia and sleep disturbance.[24] Experts stress that the relationship between sleep disturbance and completed suicide is important to recognize and further suggest that this could be used as an indicator to initiate intervention and prevention efforts in teens at risk for suicide.[24]

Other high-risk behaviors associated with inadequate sleep have been investigated. Increased rates of automobile accidents were related to earlier start times.[25] Specifically, a study in Virginia found that students that started school at 8:30 AM or later had fewer car accidents.[26] Students that attended early classes were more likely to participate in criminal activity and had a higher incidence of engagement in risk-taking behaviors such as drug or alcohol abuse.[27] Furthermore, inadequate sleep in teens has been linked to more problems with regulation of emotions and higher rates of mood disorders.[28,29] O'Brien and Mindell[29] conclude from self-reports (Sleep Habits Survey and Youth Behavior Survey) distributed to 388 adolescent participants (14-19 years) that students that slept fewer hours reported greater alcohol use than students that slept longer on school nights. Teens that do not obtain an adequate amount of sleep are also more likely to smoke cigarettes, engage in sexual activity, and use marijuana.[27,30]

Benefits of sufficient sleep

Evidence suggests that a delay in school start time promotes improvement in attendance and tardiness during first-period classes.[12,31] In Wahlstrom's[11] study, 18,000 Minneapolis high school students (9th-11th grade) showed an improvement in grades and attendance rates when bell times changed from 7:15 AM to 8:40 AM.[12] In this study, there was a significant improvement in attendance rates for 9th to 11th grade students not continuously enrolled in the same high school, with speculation offered that continuously enrolled students already had high attendance rates predelay start time so changes were not as remarkable.[12] Researchers note in the 1998 School Start Time Study that students attending schools with later start times were significantly less likely to arrive to class late because of oversleeping, compared with peers attending schools with earlier start times.[32] Research that compared the academic outcomes of 2 different middle schools in New England showed that students at the earlier starting school were tardy 4 times more frequently.[33] Edwards[34] also finds later start times related to decreased absences. Recently, in a 3-year study with 9000 students in 8 public high schools over 3 states, Wahlstrom and colleagues[35] found significant increases in attendance and reduced tardiness with a start time of 8:35 AM or later.

Importance of stakeholder consideration to adjust bell times

The decision to continue to set high school start times earlier than 8:30 AM supports the hypothesis that school officials are not using scientific evidence as the basis for their actions. With all of the current emphasis on improving K-12 education, the potential of this study to demonstrate significant changes in attendance and graduation rates of students simply by adjusting school start times is a critical component of educational reform and of critical importance to educational leaders. Scientific research has established the link between adolescent circadian rhythms, sleep debt, and negative impacts on cognitive function, behavior, attendance, health difficulties, and social and emotional health.

Prior research conducted by Wahlstrom[11] examined the effects of school start times in various districts with conclusions linked to improved graduation rates in only 1 school district 3 years after the implementation of a delayed start time of 8:30 AM. Extended research that examines the impact of delayed start times in other districts throughout the country will add rigor to the previous findings. Therefore, the first aim of this investigation is to compare predelay (8:30 AM or earlier) graduation completion rates with postdelay (later than 8:30 AM) graduation rates in the same 8 school districts 2 years after implementation. The second purpose of this study is to assess whether attendance rates improve with a delay in school start time of later than 8:30 AM in the morning.

Participants and methods

This study examines the impact of delayed school start times on the percentage of high school absences and graduation rates at the school level. The data for the study are from *School Start Time Change: An In-Depth Examination of School Districts in the United States*[36] from the Children's National Medical Center's (CNMC) Division of Sleep Medicine predelay and postdelay school start times. The CNMC team collected data from school districts throughout the nation that successfully implemented delayed start times in high schools. Additional data, graduation rates, and attendance rates are obtained from state repositories. The current research was conducted using the data from the state repositories of 29 schools in 7 states and 8 school districts (of 38 districts in the original study) specifically collecting attendance and graduation rates at 2 periods (predelay and postdelay). This design controls for school-to-school differences and eliminates competing explanations for any observed changes in the response variables. It is acknowledged that not all schools calculate the response variables using the same methodology. However, as mentioned, the design of the study, a within-subject design, allows for any school-to-school difference in the calculation of the response variable to be controlled for. In addition, the analytical technique used for this study, a general linear model (analysis of variance, or ANOVA), reduces measurement error (any school to school variability) to a greater extent than a difference score analysis, and has

Table 1
List of schools and time changes

Location	Predelay time	Delay start	Increase time in time change (min)
Bedford County public schools, Virginia	Before 2013 8:30-3:00	After 2013: 8:55-3:35	25
Jefferson Forest High School (HS)			
Liberty HS			
Stauton River HS			
Brevard PS, FL	Before 2000: 7:30-2:15	After 2000: 8:45-3:30	75
Astronaut HS.			
Coca Beach Jr/Sr HS			
Coca HS			
Eau Gallie HS			
Melbourne HS			
Merritt Island HS			
Rockledge HS			
Satellite HS			
Titusville HS			
Ithaca City SD, NY	Before 2006: 8:00-2:37	After 2006: 8:55-3:32	55
Ithaca Senior HS			
Moore County, NC	Before 2012: 8:00-3:00	After 2012: 9:00-4:00	60
North Moore HS			
Pinecrest HS			
Union Pine			
North Clackamas SD, OR	Before 1999: 7:30-2:20	After 1999: 8:45-3:20	75
Clackamas HS			
Pulaski County Special, SD, Arkansas	Before 2012: 7:30-2:40	After 2012: 8:35-3:45	65
Jacksonville HS			
Joe T. Robinson HS			
Maumelle HS			
North Pulaski HS			
Sylvan Hill HS			
Wilbur D. Mills			
Santa Rosa SD, FL	Before 2006: 8:00-2:45	After 2006: 9:15-3:15	75
Gulf Breeze			
Milton HS			
Navarre HS.			
Pace HS.			
South Washington, MN	Before 2009: 7:35-2:05	After 2009: 8:35-3:05	60
Park HS			
Woodbury HS			

increased power to conduct this analysis. This is the recommended technique for a study that may include data with potential measurement error.[37]

For this study, results are intended to be generalized to all high schools in the United States. However, the source for this study is limited to a convenience sample of districts participating in the CNMC Division of Sleep Medicine. Hence, schools and school districts are not a random sample of all high schools and this may limit the generalizability of the results. The participating 8 school districts of the 38 districts in the original CNMC study ($n = 29$ high schools) are located in 7 different states. To ensure a comprehensive treatment effect, only districts with post–start delay of more than 2 years are included. The pre-post design ensures that each school serves as its own control, minimizing effects due to school-to-school variability.

A census of the participating schools comes from the CNMC's Division of Sleep Medicine study.[36] The participating districts and the complete list of participating schools within each district along with the date of the time changes and increase in number of minutes from predelay to postdelay are included in Table 1. There is some variability in original start times (with a mean increase in minutes from pre– to post–time change of 74 minutes), but all meet the category of pre–start times of 8:30 AM or earlier and post–start times later than 8:30 AM 2 years after the time change.[33]

Variables

Attendance rates and graduation rates are measured under 2 conditions (predelay time and postdelay time). School attendance is reported as percentages and could range from 0 to 100. School start times are coded as a bivariate categorical variable coded as a 0 (early start times) and 1 (later start times). School graduation completion percentages are measured by graduation rates collected from school districts ranging from 0 to 100.

Table 2 includes the descriptive statistics for each variable. The average graduation completion rate is 79% predelay and 88% postdelay. Completion rates range predelay from 51% to 94% and postdelay from 68% to 97%. Attendance averages 90% predelay and 94% postdelay, but is less variable than graduation rates with a range of 68% to 99% predelay and 86% to 99% postdelay.

Data analysis

Data were entered in SPSS version 22 and all transformations, data cleaning, descriptive, and inferential statistics were conducted in this software package. Descriptive statistics summarized each variable to identify any potentially erroneous entries or any

Table 2
Dependent variables and descriptive statistics

Dependent variables	Descriptive statistics			
	Mean	Minimum	Maximum	SD
School attendance (predelay)	90%	68%	99%	6%
School attendance (postdelay)	94%	86%	99%	2%
School graduation (predelay)	79%	51%	94%	13%
School graduation (postdelay)	88%	68%	97%	9%

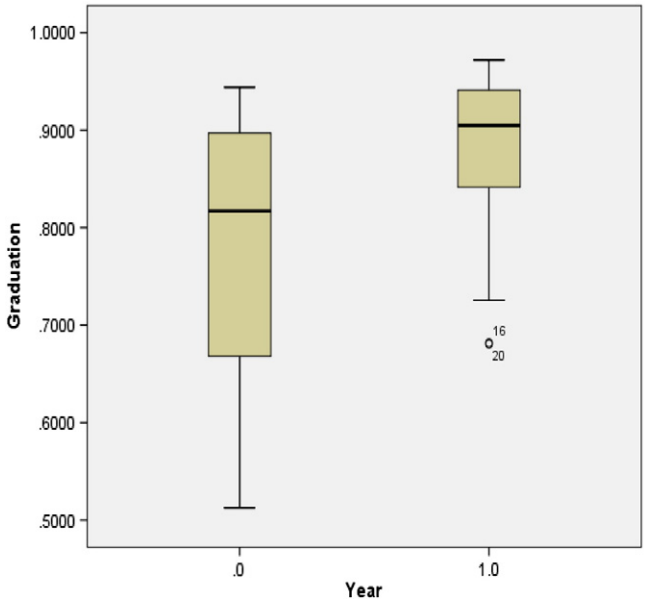

Fig. 1. Boxplot of predelay and postdelay graduation rates.

nonnormality in the continuous variables. Statistically significant relationships were determined based on an α level of .025 or less to protect against the inflation of type I error.

Analysis of variance assumptions (independence, normal distribution, and equality of variance) for both graduation rates and attendance were not met for the original variables. To remediate this, each response variable was reverse coded (subtracted by 1), and the log of this variable was calculated. The results for all inferential procedures refer to these reverse coded logs, with no evidence of violating ANOVA assumptions.

Research Question 1

What are pre– to post–start time delay differences in graduation rates in the same schools 1 year before implementation of delayed start vs 2 years after the implementation of delayed start times?

Descriptive statistics

As mentioned, average overall graduation rate (before transformation) was 83% across both the premeasures and postmeasures. Schools ranged from a minimum of 51% to a maximum of 97%. The standard deviation of 11% indicates that differences greater than 36% were considered extreme.

The next step in the descriptive statistics is a bivariate presentation of graduation rates by time. Table 2 includes the means, median, and standard deviations for predelay and postdelay graduation rates. The mean at the predelay, earlier start times, is 79%, and the mean at the postdelay is 88%. The upward trend in the rates suggests that graduation rates may be improving with changes in school start times. For both periods, the median is slightly higher than the mean, indicating that both periods may also be left skewed, similar to the aggregate data.

The boxplot in Fig. 1 provides a graphical illustration of the graduation rates at both bell times. In this figure, the median for postdelay time appears higher than for the predelay.

Inferential statistics

Repeated-measures ANOVA. The final model for research question number 1 is a repeated ANOVA, calculated to assess whether there is a significant difference in graduation rates after a school start delay of later than 8:30 AM was implemented. The equation for the model is:

$$\text{Graduation rate} = \text{year} + \text{error}.$$

The null hypothesis for the model is that no difference exists in graduation rates between predelay and postdelay years (H_0: $\mu 1 = \mu 2$). The alternative hypothesis is that there is a significant difference between predelay and postdelay years (H_0: $\mu 1 \neq \mu 2$).

Given that the assumptions are met, the model for determining if significant differences exist between predelay and postdelay graduation rates can be interpreted. Table 3 includes the result of the repeated-measure ANOVA. This table indicates that the *F* statistic of 32.465 with *df* of 28 is statistically significant, allowing rejection of the null hypothesis that there is no difference between the times ($P < .01$), well below the significance level for this study of .025. Hence significant increases occurred in graduation rates comparing predelay and postdelay times. These results mirror those in the bivariate descriptive statistics. In Fig. 1, the boxplot illustrates this trend, with the median for the postgraduation rates appearing to be greater than the median for pregraduation.

The conclusion of the analysis suggests that there is a significant difference in graduation rates when school start times are delayed. These results are made with confidence because the model using transformed data meets the assumptions of normal distribution and equal variance.

Research Question 2.

What are pre– to post–start time delay differences in the same schools 1 year before implementation of delayed start vs 2 years after the implementation of delayed start times in attendance rates?

Descriptive statistics

Table 2 includes the means, median, and standard deviations for predelay and postdelay attendance rates. The mean at the predelay, earlier start times, is 90%, and the mean at the postdelay is 94%. The upward trend in the rates suggests attendance rates may be improving with changes in school start times. For both periods, the median is slightly higher than the mean, indicating that both periods may also be left skewed, similar to the aggregate data.

The boxplot in Fig. 2 compares attendance rate predelay (0) and postdelay (1) time change and shows an average increase in attendance rates from 90% to 94%. There is at least one school in the predelay time that appears to have extremely low attendance, and one school that has extremely low attendance in the postdelay time as evidenced by the asterisks in Fig. 2.

Inferential statistics

The model for research question number 2 is a repeated ANOVA, calculated to assess whether there is a significant difference in attendance rates after a school start delay of later than 8:30 AM was implemented. The equation for the model is:

$$\text{Attendance rate} = \text{year} + \text{error}$$

Again, the null hypothesis is that there are no differences between preyear and postyear (H_0: $\mu 1 = \mu 2$) and the alternate hypothesis is that there are significant differences between predelay and postdelay attendance rates (H_0: $\mu 1 \neq \mu 2$).

The ANOVA model for attendance rate is significant between the predelay year and postdelay year at the .025 level with an *F* statistic of 12.88 and a *df* of 25.86 (Table 4). This means that delayed start

Table 3
Graduation rate fixed effects

Test of fixed effects				
Dependent variable: graduation rates				
Source	Numerator *df*	Denominator *df*	*F*	Sig.
Intercept	1	28.00	326.06	.000
Year	1	28.00	32.47	.000

time is an important and significant predictor for improved attendance rates.

The conclusion of the analysis suggests that there is a significant difference in attendance rates when school start times are delayed. The transformed data meet the assumptions of normal distribution and equal variance. Independence is still violated by the design of the model; however, running repeated measures remediates this assumption.

Results

To study the significance of delayed school start times on high school attendance and graduation rates, the following research questions guided this study: (*a*) Are there significant differences in graduation rates when comparing traditional to delayed school start times? (*b*) Are there significant differences in attendance rates when comparing traditional to delayed school start times? This study hypothesized that when schools change the start time from 8:30 AM or earlier to later than 8:30 AM, graduation rates and attendance rates would increase. The first research question investigated the potential benefits of delayed school start times of later than 8:30 AM for high school graduation rates. Twenty-nine schools were included in the sample. Two of the school districts were located in the state of Florida, totaling 18 schools. The remaining 11 schools were found in school districts located in the states of Virginia, New York, North Carolina, Oregon, Arkansas, and Minnesota.

Research Question 1: What are pre– to post–start time delay differences in graduation rates in the same schools one year before implementation of delayed start vs 2 years after the implementation of delayed start times?

The 1-way repeated-measures ANOVA (predelay and postdelay times) indicates a significant difference between the transformed graduation rates before and after delaying school start time of later than 8:30 AM. This study extends Wahlstrom's[11] study to empirically examine graduation rates before and after implementation of a delayed school start time.

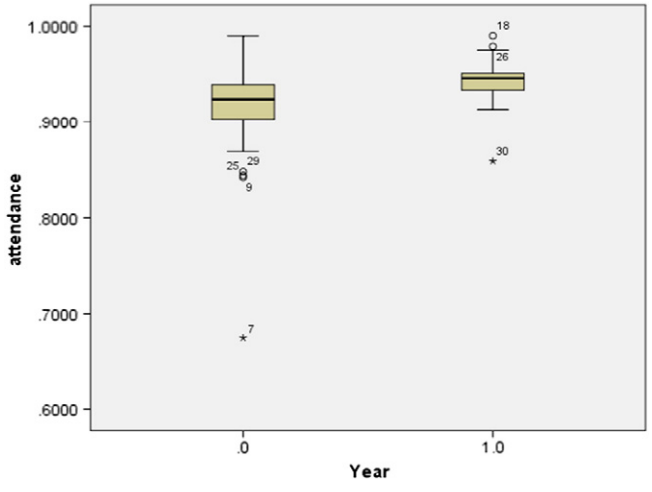

Fig. 2. Boxplot of attendance by time.

Research Question 2: What are pre– to post–start time delay differences in the same schools 1 year before implementation of delayed start vs 2 years after the implementation of delayed start times in attendance rates as a measure of social–emotional well-being?

A 1-way repeated ANOVA comparing pre– and post–time change in attendance rates increased with delays in start times. The significant results of this study are consistent with existing studies.[31,36] Wahlstrom et al.[35] used a longitudinal study, and the current pre– and post–2-year replication adds further support to their findings. The findings supported the hypothesis of the current study that students that started school later than 8:30 AM would have better attendance rates.

Discussion

The results of this study lend empirical evidence and add rigor to the argument that a shift to later school start times for high school students results in more favorable outcomes, such as attendance rates and graduation rates. This study draws from the work by Wahlstrom,[11] who found improvement in attendance and graduation rates (one district) limited to only one state.

Although this study does not specifically measure the amount of sleep, the results are consistent with prior research linking later school start times to more sleep.[11,35] The connection between later school start times and more sleep is important, but the results of significant improvements in graduation rates allow practitioners to see the positive and socially important outcome of such a policy shift, increased graduation. Linking changes in school start times to graduation rates connects outcomes to policy.

Finally, although this study does not examine social–emotional outcomes linked to the amount of sleep obtained, the results do support the improvement in attendance with later start times. Given the empirical evidence to support psychosocial outcomes and attendance already established in the literature,[24] the reasoning that later school start times allow for more sleep, which reduces negative social–emotional outcomes, promoting improved attendance is possible. Again, these connections are beyond the scope of this study, but certainly, this is a promising opportunity for further research.

Implications for future research and practical application

The current study provides statistical evidence that both graduation rates and attendance rates significantly improved after the

Table 4
ANOVA-transformed attendance

Source	Numerator *df*	Denominator *df*	*F*	Sig.
Intercept	1	28.94	943.71	.000
Year	1	25.86	12.88	.001

Dependent variable: transformed attendance. Abbreviation: ANOVA, analysis of variance.

implementation of a delayed school start time. The study adds to the existing literature and addresses the benefits of later high school start times,[9,35,10,12] contributing to improved graduation and attendance rates. Basic sleep needs are met so students attend school more frequently and graduate. With additional evidence such as this study, the policy changes so widely sought[13] can further justifications for influencing educational leaders to make change.

Implications for students

Results of the current study could impact adolescent students. This study supports a relationship between adolescent sleep and increased attendance and graduation rates. Understanding the relationship between adequate amounts of sleep and daytime functioning is important. The present study provides evidence that with a delay in start times, students reap the benefit of a school schedule that is in synchronization with their internal biological clock.

Implications for other stakeholders

The results of this study have implications for policy makers at the federal, state, and local levels looking to improve the graduation rates for high school students. The promise of increased student success and graduation completion is already driving some officials to implement later school start times in high schools.[4] Evidence contained in this study add rigor and will provide further justification for other officials to consider these changes. An adjustment to later high school start times can be unattainable without the support of key officials, and the continuing investigation of the benefits of delayed start times could encourage new support for policy change.

Stakeholders who understand adolescent sleep should continue to advocate for this reform. Through her actions in Congress since 1999, Representative Zoe Lofgren of California has prioritized the high school student and has advocated for bell times that match adolescent sleep/wake cycles. Evidence from this study suggests that the benefits of improved graduation completion rates make it an even more powerful argument. Physicians, especially those who treat adolescents, have campaigned since 1994 to allow teenagers to start school later. It would be hard to imagine that their argument has weakened given the evidence from this study that delayed school start times of later than 8:30 AM suggest improved attendance and graduation rates.

Conclusion

The overall findings from this study are consistent with, and extend the evidence in the literature. Improved attendance rates increase the likelihood of graduation completion. Every student should have an equal opportunity to graduate from school. If a delayed start time of later than 8:30 AM promotes improved student access to attending, learning, and graduating, then all of society benefits because increased graduation completion impacts quality of life.

Improving graduation completion is a clear educational benefit. Less obvious are the reasons why a delayed school start enables students to attend school, an effect beyond the scope of this study. Given the many impacts of improved attendance and graduation rates, educators and officials responsible for setting school start times should be obliged to consider a shift to later bell times if it improves adolescent well-being and daytime performance. Gaining an understanding about the underlying biological underpinnings of adolescent sleep needs is the first step to making change. The brain and the nervous system require optimal sleep to function, and adolescents have a unique set of sleep needs that should be considered before school start times are determined. The decision to start high school later requires a shift in mindset. With support of empirical investigations such as this study, educators are in a pivotal position to become change agents and advocates for high school students by teaching all stakeholders about adolescent sleep. These changes accomplish what all educators and educational leaders aspire to: student success.

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