

LITERATURE REVIEW: OPTIMAL SCHOOL START TIMES

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In the following report, Hanover Research recommends optimal school start times based on professional recommendations and findings from secondary research.

TABLE OF CONTENTS

Executive Summary and Key Findings3

 INTRODUCTION3

 KEY FINDINGS3

Section I: Optimal School Start Times for Adolescents6

 SLEEP AND SCHOOL START TIME RECOMMENDATIONS6

 Delaying Secondary School Start Times.....7

 OVERVIEW OF RESEARCH8

 Summary of Research10

 EFFECTS ON SLEEP12

 Positive Effects.....13

 Mixed or No Effects16

 EFFECTS ON ACADEMIC ACHIEVEMENT17

 Positive Effects.....17

 Mixed or No Effects19

 EFFECTS ON OTHER OUTCOMES20

 Driving Safety.....20

 Attendance and Graduation22

 Mental Health23

 Extracurricular Participation.....23

Section II: Optimal School Start Times for Pre-Adolescents 25

 SLEEP RECOMMENDATIONS.....25

 Advancing Elementary School Start Times25

 OVERVIEW OF RESEARCH26

 Effects of Sleep26

 Effects of Start Times.....27

EXECUTIVE SUMMARY AND KEY FINDINGS

INTRODUCTION

National surveys indicate that over 70 percent of adolescents receive less than eight hours of sleep per school night, which is the *minimum* recommended amount for this age group.¹ As research finds that adolescents struggle to fall asleep before 11:00 p.m. due to hormonal changes affecting their natural sleep cycle, professional associations such as the American Academy of Pediatrics (AAP) recommend that secondary schools start no earlier than 8:30 a.m.² However, due to logistical constraints, a delay in high school start times often corresponds with an advance in school start times for younger students, and the impacts of earlier school start times on them are less studied.

To support school districts in determining optimal school start time structures across school levels, Hanover Research (Hanover) reviews professional recommendations and peer-reviewed research studies related to the effects of school start times on elementary and secondary students. The report adopts the following structure:

- **Section I: Optimal School Start Times for Adolescents** presents recommendations regarding sleep duration and school start times and discusses research on the effects of secondary school start times on a variety of adolescent outcomes.
- **Section II: Optimal School Start Times for Pre-Adolescents** presents parallel recommendations for sleep duration and discusses research related to sleep, school start times, and academic and behavioral outcomes for elementary school children.

KEY FINDINGS

MIDDLE AND HIGH SCHOOL START TIMES

Based on professional recommendations and the collective findings of the scholarly literature, Hanover recommends a high school start time of 8:30 a.m. or later. Research and educational experts also suggest that middle schools start no earlier than 8:30 a.m. However, existing studies indicate that older adolescents (i.e., high school students) sleep less than their younger peers and may experience larger sleep benefits from a delay in school start time. Consequently, districts should start high schools later than middle schools, and if possible, start both at 8:30 a.m. or later.

- **An increasing number of professional associations support delaying middle and high school start times to 8:30 a.m. or later.** The American Academy of Pediatrics (AAP)

¹ [1] Kann, L. et al. "Youth Risk Behavior Surveillance — United States, 2015." *Morbidity and Mortality Weekly Report*, 65:6, June 10, 2016. pp. 43–44. https://www.cdc.gov/healthyyouth/data/yrbs/pdf/2015/ss6506_updated.pdf [2] Paruthi, S. et al. "Recommended Amount of Sleep for Pediatric Populations: A Consensus Statement of the American Academy of Sleep Medicine." *Journal of Clinical Sleep Medicine*, 12:6, 2016. p. 785. <http://www.aasmnet.org/Resources/pdf/Pediatricsleepdurationconsensus.pdf>

² American Academy of Pediatrics. "Policy Statement: School Start Times for Adolescents." *Pediatrics*, 134:3, September 2014. <http://pediatrics.aappublications.org/content/pediatrics/early/2014/08/19/peds.2014-1697.full.pdf>

notes that “a substantial body of research has now demonstrated that delaying school start times is an effective countermeasure to chronic sleep loss and has a wide range of potential benefits to students with regard to physical and mental health, safety, and academic achievement.”¹ Consequently, the AAP, American Medical Association, and American Academy of Sleep Medicine all endorse a start time of 8:30 a.m. or later for secondary students.

- **Research indicates that later school start times allow adolescents to sleep longer.** For example, multiple studies find that students gain an additional minute or more of sleep per night for every two-minute delay of school start time. While the existing research base demonstrates a strong relationship between later start times and increased sleep, some limited research also suggests that later start times have a positive effect (or at worst, no effect) on academic achievement, driving safety, attendance and graduation rates, mental health, and extracurricular participation.
- **Districts also need to consider daily student travel time when adjusting school start times.** While research studies and professional recommendations commonly focus on school start times, morning travel time to school also determines what time students must wake up. Districts with longer bus routes may need to delay school start times further compared to districts with shorter bus routes.

ELEMENTARY SCHOOL START TIMES

Hanover recommends that districts advance elementary school start times to no earlier than 8:15 a.m. The research examining the effects of school start times on elementary school students is extremely limited. However, available research suggests that by starting elementary schools too early, districts may “be shifting the problem from adolescents to younger children, instead of eliminating it altogether.”³

- **Two studies indicate that an advance in elementary school start time to between 8:15 a.m. and 8:20 a.m. has little or no effect on students’ sleeping habits or academic achievement.** In one study, a start time change from 8:20 a.m. to 7:45 a.m. at one elementary school corresponded with students in Grades 4-5 losing less than 10 minutes of sleep per night. Similarly, a county-wide study finds no correlation between later (9:15 a.m.) and earlier (8:15 a.m.) elementary school start times and the academic performance of students in Grades 3-5.
- **However, larger-scale studies considering a wider range of school start times find that earlier start times may negatively impact elementary school students.** For example, studies of statewide data including over 310,000 elementary school students in Kentucky associated earlier start times with lower test scores and increases in negative behavioral outcomes. In addition, a 2007 study with a nationally representative sample finds that a delay in the start time of an hour corresponded

³ Keller, P., O. Smith, et al. “Earlier School Start Times as a Risk Factor for Poor School Performance: An Examination of Public Elementary Schools in the Commonwealth of Kentucky.” *Journal of Educational Psychology*, 107:1, 2015. p. 242.

with an increase in sleep duration of 20 minutes for children ages between five and 12, indicating that earlier start times may negatively impact students.

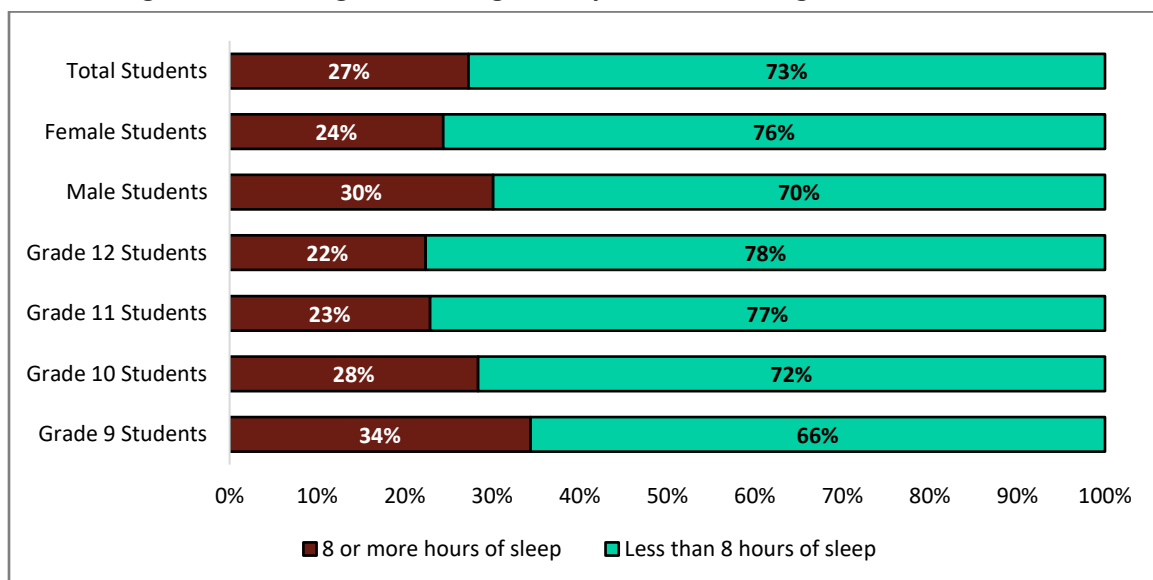
SECTION I: OPTIMAL SCHOOL START TIMES FOR ADOLESCENTS

This section presents an overview of recommendations regarding nightly sleep and school start times for adolescents and discusses research on the effects of school start times on secondary school children.

SLEEP AND SCHOOL START TIME RECOMMENDATIONS

Consensus statements published by both the American Academy of Sleep Medicine (AASM) and the National Sleep Foundation recommend that adolescents sleep from eight to 10 hours per night.⁴ However, the 2015 Youth Risk Behavior Survey (YRBS), a national survey of U.S. high school students conducted biannually by the Centers for Disease Control and Prevention (CDC), indicates that less than 28 percent of adolescents sleep eight or more hours on an average school night. Data from preceding YRBS administrations suggest that the percentage of adolescents receiving adequate sleep (i.e., eight hours or more) has decreased over the past decade, falling from 31 percent in 2007.⁵ Figure 1.1 below presents findings on school night sleep duration from the 2015 YRBS, segmented by gender and grade level.

Figure 1.1: Average School Night Sleep Duration of High Schools Students



Source: Centers for Disease Control and Prevention⁶

⁴ [1] Paruthi et al., Op. cit., p. 785. <http://www.aasmnet.org/Resources/pdf/Pediatricsleepdurationconsensus.pdf> [2]

Hirshkowitz, M. et al. "National Sleep Foundation's Sleep Time Duration Recommendations: Methodology and Results Summary." *Sleep Health*, 1:1, 2015.

⁵ Kann et al., Op. cit., pp. 43–44.

⁶ Figure adapted from: Ibid., p. 169.

Notably, research commonly associates insufficient sleep with a variety of negative health outcomes that can impact academic achievement.⁷ For example, the AASM notes the following the benefits and risks associated with adolescent sleeping patterns:⁸

- *Sleeping the number of recommended hours on a regular basis* is associated with better health outcomes including: improved attention, behavior, learning, memory, emotional regulation, quality of life, and mental and physical health.
- *Regularly sleeping fewer than the number of recommended hours* is associated with attention, behavior, and learning problems. Insufficient sleep also increases the risk of accidents, injuries, hypertension, obesity, diabetes, and depression. Insufficient sleep in teenagers is associated with increased risk of self-harm, suicidal thoughts, and suicide attempts.

DELAYING SECONDARY SCHOOL START TIMES

Advocates for delayed school start times argue that traditional middle and high school schedules fail to accommodate adolescents' biologically-determined sleep patterns. According to a research brief published by the Education Commission of the States (ECS), the onset of puberty causes adolescents to fall asleep and wake later because of a natural shift in the circadian rhythm, which regulates the sleep cycle through controlling the production of the sleep-inducing hormone melatonin. Research finds that this "biologically driven delay" in the natural sleep and wake patterns of teens and young adults totals nearly three hours.⁹

Under this schedule, the adolescent body begins producing melatonin around 11:00 p.m. and reaches peak melatonin levels close to 7:00 a.m. In contrast, adult melatonin levels peak at 4:00 a.m., leading experts to equate a consistent 7:00 a.m. wake-up time for adolescents to a 4:00 a.m. wake-up time for adults.¹⁰ Therefore, adolescents naturally find it difficult to fall asleep before 11:00 p.m.¹¹ Since experts recommend that adolescents sleep between eight to 10 hours per night, a school start time that requires students to wake up before 8:00 a.m. is likely to cause or contribute to chronic sleep deprivation.¹²

To promote healthier sleeping patterns in adolescent students, a growing number of professional associations support delaying secondary school start times to 8:30 a.m. or later. For example, in a 2014 policy statement, the American Academy of Pediatrics (AAP)

⁷ For a summary of research that finds connections between insufficient sleep and various negative mental health and behavior outcomes in youth, see: Wheaton, A., D. Chapman, and J. Croft. "School Start Times, Sleep, Behavioral, Health, and Academic Outcomes: A Review of the Literature." *Journal of School Health*, 86:5, May 2016. p. 364.

⁸ Bullets quoted verbatim from: Paruthi et al., Op. cit., p. 785.

⁹ Kelley, P. and C. Lee. "Later Education Start Times in Adolescence: Time for Change." Education Commission of the States. p. 1. <http://www.ecs.org/clearinghouse/01/12/19/11219.pdf>

¹⁰ Carrell, S., T. Maghakian, and J. West. "A's from Zzzz's? The Causal Effect of School Start Time on the Academic Achievement of Adolescents." *American Economic Journal*, 3:3, August 2011. pp. 64–65. <http://old.econ.ucdavis.edu/faculty/scarrell/sleep.pdf>

¹¹ See: [1] "Sleep Deprivation in Adolescents and Young Adults." National Adolescent and Young Adult Health Information Center, 2014. p. 1. <http://nahic.ucsf.edu/wp-content/uploads/2014/08/Sleep-Brief-FINAL.pdf>
[2] "Teens and Sleep." National Sleep Foundation. <https://sleepfoundation.org/sleep-topics/teens-and-sleep>
[3] Kelley and Lee, Op. cit., p. 1.

¹² Lahey, J. "Students Aren't Getting Enough Sleep—School Starts Too Early." *The Atlantic*, August 25, 2014. <https://www.theatlantic.com/education/archive/2014/08/surprise-students-arent-getting-enough-sleep/379020/>

notes that “a substantial body of research has now demonstrated that delaying school start times is an effective countermeasure to chronic sleep loss and has a wide range of potential benefits to students with regard to physical and mental health, safety, and academic achievement.”¹³ As such, the AAP recommends that districts delay school start times for adolescents in middle and high schools to 8:30 a.m. or later in order to improve students’ health, safety, and academic outcomes.¹⁴ In the years following the release of AAP’s policy statement, associations including the National Association of School Nurses, the Society of Pediatric Nurses, the American Medical Association, and the AASM have all issued similar position statements that support the AAP’s recommendation.¹⁵

However, despite (1) recommendations regarding adolescent sleep habits, (2) biological research finding that adolescents struggle to fall asleep before 11 p.m., (3) national surveys indicating that more than 70 percent of adolescents receive insufficient weeknight sleep, and (4) policy statements supporting delayed school start times, **recent national data indicates that fewer than 20 percent of middle and high schools have a start time of 8:30 a.m. or later.**¹⁶

OVERVIEW OF RESEARCH

Over the past two decades, a growing number of U.S. studies have assessed the effects of changes to school start times on a variety of student outcomes. Prompted in part by research indicating that children experience hormonal-driven changes in their sleep patterns, a large majority of the existing research studies focus on the effects of school start times on adolescents. For example, in a comprehensive literature review published in May 2016 in the *Journal of School Health*, Wheaton, Chapman, and Croft identified 38 U.S.- and foreign-based studies published since 1995 that consider the effects of start times on middle and high school students.¹⁷ Of these, 23 studies were conducted in U.S. public and private schools, with more than half published in 2007 or more recently.

Studies on the effects of school start times most commonly include adolescent sleep patterns as an outcome. For instance, Wheaton, Chapman, and Croft determined that week-day sleep duration is the most common student outcome measure employed in start time

¹³ American Academy of Pediatrics, Op. cit., p. 642.

¹⁴ Ibid.

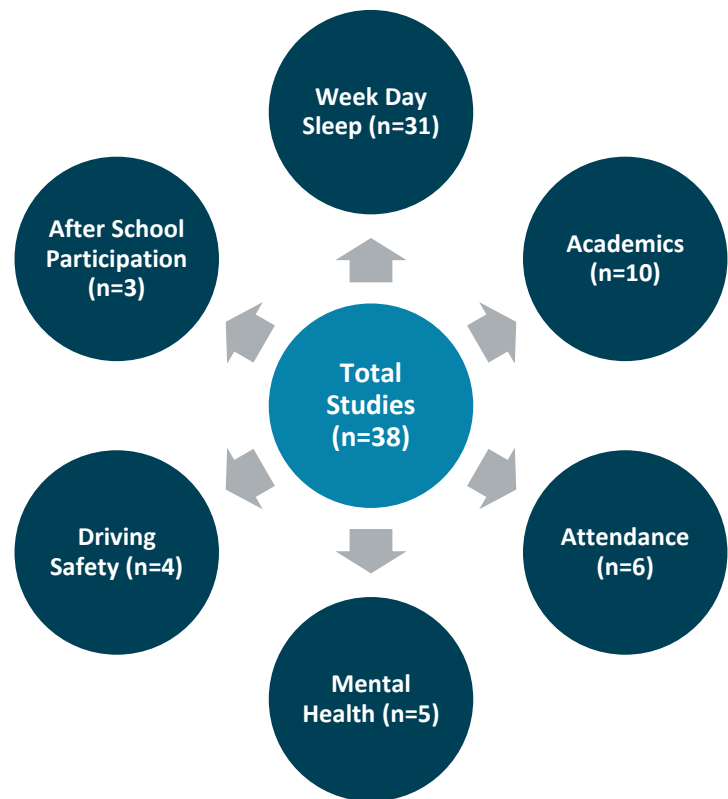
¹⁵ [1] “SPN Position Statement: Early School Start Times Consensus Statement.” Society of Pediatric Nurses and National Association of School Nurses, 2016. <http://www.pedsnurses.org/d/do/923>
[2] “AMA Supports Delayed School Start Times to Improve Adolescent Wellness.” American Medical Association, 2016. <https://www.ama-assn.org/ama-supports-delayed-school-start-times-improve-adolescent-wellness> [3] “AASM Position: Delaying Middle School, High School Start Times Is Beneficial to Students.” American Academy of Sleep Medicine, 2017. <http://www.aasmnet.org/articles.aspx?id=6847>

¹⁶ Wheaton, A., G. Ferro, and J. Croft. “School Start Times for Middle School and High School Students — United States, 2011–12 School Year.” *Morbidity and Mortality Weekly Report*, 64:30, August 7, 2015. <https://www.cdc.gov/mmwr/preview/mmwrhtml/mm6430a1.htm>

¹⁷ Wheaton, A., D. Chapman, and J. Croft. “School Start Times, Sleep, Behavioral, Health, and Academic Outcomes: A Review of the Literature.” *Journal of School Health*, 86:5, May 2016. pp. 366–374. <https://teensneedsleep.files.wordpress.com/2014/10/wheaton-et-al-school-start-times-sleep-behavioral-health-and-academic-outcomes.pdf>

research. However, less than a third of the studies included in their review measure the effects of school start times on outcomes such as academic achievement, driving safety, and extracurricular participation (Figure 1.2).¹⁸

Figure 1.2: School Start Time Research Base



Source: Journal of School Health¹⁹

In addition to the studies included in Wheaton, Chapman, and Croft’s literature review (all published on or before July 1, 2015), Hanover also reviewed more recent studies on school start times, as well as those included in two other 2016 literature reviews.²⁰ However, the review by Wheaton, Chapman, and Croft is very comprehensive and it includes all but two of the relevant sources that are in the other two 2016 research reviews.²¹

When reviewing findings from studies on the effects of school start times, it is important to keep in mind the methodological limitations of the existing research. Studies on the effects

¹⁸ Ibid.

¹⁹ Figure adapted from: Ibid., pp. 375–378.

²⁰ See: [1] Morgenthaler, T. et al. “High School Start Times and the Impact on High School Students: What We Know, and What We Hope to Learn.” *Journal of Clinical Sleep Medicine*, 12:12, 2016. <http://www.sleepeducation.org/docs/default-document-library/high-school-start-times.pdf> [2] Minges, K. and N. Redeker. “Delayed School Start Times and Adolescent Sleep: A Systematic Review of the Experimental Evidence.” *Sleep Medicine Reviews*, 2016. <http://www.sciencedirect.com/science/article/pii/S1087079215000891>

²¹ Two additional relevant studies included by: Morgenthaler et al., Op. cit.

of school start times typically employ either cross-sectional or longitudinal studies.²² Cross-sectional studies “compare different population groups at a single point in time,” while longitudinal studies compare “several observations of the same subjects over a period of time.”²³ Although longitudinal studies are “more likely to suggest cause-and-effect relationships” when compared to cross-sectional studies, both methodological designs can only draw *associations* between school start times and other variables and cannot establish *causation*.²⁴ Current research also fails to evaluate whether changes in school start times are sustained over multiple years. For example, in a 2016 literature review, Morgenthaler et al. note that studies examining the results of school start time changes over longer periods are needed “to determine whether the observed sleep increases and other outcomes are maintained.”²⁵

While studies typically control for school and student characteristics that may affect student outcomes, such controls (especially in cross-sectional studies) are imperfect. Findings from studies that rely on small sample sizes (e.g., students from a single school) or unique student populations (e.g., private boarding school students) should be interpreted with caution. Geographic location may also impact findings as the existing research does not consider the impact of school locations within a time zone on circadian rhythm or natural waking time. As Morgenthaler et al. note, “studies in states with a large distance from east to west may have children waking at a different biological time or circadian phase, such that the same school start time will result in an earlier biological time for children in the west compared with the east.”²⁶

Finally, **districts also need to consider students’ daily travel time to school when interpreting research findings.** As travel time is the second factor that determines student wake-up time, districts need to consider the effects of the start time *and* the time it takes students to travel to school.²⁷

SUMMARY OF RESEARCH

Hanover identified 16 U.S.-based studies published since 2007 that examine the effects of school start times on middle and high school students. These studies employ either a cross-sectional or longitudinal design and consider the effects of start times ranging from 7:00 a.m. and earlier to past 9:15 a.m. The following tables (Figures 1.3-1.5) provide an overview of these studies, which are grouped based on the size of the delay (or, for cross-sectional studies, the difference between start times). Please note that *positive findings* indicate that students benefited from a delayed school start time.

²² Ibid., p. 365.

²³ “What researchers mean by... cross-sectional vs. longitudinal studies.” Institute for Work & Health.
<https://www.iwh.on.ca/wrmb/cross-sectional-vs-longitudinal-studies>

²⁴ Ibid.

²⁵ Morgenthaler et al., Op. cit., p. 1687.

²⁶ Ibid.

²⁷ For example, see: Slagter, L. “Later high school start time in Ann Arbor? Here's what the survey says.” *Michigan Live*, December 23, 2016. http://www.mlive.com/news/ann-arbor/index.ssf/2016/12/survey_shows_support_for_later.html

Figure 1.3: Studies with Delays in School Start Time of Less Than an Hour (2007-2017)

AUTHOR	DATE	DESIGN	AGE	START TIMES	FINDINGS
Thacher and Onyper	2016	Longitudinal	Grades 9-12	7:45 to <u>8:30</u>	Mixed. An initial increase in sleep duration of 20 minutes did not persist, but improvements in tardiness and disciplinary violations lasted.
Boergers, Gable, and Owens	2014	Longitudinal	Grades 9-12	8:00 to 8:25	Positive. After delay, mean wake times (school days) were later, sleep duration longer, and bed times did not change.
Edwards	2012	Cross-sectional	Grades 6-9	7:30 to 8:15	Positive. Later start times corresponded with higher standardized tests scores, less time watching TV, more time doing homework, and fewer absences.
Owens, Belon, and Moss	2010	Longitudinal	Grades 9-12	8:00 to <u>8:30</u>	Positive. The delayed start time was associated with longer school night sleep durations, earlier bedtimes, later rise times.
O'Malley and O'Malley	2008	Longitudinal	Grades 9-12	7:35 to 8:15	Positive. A later start time corresponded with longer weeknight sleep duration.

Figure 1.4: Studies with Delays in School Start Time of an Hour or More (2007-2017)

AUTHOR	DATE	DESIGN	AGE	START TIMES	FINDINGS
Vorona et al.	2014	Cross-sectional	16-18 years	7:20 vs <u>8:45</u>	Positive. Adolescent car crash rates were higher in the county with the earlier start time.
Vorona et al.	2012	Cross-sectional	16-18 years	7:20 vs <u>8:45</u>	Positive. Adolescent car crash rates were higher in counties with earlier start times.
Hinrichs	2011	Cross-sectional	Grades 10-12	7:15 to <u>8:40</u> (range) ¹	Null. Hinrichs found no association between school start times and achievement on standardized assessments or attendance rates.
Danner and Phillips	2008	Longitudinal	Grades 6-12	7:30 to <u>8:30</u>	Positive. In the school year proceeding the start time change, students averaged from 12 minutes (Grade 9) to 30 minutes (Grade 12) additional minutes of sleep per night.
Wolfson et al.	2007	Cross-sectional	Grades 7-8	7:15 vs <u>8:37</u>	Mixed. Start time was associated with Grade 8 students' achievement but not with Grade 7 students' achievement.

¹Start times listed for the Minneapolis portion of the study only.

Figure 1.5: Studies with Variable Delays in School Start Time (2007-2017)

AUTHOR	DATE	DESIGN	AGE	START TIMES	FINDINGS
McKeever and Clark	2017	Longitudinal	Grades 9-12	8:30 or earlier to from <u>8:35-9:15</u>	Mixed. An initial increase in sleep duration of 20 minutes did not persist, but improvements in tardiness and disciplinary violations persisted.
Paksarian et al.	2015	Longitudinal	13-18 years	7:05 to <u>9:22</u> (range)	Mixed. Later start times associated with increased sleep for boys in urban areas. No significant effects for delays past 8:00 a.m.
Wahlstrom et al.	2014	Longitudinal	Grades 9-12	7:30-7:50 to 8:00- <u>8:55</u>	Positive. A start time of 8:30 a.m. or later allowed for more than 60 percent of students to sleep for at least eight hours per school night. The impact on achievement, attendance, and driving safety was mixed but trending positive.
Ming et al.	2011	Cross-sectional	Grades 9-12	7:00 to <u>8:45</u> (range)	Positive. Earlier start times associated with less sleep duration.
Carrell, Maghakian, and West	2011	Cross-sectional	US Air Force Academy freshman	7:00 to 7:50 (range)	Positive. Authors found a positive <i>causal</i> relationship between start times and student academic performance.
Adam, Snell, and Pendry	2007	Cross-Sectional	5-19 years	Range	Positive. An hour delay in school start time was associated with 0.57 hours of more sleep and a 0.62 hour later rise time for older children (12-19 years).

In the following paragraphs, Hanover discusses the effects of school start times on student sleep habits, academic achievement, and other outcomes for adolescents in greater detail.

EFFECTS ON SLEEP

Most research on school start times focuses on the association between start times and adolescent sleeping patterns. In their 2016 literature review, Wheaton, Chapman, and Croft note that “because delaying school start times is primarily intended to address the problem of insufficient sleep among adolescents, most of the studies [included in their review] focused on the association between school start times and sleep variables.”²⁸ While studies consistently find that students attending schools with later start times sleep in longer compared to students with earlier classes, the association between school start times and bedtime is mixed. Some studies observe no correlation between them, while others find that students with later start times have later bed times when compared to their peers attending

²⁸ Wheaton, Chapman, and Croft, Op. cit., p. 375.

schools with earlier start. Nevertheless, as the following subsections describe, students with later start times consistently sleep longer, even when they go to bed later.²⁹

POSITIVE EFFECTS

Research indicates that delayed school start times typically result in more sleep for adolescent students. In their 2016 literature review, Wheaton, Chapman, and Croft included 31 U.S.- and foreign-based studies that examined the connection between school start times and school night sleep. In 29 of these studies, a later start time is associated with longer weekday sleep, primarily due to the delay of rise times. Wheaton, Chapman, and Croft note that “most of the studies [see] a significant increase in sleep duration even with relatively small delays in start times of half an hour or so.”³⁰ When examining the 20 U.S.-based studies, specifically, seven of them “[find] that students got at least one additional minute of sleep for every two minutes of difference in start time.”³¹ While six studies observed a later bedtime among students attending schools with later start times, these students still slept more in comparison with peers attending schools with earlier start times.³²

LONGITUDINAL EVIDENCE

Experimental studies find that a 25-minute or greater delay to a start time of 8:30 a.m. or later results in significant increases in students’ sleep duration. In a 2016 literature review published in *Sleep Medicine Reviews*, Minges and Redeker only focus on experimental studies and find three U.S.-based studies employ a “pre-post no control” design (i.e., a longitudinal design).³³ As Figure 1.6 describes, the three U.S.-based studies indicate that a delay of 25 minutes to an hour in school start time corresponded with increases in sleep duration of 12 to 45 minutes.

²⁹ Ibid.

³⁰ Ibid., p. 363.

³¹ Ibid., p. 375.

³² Ibid.

³³ Minges and Redeker, Op. cit., p. 87.

Figure 1.6: U.S. Experimental Studies Examining the Effects of School Start Times on Sleep

STUDY	DESCRIPTION	OUTCOME
Boergers et al. (2014) ³⁴	The study measured the effects of a delay in the school start time (from 8:00 to 8:25 a.m.) during the winter term at an independent boarding and day school. 197 students completed a sleep habits survey before and during the change, as well as in the spring term after the change was reversed.	Positive. The delay in school start time corresponded with a significant increase in weekday sleep duration of 29 minutes. The percentage of students receiving at least eight hours of sleep increased from 18 to 44 percent. Grade 9 and 10 students were most likely to report increased sleep duration. Sleep duration reverted to original levels when the earlier start time was reinstated.
Owens et al. (2010) ³⁵	The study measured the effects of a two-month change in school start time, a delay from 8:00 a.m. to 8:30 a.m. , at a New England boarding school. 201 students in Grades 9-12 completed a sleep habits survey before and after the change.	Positive. Following the delay, the average school night sleep duration increased by 45 minutes, the number of students getting less than seven hours of sleep decreased by 79 percent, and the percentage of students reporting at least eight hours of sleep increased from 16 to 55 percent. The average bedtime advanced by 18 minutes.
Danner et Phillips (2008) ³⁶	In the 1999-2000 school year, a county-wide school district in Kentucky delayed middle and high school start times by an hour from, respectively, 8:00 a.m. and 7:30 a.m. to 9:00 a.m. and 8:30 a.m. Roughly 10,000 middle and high school students completed a sleep habits survey in the year preceding the change and then again in April of 2000. The authors only provided results at the high school-level.	Positive. In the school year proceeding the change, students averaged from 12 minutes (Grade 9) to 30 minutes (Grade 12) additional minutes of sleep per night. Changes in average sleep were significant for all grade levels. The percentage of students sleeping at least eight hours on a weeknight increased from 35.7 to 50 percent. The average amount of additional weekend sleep decreased from 1.9 to 1.1 hours.

Source: *Journal of Developmental & Behavioral Pediatrics*, *Archives of Pediatric and Adolescent Medicine*, and *Journal of Clinical Sleep Medicine*

Another similar longitudinal study by O'Malley and O'Malley examined the impact of a 30-minute delay in school start time on students in one high school in Connecticut. They found that delaying the school start time from 7:35 a.m. to 8:15 a.m. corresponded with an average increase in total sleep by 34 minutes per school night.³⁷

³⁴ Boergers, J., C. Gable, and J. Owens. "Later School Start Time Is Associated with Improved Sleep and Daytime Functioning in Adolescents." *Journal of Developmental & Behavioral Pediatrics*, 35, 2014. p. 11.
<https://www.gwern.net/docs/melatonin/2014-boergers.pdf>

³⁵ Owens, J., K. Belon, and P. Moss. "Impact of Delaying School Start Time on Adolescent Sleep, Mood, and Behavior." *Archives of Pediatric and Adolescent Medicine*, 164:7, 2010. p. 608.
http://peds.stanford.edu/documents/Adolescent_sleep.pdf

³⁶ Danner, F. and B. Phillips. "Adolescent Sleep, School Start Times, and Teen Motor Vehicle Crashes." *Journal of Clinical Sleep Medicine*, 14:6.

³⁷ O'Malley, E. and M. O'Malley. "School Start Time and Its Impact on Learning and Behavior." In *Sleep and Psychiatric Disorders in Children and Adolescents*, New York: Information Healthcare Publisher, 2008. p. 90. Accessed via:
http://www.neurofeedback.ch/downloads/Schlaf_und_Schule.pdf

CROSS-SECTIONAL EVIDENCE

Findings from cross-sectional studies also support a high school start time of 8:30 a.m. or later. For example, in a 2014 study, Wahlstrom examined sleep habit survey data from eight public high schools across Minnesota, Colorado, and Wyoming during the 2010-11 to 2012-13 school years. The population was ethnically and socio-economically diverse, with the percentage of white students ranging from 60 to 90 percent and the percentage of students receiving free or reduced price lunch ranging from 10 to 34 percent.³⁸ While all schools adjusted their school start times, Wahlstrom collected pre- and post-change data for just two schools; for the other schools, only post-change data was collected. Post-change start times ranged from 8:00 a.m. to 8:55 a.m. across schools, with half of the schools starting at 8:30 a.m. or later.³⁹ Wahlstrom found that a start time of 8:30 a.m. or later allowed for more than 60 percent of students to sleep for at least eight hours per school night.⁴⁰ Correspondingly, in a 2011 cross-sectional study of 1,941 students across five high schools, Ming et al. found an association between a start time before or at 7:30 a.m. and decreased weekday sleep duration and sleep quality, compared with a start time after 7:30 a.m.⁴¹

Similarly, in an earlier study, Wahlstrom found that **a delay in school start time from 7:15a.m. to 8:40 a.m. at seven high schools in the Minneapolis Public School District corresponded with students sleeping 50 minutes longer each night**, in comparison with students at a demographically similar district with a start time of 7:30 a.m.⁴² Correspondingly, in a 2007 study of two diverse New England urban school districts, Wolfson et al. found that **students attending a middle school that started at 8:37 a.m. slept from 37 to 65 minutes longer per weeknight** (depending on the survey period), in comparison with students attending a middle school starting at 7:15 a.m.⁴³

Moreover, in a 2007 study with a nationally representative sample, Adam, Snell, and Pendry found that **a one-hour delay in start time corresponded with 34 minutes of additional sleep for adolescents**. From a sample of 2,454 children (from ages 5.5 to 11.9) and adolescents (from ages 12 to 19.1), Adam, Snell, and Pendry used a cross-sectional method to examine the associations between “demographic characteristics, school schedules, activity choices,

³⁸ Wahlstrom, K. et al. “Examining the Impact of Later High School Start Times on the Health and Academic Performance of High School Students: A Multi-Site Study.” Center for Applied Research and Educational Improvement, 2014. p. 2.
<http://conservancy.umn.edu/bitstream/handle/11299/162769/Impact%20of%20Later%20Start%20Time%20Final%20Report.pdf?sequence=1&isAllowed=y>

³⁹ Ibid., p. 24.

⁴⁰ Ibid., p. 1.

⁴¹ Ming, X. et al. “Sleep Insufficiency, Sleep Health Problems and Performance in High School Students.” *Clinical Medical Insights: Circulatory, Respiratory and Pulmonary Medicine*, 5, 2011.
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3212860/>

⁴² Wahlstrom, K. “Changing Times: Findings From the First Longitudinal Study of Later High School Start Times.” *NASSP Bulletin*, 86:633, December 2002. pp. 12–13. <https://teensneedsleep.files.wordpress.com/2011/04/wahlstrom-changing-times-findings-from-the-first-longitudinal-study-of-later-high-school-start-times.pdf>

⁴³ Wolfson, A. et al. “Middle School Start Times: The Importance of a Good Night’s Sleep for Young Adolescents.” *Behavioral Sleep Medicine*, 5, 2007. pp. 200–201.
<https://pdfs.semanticscholar.org/ac06/e8dc184d5f3c2bd362707fdc7f135d5ac11e.pdf>

family functioning, and sleep behaviors.”⁴⁴ Of these, “the largest effect sizes were for the impact of school start times and especially the effect of travel time to school on total hours of weekday sleep.”⁴⁵ For adolescents, an hour delay corresponded with 0.57 hours of additional sleep per night and a delay of school day wake time by 0.62 hours.⁴⁶

MIXED OR NO EFFECTS

However, a smaller body of literature finds that delayed school start times are not associated with lasting sleep gains for adolescent students. For example, in an experimental study published in 2016, Thacher and Onyper examined sleep habits, academic performance, and other academic-related factors of students from a public high school in upstate New York, which delayed its start time by 45 minutes from 7:45 a.m. to 8:30 a.m. during the 2012-13 school year.⁴⁷ While surveys of student sleep habits indicated that students were sleeping for an average of 20 minutes longer in the fall following the change, by the spring, students reported sleeping for the same amount of time as they did before the change. However, the authors found lasting improvements in tardiness and disciplinary violations.⁴⁸

Additional research suggests that delays in school start times past 8:00 a.m. do not have an impact on adolescents’ average sleep duration. In what the authors describe as “the largest study to date of adolescents from across the United States,” Paksarian and Rudolph examined a subsample of a nationally representative cross-sectional survey of over 7,300 students aged 13 to 18 years old.⁴⁹ After adjusting for variables such as age, sex, school level, urbanicity, and student employment, the authors found that students overall, as well as students from specific subgroups, did not sleep longer on average with school start time delays after 8:00 a.m. However, Paksarian and Rudolph identified some differences in the effects of delayed start times before 8:01 a.m. by student gender and school location. Specifically, they found that:⁵⁰

- **Male adolescents appear to benefit from start time delays before 8:01 a.m., but female adolescents appear to be unaffected.** The data shows that for each half-hour delay in start time before 8:01 a.m., male students slept approximately 20 minutes longer; however, school start time was not associated with sleep duration for female students, no matter the delay was before or after 8:01 a.m.
- **Increases in adolescent average sleep duration were most associated with male students living in major metropolitan counties.** For male adolescents in major

⁴⁴ Adam, E., E. Snell, and P. Pendry. “Sleep Timing and Quantity in Ecological and Family Context: A Nationally Representative Time-Diary Study.” *Journal of Family Psychology*, 21:1, 2007. p. 4.
<https://www.sesp.northwestern.edu/docs/publications/181298767462eb2340d7d7.pdf>

⁴⁵ Ibid., p. 16.

⁴⁶ Ibid., p. 12.

⁴⁷ Published after Minges and Redeker’s and Wheaton, Chapman, and Croft’s 2016 reviews were submitted and so not included.

⁴⁸ Thacher, P. and S. Onyper. “Longitudinal Outcomes of Start Time Delay on Sleep, Behavior, and Achievement in High School.” *Sleep*, 39:2, 2016. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4712391/>

⁴⁹ Paksarian, D. and K. Rudolph. “School Start Time and Adolescent Sleep Patterns: Results From the US National Comorbidity Survey—Adolescent Supplement.” *American Journal of Public Health*, 105:7, July 2015.

⁵⁰ Bullets adapted from: Ibid.

metropolitan counties, each half-hour delay in start time before 8:01 a.m. was associated with nearly 34 minutes of extra sleep each night. Later school start times were unassociated with sleeping patterns for male students living in urbanized counties, and negatively associated with male students living in nonurban counties (sleep duration was 20 minutes less for these students on weeknights for each half-hour delay in start time before 8:01 a.m.).

EFFECTS ON ACADEMIC ACHIEVEMENT

Research focusing on the effects of school start times on student achievement remains inconclusive, with different studies indicating positive, mixed, or no statistically-significant impacts of school start time delays. Wheaton, Chapman, and Croft note that “some evidence suggests a positive association between later school start times and academic performance,” but “the association may be relatively weak and not universal.”⁵¹ Further complicating research findings, studies on the effects of school start times on academic achievement are typically correlational in nature and, thus, unable to provide causal evidence to confirm that changes in school start times lead to differences in student academic achievement.⁵² Research focusing on the effects of school start times on academic achievement is also limited. For example, of the 38 studies included in the review by Wheaton, Chapman, and Croft, only 10 studies examined the effects of school start times on student achievement. Similarly, as Keller et al. note in a 2015 study on school start times in Kentucky elementary schools, “a large scale investigation of the potential impact of public school start times on academic achievement is lacking.”⁵³

POSITIVE EFFECTS

Several studies suggest a positive correlation between delayed school start times and academic performance. Wheaton, Chapman, and Croft found that, of the 10 studies included in their analysis that examined the effects of school start times on student achievement, six U.S.-based studies suggested a positive association between later school start times and improved student achievement. However, of these six studies, only three had *completely* positive findings: a 2011 study published by Carrell, Maghakian, and West, a 2012 study published by Finley Edwards, and a 2005 study by Arlington Public Schools.⁵⁴

In a multi-year study of first-year students at the U.S. Air Force Academy (USAFA), Carrell, Maghakian, and West determined that a delayed school start time had a casual effect on student academic achievement. In this study, Carrell, Maghakian, and West assessed the effects of school start times on USAFA first-year students from 2004 to 2008, a dataset consisting of over 6,000 students.⁵⁵ This dataset’s unique features, as shown in Figure 1.7 below, allowed Carrell, Maghakian, and West to establish *causality*, rather than merely

⁵¹ Wheaton, Chapman, and Croft, Op. cit., p. 376.

⁵² Carrell, Maghakian, and West, Op. cit., p. 63.

⁵³ Keller, Smith, et al., Op. cit., p. 236.

⁵⁴ Wheaton, Chapman, and Croft, Op. cit., p. 377.

⁵⁵ Carrell, Maghakian, and West, Op. cit., p. 67.

correlation or association. As similar causal studies are rare, the Brookings Institute considered the findings particularly “compelling evidence.”⁵⁶

Figure 1.7: Characteristics of Carrell, Maghakian, and West’s Study of USAFA First-Years

- Students in their freshman year at USAFA are required to take a series of core courses in which attendance in their assigned section is mandatory.
- Students are randomly assigned to course sections and cannot choose which periods they take their classes.
- Not every student is assigned to a first period course.
- [The authors] exploit the fact that USAFA runs on an M/T schedule. On M Days, students have one set of classes and on T Days they have a different set of classes. The M/T schedule runs every other day. Thus, some students may have first period classes on both M and T days, others may only have a first period class on one of the schedule days, and some may not have any first period classes.
- [The authors] exploit two distinct policy changes in the USAFA class schedule. Prior to academic year 2006–2007 (AY 2006), the academic day started at 7:30 am. In AY 2006 the school day was moved 30 minutes earlier, starting at 7 am. In AY 2007, the start time was moved to 7:50 am.

Source: *American Economic Journal: Economic Policy*⁵⁷

In the Carrell, Maghakian, and West study, students with a 7:00 a.m. start time performed worse in their first period and following classes when compared to students with a start time of 7:50 a.m. The authors found that a delayed school start of 50 minutes yielded “the equivalent benefit as raising teacher quality by roughly one standard deviation.”⁵⁸ Students assigned to a 7:00 a.m. start time performed “a statistically significant 0.140 standard deviations lower on average in comparison with the latest start time,” while students starting at 7:50 a.m. did not perform at a statistically lower level. This finding aligns with research indicating that melatonin production peaks at about 7 a.m. and stops at about 8 a.m.⁵⁹

Carrell, Maghakian, and West also believe that their findings are applicable to the high school student population because they consider only freshman college students who, like high school seniors, “are still adolescents and have the same biological sleep patterns and preferences as those in their earlier teens.”⁶⁰ Moreover, according to the authors, the fact that early school start times negatively impacted the USAFA sample – a group of students with a history of high academic achievement and a preference for a regimented lifestyle – suggests that average students may experience even greater detrimental effects.⁶¹

Similarly, a 2012 study by Edwards finds that a start time of 8:00 a.m. or later is associated with higher student achievement, especially among low-achieving students. Edwards used

⁵⁶ Jacob, B. and J. Rockoff. “Organizing Schools to Improve Student Achievement: Start Times, Grade Configurations, and Teacher Assignments.” The Brookings Institution, 2011. p. 8. https://www.brookings.edu/wp-content/uploads/2016/06/092011_organize_jacob_rockoff_paper.pdf

⁵⁷ Figure bullets quoted verbatim from: Carrell, Maghakian, and West, Op. cit., pp. 67–67.

⁵⁸ Ibid., pp. 79–80.

⁵⁹ Ibid., p. 75.

⁶⁰ Ibid., p. 63.

⁶¹ Ibid.

student achievement and demographic data from North Carolina’s Wake County Public School System (WCPSS) that were collected between 1999 and 2006 in his study. Slightly over half of WCPSS middle schools over that period began at 7:30 a.m., while the others began at either 8:00 a.m. or 8:15 a.m.⁶² Edwards’ findings indicate that starting schools one hour later increases standardized test scores by 1.8 percentile points in mathematics and 1.0 percentile points in reading. However, effects on students who scored in the bottom third as opposed to the top third of test-takers are twice as large. In addition, a one-hour delay in middle school start time is associated with a 2.0 and 1.6 percentile point increase in high school mathematics and reading scores, respectively.⁶³

A 2005 study by Arlington Public Schools (APS) in Virginia suggests that **later school start times had positive impacts on middle and high school students, while earlier start times had negative impacts.** The APS study evaluated a high school start time change from 7:30 a.m. to 8:15 a.m. To accommodate districtwide transportation needs, APS also shifted the middle school start time from 8:10 a.m. to 7:50 a.m. While the grade point averages of high school students improved after the change, APS observed some academic decline at the middle school level. Therefore, APS concluded that “a more effective approach might have been to shift elementary start times.”⁶⁴

MIXED OR NO EFFECTS

Several studies find that later school start times have mixed effects on student grades and standardized test scores. In the most recent of these studies, Wahlstrom et al. obtained mixed results when evaluating the effects of later school start times on the academic achievement of 9,000 students in eight high schools across Minnesota, Colorado, and Wyoming.⁶⁵ Student performance on standardized tests increased following the start time change at three high schools, but decreased in two high schools. Similarly, student GPA in core courses increased significantly across three high schools, but demonstrated mixed results depending on the subject in two high schools.⁶⁶

Other research suggests that later school start times have little to no effect on academic achievement. For example, in a 2011 study, Peter Hinrichs examined the effects of later school start times on standardized test scores in Minneapolis-Saint Paul, Kansas, and Virginia from 1993 to 2002. In Minneapolis, where high schools delayed their start times from 7:15 a.m. to 8:40 a.m. in the 1997-98 school year, Hinrichs found no indication that this policy

⁶² Edwards, F. “Early to Rise? The Effect of Daily Start Times on Academic Performance.” *Economics of Education Review*, 31, 2012. p. 973. <https://teensneedsleep.files.wordpress.com/2011/04/edwards-early-to-rise-the-effect-of-daily-start-times-on-academic-performance-published-version.pdf>

⁶³ Ibid., p. 970.

⁶⁴ This report is no longer publicly available but was cited in a past Hanover report titled “School Start Times and Student Outcomes” (April 2016), which is available through the Customer Portal. Hanover takes the description of this study’s findings verbatim from that report.

⁶⁵ Wahlstrom et al., Op. cit., pp. 8–10.

⁶⁶ The authors examined grade point averages for first- or third- period courses in mathematics, English, social studies, and science. However, for Mahtomedi Public Schools and South Washington County high schools, the authors examined course grades. See: Ibid., pp. 40–41.

change affected test scores or attendance patterns.⁶⁷ Similarly, neither ACT scores in Kansas or End of Course (EOC) scores in Virginia indicated any effect of later school start times on student achievement (specific start times varied across Kansas and Virginia).⁶⁸ However, there are considerable limitations of this research. For example, the ACT score may not accurately reflect student learning, Hinrichs was unable to decouple the impact of schedule changes from other district and school changes (although this criticism could be leveled at many studies on school start times),⁶⁹ and the pool of students who chose to take the ACT was not necessarily representative of the entire student body.⁷⁰

A smaller, cross-sectional study finds that a delay in school start time to 8:37 a.m. is associated with improved student achievement for Grade 8 students but not for Grade 7 students. In their 2007 study involving two middle schools with different start times in demographically similar New England districts, Wolfson et al. examined student grades in addition to nightly sleep. The authors found that Grade 8 students attending a school with a start time of 8:37 a.m. performed better compared to Grade 8 students attending a middle school that started at 7:15 a.m. However, the authors found no statistically significant differences in fall quarter grades at the Grade 7 level. It is worth noting that the total sample size of this study was only 205 students.⁷¹

EFFECTS ON OTHER OUTCOMES

The following subsections discuss the effects of school start times on driving safety, attendance and graduation rates, mental health, and extracurricular participation.

DRIVING SAFETY

Surveys indicate that adolescents are more likely to drive when drowsy, a leading cause of fatal crashes for teen drivers. The CDC finds that teens (16 to 19 years old) are the most at-risk group for motor vehicle crashes, as they are nearly three times more likely to be in a fatal crash than drivers aged 20 years and older.⁷² Adolescents are also more likely to drive when drowsy. According to a survey by the AAA Foundation for Traffic Safety (AAA Foundation), one in seven licensed drivers of ages 16 to 24 years old admitted to having nodded off at least once while driving in the past year. In comparison, only one in 10 of all licensed drivers over the same period reported falling asleep while driving. Moreover, the AAA Foundation estimates that roughly one in six crashes involves a drowsy driver.⁷³

⁶⁷ Hinrichs, P. "When the Bell Tolls: The Effects of School Starting Times on Academic Achievement." *Education Finance Policy*, 6:4, 2011. pp. 492–497. <https://teensneedsleep.files.wordpress.com/2011/03/hinrichs-when-the-bell-tolls-the-effects-of-school-starting-times-on-academic-achievement.pdf>

⁶⁸ Ibid., p. 500.

⁶⁹ Jacob and Rockoff, Op. cit., p. 9.

⁷⁰ Wheaton, Chapman, and Croft, Op. cit., p. 376.

⁷¹ Wolfson et al., Op. cit., pp. 198–203.

⁷² "Teen Drivers: Get the Facts." Centers for Disease Control and Prevention. https://www.cdc.gov/motorvehiclesafety/teen_drivers/teendrivers_factsheet.html

⁷³ "Young People More Likely to Drive Drowsy." National Sleep Foundation, 2012. <http://drowsydriving.org/2012/11/young-people-more-likely-to-drive-drowsy/>

The CDC cites drowsy driving as one of the eight leading causes of teen car crashes, noting that high school students who sleep less than nine hours per night are more likely to exhibit the risk behaviors shown in Figure 1.8 below.⁷⁴

Figure 1.8: Driving-Related Risk Behaviors Associated with Insufficient or Excessive Sleep



Source: CDC⁷⁵

Available research also suggests that later school start times reduce the percentage of teenage drivers in accidents. Wheaton, Chapman, and Croft identified four studies that assessed the impact of school start times on motor vehicle crashes, all of which are U.S.-based studies. Figure 1.9 describes these studies and their respective findings. The later start times in studies tend to be 8:30 a.m. or later.

Figure 1.9: Studies on School Start times and Teen Driving Crashes

STUDY	DESCRIPTION	FINDINGS
Wahlstrom (2014) ⁷⁶	The study analyzes vehicle crash data from Minnesota, Colorado, and Wyoming for 16- to 19-year old drivers. The authors examine the number of crashes involving teen drivers in the area surrounding eight high schools before and after these schools implemented a schedule change, delaying their starting times. Pre-delay start times varied from 7:30 to 7:50 a.m. and post-delay start times from 8:00 to 8:55 a.m.	Mostly Positive. Across the four communities for which Wahlstrom had crash data, two communities saw a decrease in the rate of teen car crashes of 65 to 70 percent. A third district saw a decrease of 6 percent, while the fourth experienced an increase of 9 percent with the adoption of the later school start times.
Vorona et al. (2014) ⁷⁷	This study examines teen (16 to 18 years old) car crashes in Chesterfield and Henrico Counties (CC and HC, respectively) for the 2009-10 and 2010-11 school years. CC had a high school start time of 7:20 a.m., while HC high schools began at 8:45 a.m. Both counties are demographically similar and adult crash rates and traffic congestion did not differ between counties.	Positive. Chesterfield teens manifested a statistically higher crash rate of 48.8/1,000 licensed drivers versus Henrico's 37.9/1,000 for 2009-2010. For 2010-2011, 16- to 17-year old teens in CC demonstrated a statistically significant higher crash rate (53.2/1,000 versus 42.0/1,000), while for 16-18 teens, a similar trend was found, albeit nonsignificant. Crash peaks occurred 1 hour earlier in the morning and 2 hours earlier in the

⁷⁴ Wheaton et al., "Sleep Duration and Injury-Related Risk Behaviors Among High School Students — United States, 2007–2013." *Morbidity and Mortality Weekly Report*, 65:13, 2016. <https://www.cdc.gov/mmwr/volumes/65/wr/mm6513a1.htm>

⁷⁵ Figure adapted from: Wheaton et al., Op. cit.

⁷⁶ Wahlstrom et al., Op. cit., p. 48.

⁷⁷ Vorona, R. et al. "Adolescent Crash Rates and School Start Times in Two Central Virginia Counties, 2009-2011: A Follow-up Study to a Southeastern Virginia Study, 2007-2008." *Journal of Clinical Sleep Medicine*, 10:11, November 2014. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4224716/>

STUDY	DESCRIPTION	FINDINGS
		afternoon in Chesterfield, consistent with commute times
Vorona et al. (2011) ⁷⁸	This study examines teen (16 to 18 years old) car crashes in Virginia Beach and Chesapeake Counties (VBC and CC, respectively) over 2007-2008. High schools in VBC start between 7:20 and 7:25 a.m., while those in CC start at either 8:40 or 8:45 a.m.	Positive. Despite similar demographics and no obvious traffic-related explanations, less teen-related accidents occurred in VBC than in CC (46.6/1000 in comparison with 65.8/1000).
Danner et Phillips (2008) ⁷⁹	This study examines the teen crash rate in a Kentucky county-wide district two years prior to and two years following a delay in school start times. Specifically, in 1999, this district's high and middle schools delayed their start times by one hour, respectively, to 8:30 a.m. and 9:00 a.m.	Positive. The authors found that a delay in school start time corresponded with a drop in the teen crash rate by 16.5 percent in comparison with the rate for the two years preceding the schedule change. In contrast, the statewide teen crash rate increased by 7.8 percent over this period.

Source: Center for Applied Research and Educational Improvement and *Journal of Clinical Sleep Medicine*

ATTENDANCE AND GRADUATION

Research suggests that later school start times are associated with decreased rates of tardiness and absence. Six studies included in Wheaton, Chapman, and Croft's review suggest that "earlier start times were also related to more frequent tardiness and more absences."⁸⁰ In addition, in his 2012 study of WCPSS students, Edwards found evidence that students who started school one hour later had 1.3 fewer absences in comparison with the median (five absences).⁸¹ Similarly, Wahlstrom found that three high schools included in her study experienced significant increases in attendance after delaying start times, while no high schools experienced significant decreases in attendance.⁸² Furthermore, Wolfson et al. discovered no significant differences in absence rates between two middle schools with different start times, but noticed a significant difference in the tardiness rates between the two schools, with the middle school starting at 8:37 a.m. reporting fewer tardy students compared to the middle school starting at 7:15 a.m.⁸³ Lastly, in a study of the delayed start time at an independent school in Rhode Island, Owens et al. found that teacher-reported first class absences and tardies decreased by 45 percent following the schedule change.⁸⁴ While these positive findings are encouraging, we want to note the small sample sizes of the majority of these studies.

⁷⁸ Vorona, R., et al. "Dissimilar Teen Crash Rates in Two Neighboring Southeastern Virginia Cities with Different High School Start Times." *Journal of Clinical Sleep Medicine*, 7:2, April 2011.
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3077341/>

⁷⁹ Danner and Phillips, Op. cit.

⁸⁰ Wheaton, Chapman, and Croft, Op. cit., p. 377.

⁸¹ Edwards, Op. cit., p. 982.

⁸² Wahlstrom et al., Op. cit.

⁸³ Wolfson et al., Op. cit., p. 204.

⁸⁴ Owens, Belon, and Moss, Op. cit.

In a wide-scale, longitudinal study published in *Sleep Health* in 2017, **start times delayed from pre-8:30 to post-8:30 corresponded with significant increases in student graduation and attendance rates across high schools with diverse backgrounds.** McKeever and Clark examined the impact of delayed start times on high school absence and graduation rates across 29 schools in eight school districts in seven states that all delayed their start times from 8:30 a.m. or earlier to between 8:35 a.m. and 9:15 a.m. Across these schools, the mean graduation rate rose from 79 percent at the earlier start times to 99 percent at the later start times. Similarly, the mean attendance rate across schools prior to the delay was 90 percent and rose to 94 percent post-delay. Further statistical analysis suggests that the increases in graduation and attendance rates are significant. Due to the scope of the study, the authors note that the results are “intended to be generalized to all high schools in the United States.”⁸⁵

MENTAL HEALTH

Several studies associate later school start times with improved student mental health. Wheaton, Chapman, and Croft note that “sleep is strongly linked with many psychiatric disorders, including depression and anxiety” and there is “evidence of a causal relationship between insufficient sleep and depression, as well as mood in general.”⁸⁶ Consequently, a small number of studies include depression assessments. Four studies in Wheaton, Chapman, and Croft’s review find that students at schools with later start times received lower depression scores in comparison with students at schools with earlier start times.⁸⁷ Similarly, two experimental studies find “significant decreases in the depression scale, depressed mood score, and proportion of students who were irritated or annoyed relative to post-intervention.”⁸⁸ However, one quasi-experimental study reveals no significant differences between the intervention (schools with later start times) and the control group (schools with no start time changes) in terms of mood.⁸⁹

EXTRACURRICULAR PARTICIPATION

Several studies find that delays in school start times do not affect participation rates in afterschool activities. Only a small number of studies on school start times examine their effects on extracurricular participation. Of these, Danner and Barbara’s 2008 study of students in Grades 6-12 at a county-wide school district in Kentucky has the largest sample size (approximately 10,000 students, on average, across multiple years). In 1999, this district’s high schools and middle schools delayed their start times by one hour to 8:30 a.m. and 9:00 a.m., respectively. In addition to data from a sleep habits survey conducted in the years before and after the change, schools gathered participation rates in afterschool activities, including sports and co-curricular activities. The study finds that in the 1998-99 to the 1999-00 school years, there was a slight increase in the percentage of students who reported

⁸⁵ McKeever, P. and L. Clark. “Delayed High School Start Times Later than 8:30 Am and Impact on Graduation Rates and Attendance Rates.” *Sleep Health*, 3:2, April 2017. pp. 120–123.

⁸⁶ Wheaton, Chapman, and Croft, Op. cit., p. 377.

⁸⁷ Ibid.

⁸⁸ Minges and Redeker, Op. cit., p. 89.

⁸⁹ Ibid.

working 10 hours or more per week. However, “there were no significant differences in hours spent on homework, school sports, organized community sports, music activities, volunteer work, or hanging out with friends.”⁹⁰

Similarly, in her 2002 study of seven comprehensive high schools in the Minneapolis Public School District, Wahlstrom found that **a delay in the high school schedule from between 7:15 a.m. and 7:35 a.m. to 8:40 a.m. did not affect participation rates in afterschool extracurricular activities.** Based on 578 teacher responses to the survey administered in the fall of 1996 before the change and 335 responses in the spring of 1998 following the change, Wahlstrom discovered that the “actual participation rates in afterschool activities, including sports and co-curricular activities, remained at the same levels after the implementation of the later high school start time as they had been before the change.”⁹¹ However, coaches and activity leaders were generally supportive of the change because students were less tired and more mentally alert by the end of the day.⁹²

The findings of these larger-scale studies of public secondary schools mirror those from two smaller studies of private schools. These small studies also find that a delay in school start time does not impact students’ extracurricular participation.⁹³

⁹⁰ Danner and Phillips, Op. cit.

⁹¹ Wahlstrom et al., Op. cit., p. 16.

⁹² Ibid.

⁹³ [1] Boergers, Gable, and Owens, Op. cit., p. 15. [2] Owens, Belon, and Moss, Op. cit.

SECTION II: OPTIMAL SCHOOL START TIMES FOR PRE-ADOLESCENTS

This section presents recommendations regarding nightly sleep for pre-adolescent children and discusses the available research on the effects of sleep habits and school start times on elementary school students.

SLEEP RECOMMENDATIONS

Pre-adolescent children require more nightly sleep on average compared to teenagers. In its 2016 consensus statement, the AASM recommends that pre-adolescent, school-aged children receive the following amounts of sleep on a regular basis to promote optimal health:⁹⁴

- **Children three to five years of age:** 10 to 13 hours per 24 hours (including naps); and
- **Children six to 12 years of age:** 9 to 12 hours per 24 hours.

These recommendations align with those of the National Sleep Foundation, which recommends that preschoolers sleep from 10 to 13 hours per night and school-aged children from nine to 11 hours per night.⁹⁵ While the CDC does not collect data on sleep habits of elementary-aged students, the **National Sleep Foundation notes that elementary school children routinely receive less than the minimum recommended amount of sleep.** Based on a nationally representative survey of parents with school-aged children, the National Sleep Foundation finds that children aged six to 11 receive 8.8 hours of sleep on an average school night.⁹⁶

ADVANCING ELEMENTARY SCHOOL START TIMES

To delay start times at the high school level, districts commonly make elementary school start times earlier. To decrease transportation costs, districts often stagger school start times to allow buses to make multiple runs in the morning and afternoon. To delay the start time for high schools, districts often flip start times between elementary and high schools to enable adolescents to sleep in later.⁹⁷ However, there is limited research focusing on the effects of start times on elementary-aged students; nor do professional organizations like the AAP and the AASM provide recommendations for elementary school start times as they do for high schools. Consequently, district leaders have limited guidance when making changes to district start times that impact elementary school students.

⁹⁴ Bullets adapted from: Paruthi, S. et al., Op. cit., p. 785.

⁹⁵ Hirshkowitz et al., Op. cit.

⁹⁶ "2014 Sleep in America Poll: Sleep in the Modern Family." National Sleep Foundation, 2016. p. 26.
<https://sleepfoundation.org/sites/default/files/2014-NSF-Sleep-in-America-poll-summary-of-findings---FINAL-Updated-3-26-14-.pdf>

⁹⁷ Buckhalt, J. "Earlier School Start Times for Elementary School Students." *Psychology Today*, February 27, 2017.
<https://www.psychologytoday.com/blog/child-sleep-zzzs/201702/earlier-school-start-times-elementary-school-students>

In the following subsections, Hanover discusses the available research related to the impact of sleep and school start times on elementary school students.

OVERVIEW OF RESEARCH

Few studies examine the impact of school start times on elementary students. As noted, research indicating that hormonal-driven changes affect adolescents' sleeping patterns has prompted much of the research on the effects of school start times. Consequently, Keller et al. note in their 2015 study of school start times in Kentucky elementary schools that "very little research has examined the impact of start times for elementary school students."⁹⁸ While research associates increased sleep with positive academic and behavioral outcomes for elementary school children, available research on school start times and elementary school children is more ambiguous. Figure 2.1 below provides an overview of U.S.-based studies that examined the effects of school start times on elementary school students. Please note that a *negative finding* in the table indicates that elementary school students with an earlier start time are worse off than those with a later start time.

Figure 2.1: Summary of Studies on the Effects of Elementary School Start Times

AUTHOR	DATE	DESIGN	START TIMES	FINDINGS*
Keller et al.	2017	Cross-sectional	7:00 to 9:10 a.m. (range)	Negative. Earlier start times were associated with a variety of negative behavioral outcomes related to disciplinary action, suspension, and behavioral incidents.
Appleman, Gilbert, and Au	2015	Cross-sectional	8:20 to 7:45 a.m.	Null. An advance in school time did not have a large impact on sleep duration for students in Grades 3-5.
Dupuis	2015	Cross-sectional	N/A	Null. Elementary school start times had a small to no effect on achievement.
Keller et al.	2015	Cross-sectional	7:00 to 9:10 a.m. (range)	Negative. The study associated earlier school start times with lower test scores, albeit only in middle- and upper-class elementary schools.
Edwards	2012	Cross-sectional	9:15 vs 8:15 a.m.	Null. School start times had no effect on upper elementary school students' academic achievement across county schools.
Adam, Snell, and Pendry	2007	Cross-sectional	Range	Negative. For children between five and 12, a delay in start time of an hour corresponded with an increase in sleep duration of 0.32 hours and a later wake time of 0.40 hours.

EFFECTS OF SLEEP

Meta-analyses suggest a small association between sleep duration, cognition, and academic performance in children. For example, in a 2012 meta-analysis that encompasses 86 studies and over 35,000 students, Astill et al. found a "small, but significant association

⁹⁸ Keller, Smith, et al., Op. cit., p. 236. <https://www.apa.org/pubs/journals/releases/edu-a0037195.pdf>

between sleep duration and cognition ($r=0.08$) and behavioral problems ($r=0.09$).⁹⁹ Similarly, in a three-part meta-analysis that includes over 13,000 children and adolescents, Dewald et al. found that sleepiness, sleep quality, and sleep duration all had a small, but significant effect on school performance. Specifically, “sleepiness showed the strongest relation to school performance ($r=0.133$), followed by sleep quality ($r=0.096$) and sleep duration ($r=0.069$).”¹⁰⁰ However, the correlation coefficients, or effect sizes, in both studies are considered small. For example, John Hattie, the researcher who published a synthesis of over 800 meta-analyses related to student achievement, argues that interventions should be measured against a low bar of $d=0.40$, rather than $d=0.00$ (note that “ r ” and “ d ” are both measures of effect size, with “ r ” measuring the size of associations and “ d ” the size of differences between two means).¹⁰¹

EFFECTS OF START TIMES

SLEEP

A 2015 study indicates that an advance in school start time from 8:20 a.m. to 7:45 a.m. does not have large effects on the total amount of sleep for students in Grades 3-5. Appleman, Gilbert, and Au asked over 600 students in Grades 3-5 in a predominantly white northeastern public elementary school to complete a self-administered survey before and after an advance in school start time. Specifically, students in Grade 3 moved from a start time of 9:10 a.m. (the start time of the lower elementary school) to 7:45 a.m. and students in Grade 4 and 5 moved from a start time of 8:20 a.m. to 7:45 a.m. While the authors were not permitted to directly identify students, “preventing direct longitudinal comparison,” more than 90 percent of students initially surveyed continued to the next grade in the same school system.¹⁰² Figure 2.2 below presents the study’s findings related to wake-up time, bed time, and average total sleep before and after the change. On average, students lost less than 10 minutes of sleep per night following the change, but students in Grade 3 slept for longer following the change.

Figure 2.2: Summary of Wake Times, Bed Times, and Total Sleep in Grades 3-5

GRADE	PRE-CHANGE (8:20 A.M.)	POST-CHANGE (7:45 A.M.)	DIFFERENCE
Average Wake-Up Time			
3	6:49 a.m.	6:27 a.m.	+8 min
4	6:56 a.m.	6:22 a.m.	-34 min
5	6:59 a.m.	6:23 a.m.	-36 min
Average Bed Time			
3	8:37 p.m.	8:22 p.m.	+15 min

⁹⁹ Astill, R. et al. “Sleep, Cognition, and Behavioral Problems in School-Age Children: A Century of Research Meta-Analyzed.” *Psychological Bulletin*, 138:6, 2012. p. 1124.

<https://pdfs.semanticscholar.org/ba10/43613932e94a29f69d2f562dbc4072565bd8.pdf>

¹⁰⁰ Dewald, J. et al. “The influence of sleep quality, sleep duration and sleepiness on school performance in children and adolescents: A meta-analytic review.” *Sleep Medicine Reviews*, 14, 2010. Pp. 179-182.

https://www.researchgate.net/publication/41111163_The_Influence_of_Sleep_Quality_Sleep_Duration_and_Sleepiness_on_School_Performance_in_Children_and_Adolescents_A_Meta-Analytic_Review

¹⁰¹ [1] Hattie, J. *Visible Learning: A Synthesis of Over 800 Meta-Analyses Relating to Achievement*. Routledge, 2009. p. 17. [2] “Statistics for Psychology.” University of Bath.

<http://staff.bath.ac.uk/pssiw/stats2/page2/page14/page14.html>

¹⁰² Appleman, E., K.S. Gilbert, and R. Au. “School Start Time Changes and Sleep Patterns in Elementary School Students.” *Sleep Health*, 1, 2015. p. 110. <http://www.sciencedirect.com/science/article/pii/S2352721815000522>

GRADE	PRE-CHANGE (8:20 A.M.)	POST-CHANGE (7:45 A.M.)	DIFFERENCE
4	8:52 p.m.	8:22 p.m.	+30 min
5	9:10 p.m.	8:43 p.m.	+27 min
Average Total Sleep Time (hours and minutes)			
3	10:11	10:35	+24
4	10:03	9:59	-4
5	9:49	9:40	-9

Source: *Sleep Health*¹⁰³

However, a 2007 study with a nationally representative sample suggests a stronger relationship between delayed start times and increased sleep duration for elementary children. Using a sample of 2,454 children (from ages 5.5 to 11.9) and adolescents (from ages 12 to 19.1), Adam, Snell, and Pendry found that a delay in start time of an hour corresponded with an increase in sleep duration of 0.33 hours and a later wake time of 0.40 hours for children.¹⁰⁴ However, as noted in Section I, the effects of school start times were stronger for adolescents when compared to younger children.

ACHIEVEMENT AND BEHAVIOR

Limited evidence suggests that delays in school start times positively affect the academic achievement of elementary school students. For example, Keller et al. evaluated the impact of school start times on elementary students' scores on the Kentucky Performance Rating for Educational Progress (K-PREP). They considered data from over 310,000 students across 718 public elementary schools in Kentucky, including any school serving a combination of students in Kindergarten through Grade 6.¹⁰⁵ While start times ranged from 7:00 a.m. to 9:10 a.m., 49 percent of schools started between 7:20 a.m. and 7:59 a.m. and 31 percent between 8:00 a.m. and 8:29 a.m. The study associated earlier school start times with lower test scores, albeit only in middle- and upper-class elementary schools. The authors, who found the results surprising, attributed students' lower test scores to the "physical, behavioral, and psychological ramifications of sleep deprivation."¹⁰⁶ In a later study, Keller et al. hypothesize that "students who are struggling with poverty face such a wide range of obstacles to their achievement and to their sleep quality that school start times simply have little impact."¹⁰⁷

In contrast, in a 2012 study of WCPSS, Edwards found that school start times had no effect on upper elementary school students' academic achievement. Specifically, he examined the impact of school start times on test scores in mathematics and reading, and observed no relationship for students in Grades 3-5. However, as WCPSS elementary schools all started much later compared to the district's middle schools (over half of elementary schools started at 9:15 a.m., with the remainder starting at 8:15 a.m.), it was unclear whether school start

¹⁰³ Ibid.

¹⁰⁴ Adam, Snell, and Pendry, Op. cit., p. 12.

¹⁰⁵ [1] Keller, Smith, et al., Op. cit., p. 237. [2] Keller, P., L. Gilbert, et al. "Earlier School Start Times Are Associated with Higher Rates of Behavioral Problems in Elementary Schools." *Sleep Health*, 3, 2017. p. 114.
<http://www.sciencedirect.com/science/article/pii/S2352721817300049>

¹⁰⁶ Keller, Smith, et al., Op. cit., pp. 239–243.

¹⁰⁷ Keller, Gilbert, et al., Op. cit., p. 114.

times did not affect elementary school students who were not affected by adolescent hormonal changes, or whether school start times in this analysis were not early enough to have a negative impact on student achievement.¹⁰⁸ Similarly, an internally published study from the Center of Applied Research for Applied Research and Educational Improvement finds small or no associations between start times and the achievement for elementary school students in Wayzata Public Schools (MN), and no association between elementary start times and students’ later middle school achievement.¹⁰⁹

A 2017 study published in *Sleep Health* links earlier start times with increased negative behavioral outcomes for elementary school students. In a follow-up study, Keller et al. again considered the impact of start times on elementary school students across Kentucky, but with a focus on behavioral outcomes. The authors found that earlier school start times were associated with more total disciplinary events, out-of-school suspensions, expulsions with services, and behavioral problems.¹¹⁰ Figure 2.3 below lists the behavioral outcomes associated with a one-hour delay in elementary school start time. Please note that these findings correspond with research that associates insufficient sleep with increased behavior problems, including aggression and inattentiveness, for children aged five to 11.¹¹¹

Figure 2.3: Behavioral Outcomes Associated with a One-Hour Later Elementary School Start Time



Source: *Sleep Health*¹¹²

¹⁰⁸ Edwards, Op. cit., pp. 980–981.

¹⁰⁹ Dupuis, D. “The Association Between Elementary School Start Time and Students’ Academic Achievement in Wayzata Public Schools.” Center for Applied Research and Educational Improvement, 2015. p. 12. http://conservancy.umn.edu/bitstream/handle/11299/181187/2015-12-02%20Wayzata%20Public%20Schools%20Elementary%20School%20Start%20Time%20Report_FINAL.pdf?sequence=1&isAllowed=y

¹¹⁰ Keller, Gilbert, et al., Op. cit., p. 116.

¹¹¹ Bagley, E. and M. El-Sheikh. “Children’s Sleep and Internalizing and Externalizing Symptoms.” In *The Oxford Handbook of Infant, Child, and Adolescent Sleep and Behavior*, New York: Oxford University Press, 2013. pp. 382–384. <https://books.google.com/books?id=uVkgAAQBAJ&lpg=PA381&ots=U6kZNspSCU&dq=Children’s%20sleep%20and%20internalizing%20and%20externalizing%20symptoms&lr&pg=PR4#v=onepage&q=Children’s%20sleep%20and%20internalizing%20and%20externalizing%20symptoms&f=false>

¹¹² Figure adapted from: Ibid.

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